

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY
WITH INDEXES

(Supplement 244)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in September 1989 in

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



National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
Washington, DC

1989

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 465 reports, journal articles and other documents originally announced in September 1989 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

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

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

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

An annual cumulative index will be published.

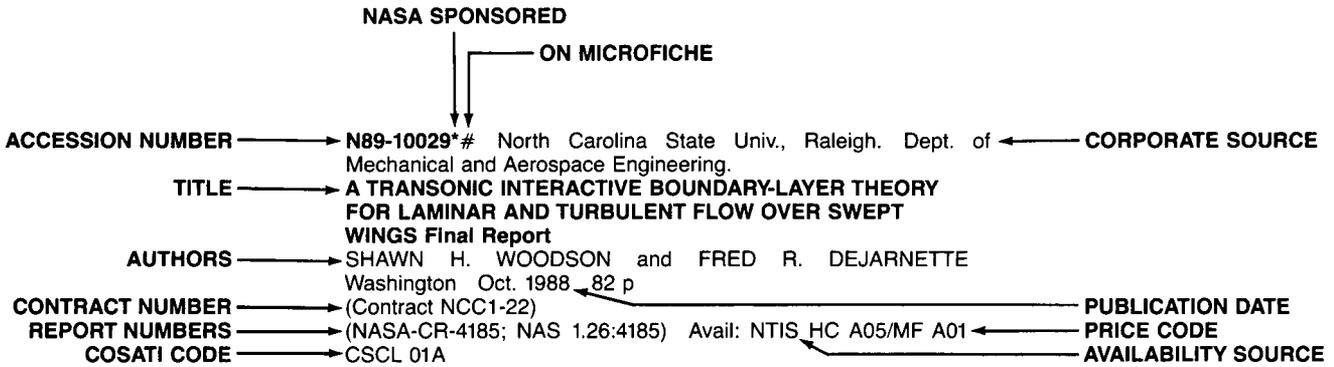
Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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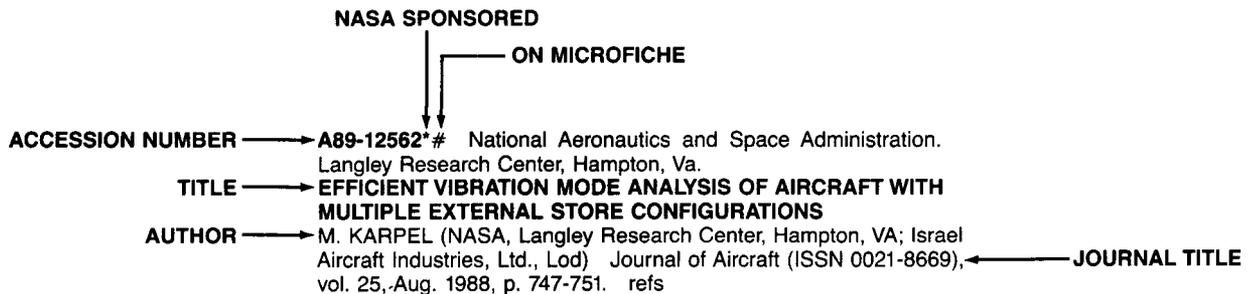
TYPICAL REPORT CITATION AND ABSTRACT



A 3-D laminar and turbulent boundary-layer method is developed for compressible flow over swept wings. The governing equations and curvature terms are derived in detail for a nonorthogonal, curvilinear coordinate system. Reynolds shear-stress terms are modeled by the Cebeci-Smith eddy-viscosity formulation. The governing equations are discretized using the second-order accurate, predictor-corrector finite-difference technique of Matsuno, which has the advantage that the crossflow difference formulas are formed independent of the sign of the crossflow velocity component. The method is coupled with a full potential wing/body inviscid code (FLO-30) and the inviscid-viscous interaction is performed by updating the original wing surface with the viscous displacement surface calculated by the boundary-layer code. The number of these global iterations ranged from five to twelve depending on Mach number, sweep angle, and angle of attack. Several test cases are computed by this method and the results are compared with another inviscid-viscous interaction method (TAWFIVE) and with experimental data.

Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



A coupling method for efficient vibration mode analysis of aircraft with multiple external store configurations is presented. A set of low-frequency vibration modes, including rigid-body modes, represent the aircraft. Each external store is represented by its vibration modes with clamped boundary conditions, and by its rigid-body inertial properties. The aircraft modes are obtained from a finite-element model loaded by dummy rigid external stores with fictitious masses. The coupling procedure unloads the dummy stores and loads the actual stores instead. The analytical development is presented, the effects of the fictitious mass magnitudes are discussed, and a numerical example is given for a combat aircraft with external wing stores. Comparison with vibration modes obtained by a direct (full-size) eigensolution shows very accurate coupling results. Once the aircraft and stores data bases are constructed, the computer time for analyzing any external store configuration is two to three orders of magnitude less than that of a direct solution.

Author

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 244)

OCTOBER 1989

01

AERONAUTICS (GENERAL)

A89-40251

AIRBORNE RECONNAISSANCE XII; PROCEEDINGS OF THE MEETING, SAN DIEGO, CA, AUG. 16, 17, 1988

PAUL A. HENKEL, ED. (General Dynamics Corp., Fort Worth, TX), WAYNE W. SCHURTER, ED. (McDonnell Aircraft Co., Saint Louis, MO), and FRANCIS R. LAGESSE, ED. Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 979), 1989, 209 p. For individual items see A89-40252 to A89-40273.

(SPIE-979)

The present conference on airborne reconnaissance discusses sensor hardware, imagery evaluation/exploitation, and state-of-the-art electrooptical systems. Attention is given to a low intensity reconnaissance aircraft and product-management system, tactical communications for the support of intelligence, the RS-170 reconnaissance camera for military applications, the use of magnetic suspension for sensor-vibration isolation, the application of parallel processing to image exploitation, and a high data rate airborne rotary digital recorder with long record time. Also treated are conformed-panoramic electrooptic sensors, the optical butting of matrix arrays, the model 324 advanced-technology RPV, and the role of mission planning in mission data management for tactical reconnaissance. O.C.

A89-40856

THE US AIRBORNE RADAR SCENE

BILL SWEETMAN *Interavia* (ISSN 0020-5168), vol. 44, May 1989, p. 449-453.

A technology development status and production program economics evaluation is presented for the most prominent contractors in the U.S. military aircraft radar industry, which are currently engaged in the production of radars for the B-1B, B-2, F-14, F-15, and F-18, as well as in the USAF ATF competition. It is generally accepted that mm-wave ICs (MMICs) will be a critical technology in the ATF's active-array radar. One of the manufacturers discussed has supplemented its developmental work in MMICs with inverse-SAR technology, which relies on the movement of the target to achieve a clear image; a radar of this type is used by the P-3C ASW aircraft. Attention is given to the prospects for the Joint Surveillance Target Attack Radar System. O.C.

A89-41057

SOVIET AEROSPACE INDUSTRY - PERESTROIKA'S CHANGES GRIP SOVIET AEROSPACE INDUSTRY

DONALD E. FINK *Aviation Week and Space Technology* (ISSN 0005-2175), vol. 130, June 5, 1989, p. 34, 35, 37.

A political background evaluation is made of the recent opening of Soviet aerospace facilities, including the design bureaus of Antonov, Ilyushin, Mikoyan, Mil, and Sukhoi, to Western journalists. Visits to these design and research institutes, as well as to various manufacturing plants, indicate that the Soviets are producing

state-of-the-art aerospace equipment whose sophistication is comparable to that of its Western counterparts. Industrial managers are uniformly found to be preoccupied with the implementation of 'perestroika' political-economic reforms, turning their enterprises into profit-making centers. O.C.

A89-41059

SOVIET AEROSPACE INDUSTRY - MOTORWORKS TAPS SKILL OF SEVERAL FACTORIES TO PRODUCE POWERPLANTS

Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, June 5, 1989, p. 49, 50.

The Zaporozhye Motorworks of the USSR, which produces more than 5000 engines/year for civil aircraft to designs produced by specialized bureaus, has a special relationship with the Progress Design Bureau located nearby. The powerplants currently in production at Zaporozhye are the D-18T turboprop for the An-124 and An-225 heavy-lift transports, the D-36 turboprop powering the An-72 STOL transport, and the D-136 turboshaft, which powers the Mi-26 helicopter. A total of five factories located throughout the Ukraine are associated in these production efforts; communications among them are maintained by a fleet of transport aircraft and helicopters. O.C.

A89-41061

SOVIET AEROSPACE INDUSTRY - CERTIFICATION OF SUPER HEAVY-LIFT ANTONOV AN-225 PLANNED FOR 1990

Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, June 5, 1989, p. 72, 73, 77.

Two An-225 superheavy-lift six-engined aircraft will participate in a flight test/development program leading to certification in 1990. Heavy, outsized payloads can be accommodated either in the main-deck cargo compartment or externally, on upper-fuselage attach points; the USSR is believed to have a requirement for dozens of such superheavy-lift transports. An-225 development costs were minimized, and the design process accelerated, by basing the aircraft to the greatest possible extent on the An-124 four-engine transport. An account is also given of other, smaller Antonov aircraft currently in production or under development. O.C.

A89-41062

SOVIET AEROSPACE INDUSTRY - MIL MI-28 ATTACK HELICOPTER IN FINAL TESTS PRIOR TO FULL-SCALE PRODUCTION

Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, June 5, 1989, p. 78, 79.

The two-seat Mi-28 attack helicopter has entered its final prototype test phase and will be put into full-scale production by 1991. The Mi-28 carries a range of air-to-ground armament, including rockets, missiles, and a 30-mm cannon mounted beneath the fuselage, on the centerline. The Mi-28 power train is an all-new design with novel dynamic components. The crew stations are reinforced with heavy armor that combines steel and titanium. The bulk of the remaining structure is of conventional Al alloy monocoque construction. Mi-28 prototypes have been flown to speeds of 300 km/hr in level flight. Two 2200-shp turboshaft engines are used. O.C.

01 AERONAUTICS (GENERAL)

A89-41064

SOVIET AEROSPACE INDUSTRY - SUKHOI DESIGN BUREAU EXPANDS CIVIL AIRCRAFT DEVELOPMENT EFFORTS

Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, June 5, 1989, p. 90-92.

A tour of the USSR's Sukhoi Design Bureau reveals wide-ranging design development projects involving state-of-the-art materials and structures. Attention is given to the unique case of the projected Su-51, for which a joint venture with a foreign business jet manufacturer (such as Gulfstream) is sought; the aircraft would be a two- or three-engine supersonic cruise business jet that could be produced (depending on the number of engines of the configuration ultimately chosen) in 40-seat 'tourist', 21-seat 'business class', or 12-seat 'deluxe corporate' versions. The engine used by the Su-51 would be the AI-36, which is a nonafterburning version of the AI-21 series fighter aircraft turbojet engine. O.C.

A89-41651

RECENT PROGRESS IN THE NATIONAL AEROSPACE PLANE PROGRAM

ROBERT BARTHELEMY (USAF, Washington, DC) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 4, May 1989, p. 3-12.

The goal of the NASP (National Aerospace Plane) program is to develop and demonstrate the feasibility of a horizontal take-off and landing aircraft that utilizes conventional airfields, accelerates to hypersonic speeds, achieves orbit in a single stage, delivers useful payloads to space, returns to earth with propulsive capability, and has the operability, flexibility, supportability, and economic potential of airplanes. The technological requirements of such a craft are examined, and current research efforts are described. I.E.

A89-42488

FLYING WINGS (2ND REVISED AND ENLARGED EDITION) [LETAIUSHCHIE KRYL'IA /2ND REVISED AND ENLARGED EDITION/]

IGOR' K. KOSTENKO Moscow, Izdatel'stvo Mashinostroenie, 1988, 105 p. In Russian. refs

The history of the development of tailless aircraft of the flying wing type is reviewed with emphasis on the work of Soviet scientists and designers in this field. The aerodynamics and flight dynamics of aircraft and gliders based on the flying wing design are discussed in a popular manner. Data on the current Soviet-made and foreign models of flying wings are presented. V.L.

A89-42928

THOROUGHGOING DV-SUPPORT FROM PROJECT PLANNING TO FACTORY CONTROL - PRACTICAL EXAMPLE FROM NEAR-DEVELOPMENT AIRCRAFT DESIGN [DURCHGAENGIGE DV-UNTERSTUETZUNG VON DER PROJEKTIERUNG BIS ZUR WERKSTATTSTEUERUNG - PRAXISBEISPIEL AUS DEN ENTWICKLUNGSNAHEN FLUGZEUGBAU]

DIERK MINKE (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) (Mega: das Technik-Magazin fuer Fuehrungskraefte, no. 1, 1988) IN: Research and development: Technical and scientific publications 1988. Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, p. 35-40. In German. (MBB-UD-526-88-PUB)

The planned development of air and space travel programs is conducted according to an internationally sanctioned phase concept. The various phases of this concept are described and graphically shown. An actual program development is described as an example. C.D.

A89-42947

SOVIET SST: THE TECHNOLITICS OF THE TUPOLEV-144

HOWARD MOON New York, Orion Books, 1989, 288 p. refs

The history of the unsuccessful Soviet effort to develop an SST aircraft, the TU-144, is recalled, considering both political and technological aspects. Consideration is given to the relationship between the designer Tupolev and the Soviet state, the TU-104

and TU-114, the international competition in SST development beginning in the late 1950s, reports of SST espionage, the 1969 TU-144 prototype and comparisons with the Concorde, engines and internal and external aerodynamics, and radical changes in the 1972 production model. Also discussed are the catastrophic crash of the production model, much slower progress during 1973-1977, the apparent second crash of 1978, and the final role of the TU-144 as a bomber testbed and record-setter. T.K.

A89-43077#

SOARING ON INTELLIGENT WINGS - AERODYNAMICISTS AT MBB ARE ALREADY AT WORK ON TOMORROW'S PROJECTS

New-Tech News, no. 1, 1989, p. 29-33.

The process of designing a wing for a commercial aircraft, which entails finding a wide variety of optimal compromises between conflicting criteria and constraints for the other aircraft-engineering disciplines, is discussed. Particular attention is given to the design of the 'intelligent wing', which is a comprehensive complex concept presenting an interdisciplinary challenge to all the fields of aircraft engineering. One of the basic technologies involved in the intelligent wing design is the laminar-flow technology, the intent of which is to keep the air layers in the immediate proximity of the wing surface in a particular state, so as to decrease friction and thus achieve considerable reduction in drag. Another concept being investigated is a variable camber; this involves using the high-lift flaps already on the wing to optimize the performance and wing-loading factors during cruising. I.S.

A89-43112#

IA63 PAMPA - THE COMPLETION OF AN AIRCRAFT DEVELOPMENT PROGRAM [IA63 PAMPA - ABSCHLUSS EINER FLUGZEUGENTWICKLUNG]

BERND STRAETER, KARL-HEINZ MOHR, and ALFONS TRZECIOK Dornier Post (ISSN 0012-5563), no. 3, 1988, p. 17-20. In German.

The development and testing of the IA63, a fighter-type jet trainer for the Argentine Air Force, is reviewed and illustrated with graphs and photographs. Consideration is given to the project organization, division of responsibilities, and financial arrangements; the aircraft design requirements; the extensive structural testing program to demonstrate component strength, stiffness, and fabricability (especially for the integrally machined supercritical wing panels); ground tests of the ejection seat; plans for fatigue-life testing; the successful integration, ground, and flight testing of two prototype aircraft; and favorable pilot opinions. The importance of thorough preliminary studies and early testing for the success of the development program is stressed, and marketing plans are discussed. T.K.

N89-23406*# National Aeronautics and Space Administration, Washington, DC.

NASA AERONAUTICS RESEARCH AND TECHNOLOGY Annual Report

1986 60 p Original doc. contains color illustrations (NASA-EP-259; NAS 1.19:259) Avail: NTIS HC A04/MF A01 CSCL 01B

The technical accomplishments and research highlights of 1986 are featured, along with information on possible areas of future research. These include hypersonic, supersonic, high performance, subsonic, and rotorcraft vehicle technology. Fundamental disciplinary research areas discussed include aerodynamics, propulsion, materials and structures, information sciences and human factors, and flight systems/safety. A description of the NASA organization and facilities is given. A.D.

N89-23407# Horizons Technology, Inc., Oakton, VA. AN ANALYSIS OF ELECTRONIC AIDS TO MAINTENANCE (EAM) FOR THE LIGHT HELICOPTER FAMILY (LHX) Final Report, Sep. 1985 - May 1987

EDWARD W. FREDERICKSON, JOHN W. LINDQUIST, and JULIE B. LEMEN Jan. 1989 85 p

AERODYNAMICS

(Contract DAAG09-85-G-0035)
(AD-A205440; ARI-RN-89-09) Avail: NTIS HC A05/MF A01
CSCL 01/3

Substantial savings in maintenance manpower and training time, special tools, test equipment, and the storage and handling of repair parts have been predicted for weapons systems that incorporate electronic aids to maintenance (EAM) in their design. Performance deficiencies of weapon system's EAM could have serious consequences to both system availability and MPT (Manpower, Personnel, and Training) requirements. This report provides an overview of contemporary EAM technology. It identifies failures or inadequacies for EAM used in recent weapons systems and projects the results of EAM performance for the Light Helicopter Family (LHX). It also identifies MPT-related solutions relevant to the use of EAM in the LHX program. GRA

N89-24261# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.

TECHNOLOGY OF AIRCRAFT CONSTRUCTION (SELECTED CHAPTERS)

A. L. ABIBOV, N. M. BIRYUKOV, V. V. BOYTISOV, V. P. GRIGORYEV, and S. V. YELISEYEV 13 Oct. 1988 74 p Transl. into ENGLISH from *Tekhnologiya Samoletostroyeniya* (USSR), *Mashinostroyeniye*, 1970 p 482-510 (AD-A199946; FTD-ID(RS)T-0616-88) Avail: NTIS HC A04/MF A01 CSCL 01/3

The characteristics and applications of reinforced plastics especially in regard to aircraft construction are discussed. The assembling of aircraft parts is considered. Attention is given to manufacturing practices and quality control. Examples are given. A.D.

N89-24262* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NUMERICAL AERODYNAMIC SIMULATION

1989 33 p Original document contains color illustrations (NASA-EP-262; NAS 1.19:262) Avail: Issuing Activity CSCL 01/2

An overview of historical and current numerical aerodynamic simulation (NAS) is given. The capabilities and goals of the Numerical Aerodynamic Simulation Facility are outlined. Emphasis is given to numerical flow visualization and its applications to structural analysis of aircraft and spacecraft bodies. The uses of NAS in computational chemistry, engine design, and galactic evolution are mentioned. A.D.

N89-24263# General Accounting Office, Washington, DC. National Security and International Affairs Div.

US MILITARY AIRCRAFT COPRODUCTION WITH JAPAN

JOSEPH E. KELLEY 1989 12 p (AD-A206430; GAO/T-NSIAD-89-6) Avail: NTIS HC A03/MF A01 CSCL 01/3

The United States enters into coproduction arrangements primarily for defense and foreign policy reasons. Basically, the Departments of Defense (DOD) and State have the authority and responsibility for negotiating and concluding coproduction agreements, usually Memorandums of Understanding (MOU). These government to government MOUs with Japan are commonly implemented by commercial licensed production and technical assistance agreements with the U.S. manufacturers. The F-15 program was begun at a time when Japan was targeting its aircraft industry, as well as other high technology industries, for development. Japan was steadily reducing the importance of its lower technology industries, such as shipbuilding, and favoring the development of high-technology export industries. Japan's major aircraft manufacturers expanded and upgraded their production facilities in order to handle their F-15, P-3C, and Boeing 767 work shares. Through these military and civil programs, combined, the Japanese companies expanded their production capacity, technology base, and aircraft production labor force. GRA

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

A89-39867* California Univ., Los Angeles.

ON SOME NUMERICAL SCHEMES FOR TRANSONIC FLOW PROBLEMS

MARCO MOSCHE MOSTREL (Bell Communications Research, Inc., Piscataway, NJ; California, University, Los Angeles) *Mathematics of Computation* (ISSN 0025-5718), vol. 52, April 1989, p. 587-613. refs (Contract N00014-86-K-0691; NAG2-70)

New second-order-accurate finite-difference approximations for a class of nonlinear PDEs of mixed type, which includes the two-dimensional low-frequency transonic small-disturbance equation (TSD) and full-potential equation (FP), are presented. For the TSD equation, the scheme is implemented via a time-splitting algorithm; the inclusion of flux limiters keeps the total variation nonincreasing and eliminates spurious oscillations near shocks. Global-linear-stability, TVD, and entropy-stability results are proved. Numerical results for the flow over a thin airfoil are presented. Current techniques used to solve the TSD equation may easily be extended to second-order accuracy by this method. For the FP equation, the new scheme requires no subsonic/supersonic switching and no numerical flux biasing. Global linear stability for all values of the Mach number is proved. Author

A89-40893#

MEASUREMENTS OF LAMINAR SEPARATION BUBBLE ON B3 AIRFOIL

KENICHI RINOIE, AKITO IWASAKI, KAORU TATSUMI, YASUTO SUNADA, and JUNZO SATO (Tokyo, University, Japan) *Tokyo, University, Faculty of Engineering, Journal, Series A* (ISSN 0563-7945), no. 26, 1988, p. 30, 31. In Japanese, with abstract in English.

Measurements have been done to investigate the structure of the laminar separation bubble on the airfoil. Measurements of mean velocities, turbulent stresses, and turbulent triple products have been made for the laminar separation bubble formed on B3 airfoil which has a step-like design pressure distribution. Results show that the turbulent stresses start to increase just after the laminar separation point and attain maxima before the flow reattaches to the airfoil surface. Turbulent energy balances were estimated from results. Author

A89-40901#

LARGE-SCALE VISCOUS SIMULATION OF LAMINAR VORTEX FLOW OVER A DELTA WING

ARTHUR RIZZI (Flygtekniska Forsöksanstalten, Bromma; Kungliga Tekniska Hogskolan, Stockholm, Sweden) and BERNHARD MUELLER (Flygtekniska Forsöksanstalten, Bromma, Sweden) *AIAA Journal* (ISSN 0001-1452), vol. 27, July 1989, p. 833-840. Research supported by the Styrelsen for Teknisk Utveckling and U.S. Navy. refs

The Navier-Stokes equations for laminar compressible flow around a 65-deg sweep delta wing with round leading edge are presently solved by a numerical method on a large scale, using a 129 x 49 x 65-point mesh for transonic (freestream Mach=0.85, freestream Re=2.38 million) flow at alpha=10 deg. The results thus obtained exhibit primary, secondary, and even tertiary vortices; comparisons conducted with experimental results indicate that the interaction of primary and secondary vortices is obtained correctly, and indeed more realistically than would be the case with the Euler equations. O.C.

A89-40902#

NUMERICAL STUDY OF TWO-DIMENSIONAL IMPINGING JET FLOWFIELDS

C. J. HWANG and J. L. LIU (National Cheng Kung University, Tainan, Republic of China) AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 841, 842. Previously cited in issue 07, p. 941, Accession no. A88-22528. refs

A89-40903#

NUMERICAL SOLUTION OF NAVIER-STOKES EQUATIONS FOR TWO-DIMENSIONAL VISCOUS COMPRESSIBLE FLOWS

SUNIL KUMAR CHAKRABARTTY (National Aeronautical Laboratory, Bangalore, India) AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 843, 844.

A nodal-point, finite-volume space discretization of viscous fluxes in compressible Navier-Stokes equations is presented. To advance the solution in time, an explicit five-stage Runge-Kutta scheme has been used. To accelerate the rate of convergence to steady state, local time stepping, residual averaging, and enthalpy damping have been employed. The scheme has been evaluated by solving laminar flow over a semi-infinite flat plate and an NACA 0012 air foil using thin-layer approximation. It has been observed here that fourth-order artificial dissipation is sufficient for numerical stability. The results have been compared with available theoretical and numerical solutions. Author

A89-40905*# California State Univ., Long Beach.

CALCULATION OF FLOW OVER ICED AIRFOILS

TUNCER CEBECI (California State University, Long Beach) AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 853-861. Previously cited in issue 07, p. 927, Accession no. A88-22078. refs (Contract NAG3-601)

A89-40908*# Iowa State Univ. of Science and Technology, Ames.

THREE-DIMENSIONAL DUAL-POTENTIAL PROCEDURE FOR INLETS AND INDRAFT WIND TUNNELS

K. V. RAO, R. H. PLETCHER (Iowa State University of Science and Technology, Ames), and JOSEPH L. STEGER (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 876-884. Previously cited in issue 08, p. 1044, Accession no. A87-22729. refs (Contract NCA2-17)

A89-40909*# Analytical Services and Materials, Inc., Hampton, VA.

NEWTON SOLUTION OF INVISCID AND VISCOUS PROBLEMS

V. VENKATAKRISHNAN (Analytical Services and Materials, Inc., Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 885-891. Research supported by NASA. Previously cited in issue 07, p. 935, Accession no. A88-22305. refs

A89-40913#

SHOCK STANDOFF FROM BLUNT CONES IN HIGH-ENTHALPY NONEQUILIBRIUM NITROGEN FLOW

S. L. GAI (University College, Canberra, Australia) and P. R. A. LYONS (Australian National University, Canberra, Australia) AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 918-920. Research supported by the Australian Research Grants Scheme. refs

Measurements of standoff distance from blunted cones of various bluntness ratio in high-enthalpy nonequilibrium nitrogen flow have been made. The results show that the nondimensional shock detachment distance is a function both of bluntness ratio and the relaxation distance. The results show that shock detachment is more influenced by flow nonequilibrium in the shock layer than the conical afterbody. Author

A89-40959

A NUMERICAL METHOD FOR CALCULATING SUBSONIC FULLY UNSTEADY AERODYNAMIC CHARACTERISTICS OF WINGS IN TIME DOMAIN

ZHENGYIN YE, LINGCHENG ZHAO, and YONGNIAN YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 2, Feb. 1989, p. 6-11. refs

In the case of arbitrary wing movement which begins impulsively from rest at some angle-of-attack, the present numerical method

for calculating fully unsteady wing aerodynamic loads in subsonic flow will yield the time-varying aerodynamic characteristics as well as the velocity field, directly in the time domain. The method is noted to be applicable to complex wing planforms, and is able to take wing thicknesses into account. O.C.

A89-41045

A DIRECT VISCID-INVISCID INTERACTION SCHEME FOR THE PREDICTION OF TWO-DIMENSIONAL AEROFOIL LIFT AND PITCHING MOMENT IN INCOMPRESSIBLE FLOW

F. N. COTON and R. A. MCD. GALBRAITH (Glasgow, University, Scotland) Aeronautical Journal (ISSN 0001-9240), vol. 93, April 1989, p. 132-140. refs

This paper presents a method for assessing two-dimensional aerofoil lift and pitching moment characteristics including trailing edge and gross laminar separation. The model used is a direct viscid-inviscid interaction scheme based on a vortex panel method with boundary-layer corrections and an inviscidly modelled wake. The integral boundary-layer methods adopted behave well in the region of separation and thus, good comparisons with measured separation characteristics are obtained. Generally the predictions of lift and pitching moment may be considered to be within the experimental error, but where this is not the case, the applicability of the modelling technique is discussed. Author

A89-41082

ANALYSIS OF THE INFLUENCE OF THE END-WALL BOUNDARY LAYER GROWTH ON THE PERFORMANCE OF MULTISTAGE COMPRESSORS

RAFFAELE TUCCILLO (Napoli, Universita, Naples, Italy) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 5, no. 1-4, 1988, p. 119-133. refs

A method is proposed for a through-flow analysis of multistage axial flow compressors, based upon the matching between inviscid calculation and prediction of the end-wall boundary-layer development. The results presented show the variation of flow distribution and blade loading at several flow conditions, owing to the different boundary-layer thicknesses that occur when mass flow rate changes. Furthermore, the method is suitable for use with optimizing techniques, since it takes into account the influence of the main geometrical features of the compressor. Author

A89-41091

THE EFFECTS OF WAKE MIGRATION DURING ROLL-UP ON BLADE AIR LOADS

R. H. MILLER, S. C. ELLIS (MIT, Cambridge, MA), and L. DADONE (Boeing Helicopters, Philadelphia, PA) Vertica (ISSN 0360-5450), vol. 13, no. 1, 1989, p. 1-15. refs

The rolling-up of the near wake, during the time between its birth and its encounter with the immediately-following blade, is examined both in hover and in forward flight. It is shown that, in hovering flight, the tip vortex migrates down during roll-up but in forward flight the outer wake migrates up, coming closer to the following blade, and producing higher wake interaction loadings. A simple and computationally efficient method is proposed for incorporating these effects into existing airload codings and their effect on the airloads determined. These airloads are sensitive to the assumptions used in developing the computational algorithms, requiring further refinements as discussed. Results of preliminary calculations, coupling the proposed wake model with a current forward flight rotor analysis, are also shown. Author

A89-41117#

THE INVESTIGATION OF DYNAMIC DISTORTIONS IN FLOWFIELD DOWNSTREAM OF STRONG SHOCK BOUNDARY INTERACTION

ZHONGWEI HE (Nanjing Aeronautical Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), April 1989, p. 15-20, 71. In Chinese, with abstract in English.

For a given boundary layer, the dynamic flow distortion in a two-dimensional convergent-divergent duct at the interaction point of typical strong shocks to turbulent boundary layer is investigated. It is experimentally found that four turbulence peaks exist along

the height of the duct downstream of the interaction region, and that each peak corresponds to an inflection point of the pitot pressure profile. The effects of shock strength and the duct geometry on the dynamic flow distortions are discussed. The power spectral density and probability density function (PDF) of pitot pressure signals on the typical conditions of the turbulence profile are analyzed in detail. It is noted that the pattern of the PDF of the pitot pressure signals in the vortex sheet at the intersection of the gamma-shocks is similar to that of a sine wave in Gaussian noise. C.D.

A89-41119#**THE CHARACTERISTICS OF THE TURBULENCE GENERATOR AND THE SIMULATION OF THE FLOW REGULATION**

WANGXING SHI (Nanjing Aeronautical Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), April 1989, p. 26-30, 72. In Chinese, with abstract in English. refs

The unsteadiness of pitot pressure distortion flow formed by an axial symmetric turbulence generator is investigated. The flow can be classified as steady or unsteady depending on whether the location and the dimension of the low-pressure zone in the flow change with time. The measurement repeatability of the distortion factor in steady flow is better than that in unsteady flow. A simple and available method to simulate flow profiles is also described. C.D.

A89-41121#**MODIFICATION IN ENGINEERING CALCULATION METHOD FOR INLET DESIGN**

XUELAING ZHANG (Chengdu Aircraft Corp., People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), April 1989, p. 34-37, 73. In Chinese, with abstract in English.

Some modifications are conducted in engineering calculations to make inlet design available for computation. Two-dimensional oblique shock angle, total pressure recovery coefficient at rounded lip, subsonic critical flow coefficient, and minimum throat area are addressed. It is shown that the calculation with the modified method is precise enough to satisfy the needs to select and analyze parameters in inlet design. The modified method can be used in CAD of an inlet. C.D.

A89-41201**NASA ADDS TO UNDERSTANDING OF HIGH ANGLE OF ATTACK REGIME**

WILLIAM B. SCOTT Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, May 22, 1989, p. 36-38, 42.

A highly instrumented F/A-18 aircraft has been used by NASA over the course of 83 flights to date to reach stabilized angles-of-attack (AOAs) as great as 55 deg. The flight test results thus obtained will be integrated with CFD predictions to arrive at a deeper understanding of fighter behavior in extreme-AOA maneuvers. The aircraft experiences a pronounced wing rock at 47 deg AOA which then decreases at 50 deg. The forebody vortices detected in flight are relatively weak at less than 25 deg AOA. At 35 deg, in stabilized flight, most of the lift appears to be generated by the aircraft's fuselage and leading-edge extensions. O.C.

A89-41570#**SIMULATION OF THE INTERACTION BETWEEN AERODYNAMICS AND VEHICLE DYNAMICS IN GENERAL UNSTEADY GROUND EFFECT**

D. T. MOOK and A. O. NUHAIT (Virginia Polytechnic Institute and State University, Blacksburg) IN: Intersociety Advanced Marine Vehicles Conference and Exhibit, Arlington, VA, June 5-7, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 430-438. refs (AIAA PAPER 89-1498)

A method for modeling general unsteady lifting flows and a method for simulating dynamic-aerodynamic interaction are described. The aerodynamic model is general enough to treat multiple closely coupled lifting components; ground effect is taken into account by placing images of the components and their wakes

below the ground. Loads predicted by the aerodynamic model are in good agreement with wind-tunnel data for several cases of steady flow and one case of unsteady flow. The numerical simulation of aerodynamic-dynamic interaction is achieved by integrating the equations of motion of both the flowing air and the vehicle. The result is that the entire flowfield, the aerodynamic loads, and the motion of the vehicle are predicted simultaneously and interactively as functions of time. The technique is used to predict the response of a general-aviation vehicle in pitch to a sudden change in the tail deflection. Simulations are computed both in and out of ground effect. Author

A89-41759#**A COMPARATIVE STUDY OF THE COAKLEY AND TVD SCHEMES FOR STEADY-STATE CALCULATIONS OF ONE-DIMENSIONAL EULER EQUATIONS**

SHEN-MIN LIANG, CHIEN-LAI HU, and JYH-JANG CHAN (National Cheng Kung University, Tainan, Republic of China) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 10, Feb. 1989, p. 23-29. refs

Numerical solutions of quasi-one-dimensional nozzle flows have been obtained by the Coakley (1953) second-order upwind scheme and the second-order TVD scheme of Yee et al. (1985). The Coakley scheme generates an overshoot at the vicinity of the shock which can be removed by modifying the algorithm. Under conditions of a preassigned tolerance and a given Courant number, it is shown that the Coakley scheme converges faster than the TVD scheme both in CPU time and in iteration number. R.R.

A89-41760#**SHOCK FITTING ALGORITHM APPLIED TO A TRANSONIC, FULL POTENTIAL FLOW**

LIH-WU HOURNG and KUAN-YUAN HWANG (National Central University, Chungli, Republic of China) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 10, Feb. 1989, p. 31-39. Sponsorship: National Science Council of the Republic of China. refs (Contract NSC-76-0401-E008-06)

A full potential equation is used to analyze transonic flows past a cylinder or sphere. Governing equation is discretized by Jameson's rotated difference scheme. To locate the position and shape of the shock, a shock fitting equation is derived to match the jump condition across the shock. The initially guessed shock will move according to the shock fitting equation during the numerical calculations till it reaches the correct position. For flowfield past a sphere, results show a great agreement with previous works for freestream Mach number ranging from 1.03 to 1.3. The jump of the flowfield properties across the shock is clearly seen. Author

A89-41771**THE EFFECT OF AN ADVERSE PRESSURE GRADIENT ON THE DRAG REDUCTION PERFORMANCE OF MANIPULATORS**

A. M. SAVILL (Cambridge, University, England) International Journal of Heat and Fluid Flow (ISSN 0142-727X), vol. 10, June 1989, p. 118-124. Research supported by Rolls-Royce, PLC. refs

Skin friction data obtained with a sublayer-scale fence, razor blade, and log-layer-sized Preston tube are presented for both natural and manipulated boundary layers subjected to a strong adverse pressure gradient. The objective was to investigate how the imposition of this additional straining downstream of the device would influence the subsequent development of the manipulated boundary layer. An attempt was also made to predict the response of the boundary layer to such disturbances by applying an algebraic stress model approximation to the turbulent transport equation. K.K.

A89-41775**ADIABATIC COMPRESSIBLE FLOW IN PARALLEL DUCTS - AN APPROXIMATE BUT RAPID METHOD OF SOLUTION**

G. J. PARKER (Canterbury, University, Christchurch, New

Zealand) International Journal of Heat and Fluid Flow (ISSN 0142-727X), vol. 10, June 1989, p. 179-181.

An approximate method of solution which is direct, fast, and accurate is developed by examining the nature of exact solutions for the adiabatic one-dimensional flow of perfect gases in ducts. Observations for exact solutions are presented as well as the procedure for an approximate solution, and comparisons with exact solutions. K.K.

A89-41776

AIAA COMPUTATIONAL FLUID DYNAMICS CONFERENCE, 9TH, BUFFALO, NY, JUNE 13-15, 1989, TECHNICAL PAPERS
Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, 684 p. For individual items see A89-41777 to A89-41841.

The conference presents papers on an adaptive Cartesian mesh algorithm for the Euler equations in arbitrary geometries, an implementation of a grid-independent upwind scheme for the Euler equations, design of optimally smoothing multi-stage schemes for the Euler equations, and a computational fluid dynamics algorithm on a massively parallel computer. Consideration is also given to nonreflecting boundary conditions for Euler equation calculations, sonic-point capturing, improvements and applications of a streamwise upwind algorithm, upwind algorithms based on a diagonalization of the multidimensional Euler equations, and applications of Lagrangian time to steady supersonic airfoil. Other topics include a second-order projection method for the incompressible Navier-Stokes equations on quadrilateral grids, flow discretization by complementary volume techniques, and unstructured grid generation for nonconvex domains. K.K.

A89-41777#

AN ADAPTIVE CARTESIAN MESH ALGORITHM FOR THE EULER EQUATIONS IN ARBITRARY GEOMETRIES

MARSHA J. BERGER (New York University, NY) and RANDALL J. LEVEQUE (Washington, University, Seattle) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1-7. refs (Contract DE-AC02-76ER-03077; AF-AFOSR-86-0148; NSF ASC-88-58101; NSF DMS-86-57319) (AIAA PAPER 89-1930)

The paper presents a Cartesian mesh algorithm with adaptive refinement to compute flows around arbitrary geometries. Cartesian meshes have been less popular than unstructured or body-fitted meshes because of several technical difficulties. An approach that resolves many of these problems is presented. Cartesian meshes have the advantage of allowing the use of high resolution methods that are difficult to develop on unstructured grids. They also allow for efficient implementation on vector computers without using gather-scatter operations except at boundary cells. Some preliminary computational results using lower order boundary conditions are presented. Author

A89-41779#

SOLUTION OF THE 2D NAVIER-STOKES EQUATIONS ON UNSTRUCTURED ADAPTIVE GRIDS

D. G. HOLMES (GE Research and Development Center, Schenectady, NY) and S. D. CONNELL (General Electric Co., Aircraft Engines Business Group, Cincinnati, OH) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 25-39. refs (AIAA PAPER 89-1932)

This paper presents a solution adaptive scheme for solving the Navier-Stokes equations on an unstructured mixed grid of triangles and quadrilaterals. The solution procedure uses an explicit Runge-Kutta finite volume time marching scheme. The solution is begun on a coarse grid and points are added adaptively during the solution procedure using criteria such as pressure and velocity gradients. In viscous regions the gradients are essentially one dimensional, and use is made of quadrilateral elements in these regions to facilitate the one dimensional refinement required for

the efficient resolution of boundary layers and wakes. The effect of turbulence is modeled by the inclusion of a K-epsilon turbulence model. When used for analyzing flows in turbomachinery blade rows, terms representing the effects of changes in streamsheet thickness and radius, and the effects of rotation are included. Axisymmetric flows with swirl can also be analyzed. Solutions are presented for several examples that illustrate the capability of the algorithm. Author

A89-41780*# Michigan Univ., Ann Arbor.

DESIGN OF OPTIMALLY SMOOTHING MULTI-STAGE SCHEMES FOR THE EULER EQUATIONS

BRAM VAN LEER, CHANG-HSIEN TAI, and KENNETH G. POWELL (Michigan, University, Ann Arbor) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 40-59. Research supported by Boeing Commercial Airplane Co. refs (Contract NAG1-869) (AIAA PAPER 89-1933)

In this paper, a method is developed for designing multi-stage schemes that give optimal damping of high-frequencies for a given spatial-differencing operator. The objective of the method is to design schemes that combine well with multi-grid acceleration. The schemes are tested on a nonlinear scalar equation, and compared to Runge-Kutta schemes with the maximum stable time-step. The optimally smoothing schemes perform better than the Runge-Kutta schemes, even on a single grid. The analysis is extended to the Euler equations in one space-dimension by use of 'characteristic time-stepping', which preconditions the equations, removing stiffness due to variations among characteristic speeds. Convergence rates independent of the number of cells in the finest grid are achieved for transonic flow with and without a shock. Characteristic time-stepping is shown to be preferable to local time-stepping, although use of the optimally damping schemes appears to enhance the performance of local time-stepping. The extension of the analysis to the two-dimensional Euler equations is hampered by the lack of a model for characteristic time-stepping in two dimensions. Some results for local time-stepping are presented. Author

A89-41784#

A MASSIVELY PARALLEL THREE-DIMENSIONAL EULER/NAVIER-STOKES METHOD

LYLE N. LONG, M. M. S. KHAN, and H. THOMAS SHARP (Lockheed Aeronautical Systems Co., Burbank, CA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 89-102. refs (AIAA PAPER 89-1937)

This paper describes a method for solving the three-dimensional Euler and Navier-Stokes equations using the massively parallel Connection Machine computer. The program uses a finite-volume, Runge-Kutta time-marching scheme and can accept structured or unstructured grids. The computer program is written entirely in (asterisk)LISP. Significant computational speed-ups were obtained over similar codes developed for vector supercomputers. Author

A89-41785#

DEVELOPMENT OF A NAVIER-STOKES CODE ON A CONNECTION MACHINE

RAMESH K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 103-108. refs (AIAA PAPER 89-1938)

The results of adaptation of a 2-D Navier-Stokes code on a 16000-processor Connection Machine CM2 are presented. The Navier-Stokes code solves the two-dimensional, unsteady, compressible, viscous-flow equations of fluid dynamics for flow past arbitrary bodies by use of an explicit, finite-volume multistage, Runge-Kutta time-stepping scheme. The code conversion issues

such as domain decomposition and boundary-condition implementation, are highlighted. The performance of the code is evaluated by calculating the flowfield of the impingement of an oblique shock on a flat plate. Runtime comparisons are made on VAX-8800, Convex CX-2, Cray X-MP, and CM2. Author

A89-41786#
IMPLEMENTATION OF A ROTARY-WING
THREE-DIMENSIONAL NAVIER-STOKES SOLVER ON A
MASSIVELY PARALLEL COMPUTER

BRIAN E. WAKE and T. ALAN EGOLF (United Technologies Research Center, East Hartford, CT) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 109-124. refs (AIAA PAPER 89-1939)

An unsteady, compressible, three-dimensional Navier-Stokes solver (NSR3D), has been implemented using FORTRAN with 8X array extensions on the massively parallel Connection Machine (CM-2). The ADI flow solver was originally developed for helicopter applications, and has also been applied to Propfan configurations. In this paper, the changes to the original algorithm necessary to overcome communication bottlenecks on the CM-2 are described. The modified implicit solver has achieved CRAY speeds on a 16384 processor CM-2. In addition, the CM-2 and FORTRAN 8X array extensions, including coding examples, are briefly described. Some programming issues for difficult problems such as solving the linear systems, the boundary conditions, and the dissipation switching are discussed. Author

A89-41789#
NON-REFLECTING BOUNDARY CONDITIONS FOR EULER
EQUATION CALCULATIONS

MICHAEL B. GILES (MIT, Cambridge, MA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 143-153. refs (AIAA PAPER 89-1942)

This paper presents a unified theory for the construction of steady-state and unsteady non-reflecting boundary conditions for the Euler equations. These allow calculations to be performed on truncated domains without the generation of spurious non-physical reflections at the far-field boundaries. The general theory, developed previously by mathematicians, is presented in a more easily understood form based upon fundamental ideas of Fourier analysis and eigenvectors. The application to the Euler equations is given, and the relation to standard 'quasi-one-dimensional' boundary conditions is explained. Results for turbomachinery problems show the effectiveness of the new boundary conditions, particularly the steady-state non-reflecting boundary conditions. Author

A89-41790#
FAR FIELD NUMERICAL BOUNDARY CONDITIONS FOR
INTERNAL AND CASCADE FLOW COMPUTATIONS

CH. HIRSCH (Brussel, Vrije Universiteit, Brussels, Belgium) and A. VERHOFF (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 154-168. refs (Contract N62271-86-M-0202; N62271-87-M-0215) (AIAA PAPER 89-1943)

Linearized solutions of the Euler equations are developed for the far field perturbations from the uniform free stream, for ducts and cascades. The solutions are based on the conditions that the waves associated with incoming characteristics should decay to zero in the far field, while the variables associated to the outgoing characteristics are derived from the numerical internal solution. The exact linearized solutions are based on a Fourier expansion in the direction along the inlet or exit boundaries. Results, obtained from Euler codes are shown for ducts and cascades, comparing the results for exit boundaries at increasingly closer distance to the central flow region. The results show that the corrections to

the uniform boundary conditions derived from the analysis allow a considerable reduction of the computational domain, with the corresponding savings in computational times. Author

A89-41792*# Michigan Univ., Ann Arbor.

SONIC-POINT CAPTURING

BRAM VAN LEER, WEN-TZONG LEE, and KENNETH G. POWELL (Michigan, University, Ann Arbor) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 176-187. refs (Contract NSF EET-88-57500; NAG1-869) (AIAA PAPER 89-1945)

A prototype scheme that produces perfectly smooth transonic solutions to nozzle-flow problems is derived and tested. The basic upwind scheme is described as well as satisfying the entropy condition, treatment of the source term, and numerical verification. The analysis yielded a numerical flux function for use near a sonic point, which is based on a full model of a transonic expansion wave, and a matched treatment for the source term. K.K.

A89-41794*# Duke Univ., Durham, NC.

ON THE ROLE OF ARTIFICIAL VISCOSITY IN
NAVIER-STOKES SOLVERS

APARAJIT J. MAHAJAN, EARL H. DOWELL, and DONALD B. BLISS (Duke University, Durham, NC) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 197-202. refs (Contract NAG3-724) (AIAA PAPER 89-1947)

A method is proposed to determine directly the amount of artificial viscosity needed for stability using an eigenvalue analysis for a finite difference representation of the Navier-Stokes equations. The stability and growth of small perturbations about a steady flow over the airfoils are analyzed for various amounts of artificial viscosity. The eigenvalues were determined for a small perturbation about a steady inviscid flow over a NACA 0012 airfoil at a Mach number of 0.8 and angle of attack of 0 degrees. The movement of the eigenvalue constellation with respect to the amount of artificial viscosity is studied. The stability boundaries as a function of the amount of artificial viscosity from both the eigenvalue analysis and the time marching scheme are also presented. This procedure not only allows for determining the effect of varying amounts of artificial viscosity, but also for the effects of different forms of terms for artificial viscosity. Author

A89-41795#

A VECTORIZED GAUSS-SEIDEL LINE RELAXATION SCHEME
FOR SOLVING 3D NAVIER-STOKES EQUATIONS

D. L. MCMASTER, J. S. SHANG, and D. GAITONDE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 203-211. refs (AIAA PAPER 89-1948)

A vectorized version of MacCormack's 1984 explicit/implicit line Gauss-Seidel method for three-dimensional flow computation is described. Second-order spatial differencing has been implemented for this algorithm without sacrificing the data processing rate. Test cases are examined for numerical accuracy and convergence rate. For the vectorized procedure, the data processing rate is three times faster than for a non-vectorized code based on the same algorithm. Convergence is six times faster than a fully-vectorized explicit code based on MacCormack's 1969 predictor-corrector procedure. Author

A89-41797#

RNG-BASED TURBULENCE TRANSPORT APPROXIMATIONS
WITH APPLICATIONS TO TRANSONIC FLOWS

LUIGI MARTINELLI and VICTOR YAKHOT (Princeton University, NJ) IN: AIAA Computational Fluid Dynamics Conference, 9th,

02 AERODYNAMICS

Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 221-231. refs
(AIAA PAPER 89-1950)

An algebraic eddy viscosity model, as well as a differential two equation k-epsilon model based on the Renormalization Group Theory of turbulence are proposed for closure of the compressible Reynolds averaged equations. The first model, although free from uncertainties related to the determination of modeling constants, still requires the specification of a length-scale which leads to a reduction of the generality of the model. The second model proposed is far more general. Not only does it remove the need for the determination of a length scale, but it also incorporates the low Reynolds number modeling in a form that does not depend directly on information about the wall location. This feature makes the RNG-based k-epsilon model suitable for calculation on unstructured meshes. The applicability of the RNG-based turbulence transport approximations for mildly compressible flows is demonstrated by the successful simulation of several transonic flows. Author

A89-41798*# Rome Univ. (Italy).

SUPERSONIC FLOW COMPUTATIONS BY TWO-EQUATION TURBULENCE MODELING

FRANCESCO GRASSO (Roma I, Universita, Rome, Italy) and CHARLES G. SPEZIALE (NASA, Langley Research Center; Institute for Computer Applications in Science and Engineering, Hampton, VA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 232-239. refs
(AIAA PAPER 89-1951)

In the present work a solver for the Reynolds averaged compressible Navier-Stokes equations, to compute high speed turbulent flows characterized by interacting shock waves and viscous layers, is presented. A k-epsilon turbulence model that accounts for compressibility effects is developed. The numerical algorithm is based on a finite volume multistage Runge Kutta technique that is explicit for the solution of the mean flow variables, and implicit for the solution of the k-epsilon equations. The model is validated by extensive comparison with experimental results of flows over compression ramps characterized by interacting shock waves/boundary layers. Author

A89-41799#

TURBULENCE MODELS FOR 3D TRANSONIC VISCOUS FLOWS

YOKO TAKAKURA (Fujitsu, Ltd., Scientific Systems Dept., Tokyo, Japan), SATORU OGAWA, and TOMIKO ISHIGURO (National Aerospace Laboratory, Tokyo, Japan) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 240-248. refs
(AIAA PAPER 89-1952)

Computation of three-dimensional transonic viscous flows around the ONERA-M6 wing is performed by using the Harten-Yee TVD scheme with modification of geometrical treatment in order to seek better turbulence models. The models used here are the Jones-Launder (k-epsilon) model and the subgrid-scale model in the large eddy simulation (LES), and for comparison with the Baldwin-Lomax model. The diagonalization of flow equation system including a two-equation model necessary to perform the TVD scheme and the improvement accompanied by extending the LES to compressible flow problems are presented, and then the utilities of both models in compressible flow problems with shock waves have been investigated. The k-epsilon model and the LES work well in the large reverse flow problem by adjusting the coefficients compared with the Baldwin-Lomax model. Author

A89-41800*# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

AN EFFICIENT CELL-VERTEX MULTIGRID SCHEME FOR THE THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS

R. RADESPIEL, C. ROSSOW (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany), and R. C. SWANSON (NASA, Langley Research Center, Hampton, VA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 249-260. refs
(AIAA PAPER 89-1953)

A cell-vertex scheme for the three-dimensional Navier-Stokes equations, which is based on central difference approximations and Runge-Kutta time stepping, is described. Using local time stepping, implicit residual smoothing with locally varying coefficients, a multigrid method and carefully controlled dissipative terms, very good convergence rates are obtained for two- and three-dimensional flows. Details of the acceleration techniques, which are important for convergence on meshes with high aspect-ratio cells, are discussed. Emphasis is put on the analysis of the stability properties of the implicit smoothing of the explicit residuals with coefficients, which depend on cell aspect ratios. Author

A89-41802*# Tokyo Univ. (Japan).

USE OF HIGH-RESOLUTION UPWIND SCHEME FOR VORTICAL FLOW SIMULATIONS

KOZO FUJII (Tokyo University, Sagami-hara, Japan) and SHIGERU OBAYASHI (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 270-279. refs
(AIAA PAPER 89-1955)

For vortical flow simulations at high Reynolds number, it is important to keep the artificial dissipation as small as possible since it induces unphysical decay of the vortex strength. One way to accomplish this is to decrease the grid spacing. Another way is to use computational schemes having little dissipation. In the present paper, one of the high-resolution upwind schemes called 'MUSCL with Roe's average' is applied to vortical flow simulations. Two examples are considered. One is the leading-edge separation-vortex flow over a strake-delta wing. The other is a high-angle of attack supersonic flow over a spaceplane-like configuration. The comparison with the central difference solutions indicates that the present upwind scheme is less dissipative and thus has better resolution for the vortical flows. Author

A89-41804*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, CA.

IMPROVEMENTS AND APPLICATIONS OF A STREAMWISE UPWIND ALGORITHM

SHIGERU OBAYASHI and PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 292-302. refs
(AIAA PAPER 89-1957)

An improved streamwise upwind algorithm has been used to study conical flow fields. In the present method, additional terms have been introduced in the cross-flow direction to prevent solution decoupling in supersonic flows, and the local Mach number is taken into account in order to evaluate the rotated differencing. It is found that the formula captures oblique shock waves in the same manner as Roe's (1986) formula, has good convergence properties, and accurately computes shear flows. R.R.

A89-41805#

AN ADAPTIVE GRID POLYGONAL FINITE VOLUME METHOD FOR THE COMPRESSIBLE FLOW EQUATIONS

R. STRUIJS, P. VANKEIRSBILCK, and H. DECONINCK (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p.

303-311. Research supported by HERMES Research and Development Program. refs
(AIAA PAPER 89-1959)

An implicit upwind relaxation solver for the Euler equations is presented, based on polygonal finite volumes with an arbitrary number of edges and with a centered definition of the unknowns. Grids of this type allow the combination of structured quadrilaterals well suited for discretizing boundary layers, together with classical unstructured grids based on triangles. A simple refining strategy has been implemented which proved to be very effective in controlling the size of the region to be refined. This strategy uses the fact that polygonal finite volumes with an arbitrary number of edges are allowed. Fast relaxation to a steady state is achieved by point Gauss Seidel solution of the Newton linearized conservation equations, together with an implicit characteristic boundary condition treatment. The superior flexibility of the polygonal method is demonstrated on transonic and supersonic testcase computations. Author

A89-41806#
MULTIGRID EULER SOLVER ABOUT ARBITRARY AIRCRAFT CONFIGURATIONS WITH CARTESIAN GRIDS AND LOCAL REFINEMENT

B. EPSTEIN, A. L. LUNTZ, and A. NACHSHON (Israel Aircraft Industries, Ltd., Lod) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 312-321. refs
(AIAA PAPER 89-1960)

A three-dimensional Euler code is described, for flow calculations about arbitrary aircraft configurations. The method uses Multigrid Calculations with equally meshed Cartesian (not necessarily rectangular) grids and local refinement. The use of local computational grids which are not aligned to the body surface, or even, possibly, not aligned to one another, removes the need for complicated grid generation. Satisfactory boundary condition implementation is an important part of the algorithm. Application examples show the ability of the code to produce results in good agreement with experiment, for a wide range of flight conditions. The code provides also various data for analysis of the flow field surrounding the configuration. Author

A89-41807#
AN INVISCID/VISCOUS COUPLING APPROACH FOR VORTEX FLOWFIELD CALCULATIONS

K. D. LEE (Illinois, University, Urbana) and S. A. BRANDT IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 322-332. refs
(AIAA PAPER 89-1961)

A new computational approach is developed for the analysis of vortex dominated flowfields around highly swept wings at high angles of attack. In this approach, an inviscid Euler technology is coupled with viscous models, similar to inviscid/boundary-layer coupling. The viscous nature of the vortex core is represented by an algebraic model derived from the Navier-Stokes equations. The approach also accounts for the effects of the viscous shear layer near a wing surface through a modified surface boundary condition. The inviscid/viscous coupling consistently provides improved predictions of leading edge separation, vortex bursting, and secondary vortex formation at relatively low computational cost. Results for several cases are compared with wind tunnel tests and other Euler and Navier-Stokes solutions. Author

A89-41808#
APPLICATIONS OF LAGRANGIAN TIME TO STEADY SUPERSONIC AIRFOIL COMPUTATION

C. Y. LOH and W. H. HUI (Waterloo, University, Canada) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 333-342. Research supported by NSERC. refs
(AIAA PAPER 89-1963)

A Lagrangian method based on the formulation of Hui and Van Roessel (1985) is used to compute steady inviscid supersonic flows past an airfoil. In the method, the stream function and the Lagrangian time are employed as the independent variables, and the flow tangency condition at the body surface and the Rankine-Hugoniot conditions at the bow shock are satisfied on the exact fixed coordinate lines. The scheme is shown to be fast to execute and to provide accurate predictions of pure expansion flows, pure compression flows, and flows with only a boundary shock. R.R.

A89-41814*# Toledo Univ., OH.
FLOW OF RAREFIED GASES OVER TWO-DIMENSIONAL BODIES

DUEN-REN JENG, KENNETH J. DE WITT, THEO G. KEITH, JR. (Toledo, University, OH), and CHAN-HONG CHUNG IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 389-399. refs
(Contract NAG3-577)
(AIAA PAPER 89-1970)

A kinetic-theory analysis is made of the flow of rarefied gases over two-dimensional bodies of arbitrary curvature. The Boltzmann equation simplified by a model collision integral is written in an arbitrary orthogonal curvilinear coordinate system, and solved by means of finite-difference approximation with the discrete ordinate method. A numerical code is developed which can be applied to any two-dimensional submerged body of arbitrary curvature for the flow regimes from free-molecular to slip at transonic Mach numbers. Predictions are made for the case of a right circular cylinder. Author

A89-41815*# Eloret Corp., Sunnyvale, CA.
A MULTI-TEMPERATURE TVD ALGORITHM FOR RELAXING HYPERSONIC FLOWS

JEAN-LUC CAMBIER (Eloret Institute, Sunnyvale, CA) and GENE P. MENEES (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 400-414. refs
(AIAA PAPER 89-1971)

In this paper, the extension of a multispecies TVD algorithm, second-order accurate for real-gas flows to a multitemperature formulation is described. The convection algorithm is coupled to internal relaxation processes, and the features of the coupling are examined. The first version consists of a three-temperature model, where translational-rotational, vibrational, and electronic energy modes are separately convected. Although several species are present, there is only one vibrational temperature in this model. The second version generalizes to a vibrational temperature for each molecular specie, with additional couplings between species. The algorithms are applied to a generic two-dimensional flow field, and results are compared with experimental observations. Author

A89-41816*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

UPWIND-BIASED, POINT-IMPLICIT RELAXATION STRATEGIES FOR VISCOUS, HYPERSONIC FLOWS

PETER A. GNOFFO (NASA, Langley Research Center, Hampton, VA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 415-425. refs
(AIAA PAPER 89-1972)

An upwind-biased point-implicit relaxation algorithm for obtaining the numerical solution to the governing equations for three-dimensional viscous hypersonic flows in chemical and thermal nonequilibrium is described. Details of the algorithm development, in the context of an 11-species two-temperature reacting gas model, are emphasized. Because of the point-implicit relaxation strategy, the algorithm remains stable at large Courant numbers without

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the necessity of solving large block-tridiagonal systems. Predictions for the hypersonic flow of air in chemical and thermal nonequilibrium (velocity = 8917 m/s, altitude = 78 km) over the Aeroassist Flight Experiment configuration, obtained on a multidomain grid, are discussed. Author

A89-41818*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A FULLY-COUPLED IMPLICIT METHOD FOR THERMO-CHEMICAL NONEQUILIBRIUM AIR AT SUB-ORBITAL FLIGHT SPEEDS

CHUL PARK (NASA, Ames Research Center, Moffett Field, CA) and SEOKKWAN YOON (MCAT Institute, Moffett Field, CA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 440-449. refs (AIAA PAPER 89-1974)

A CFD technique is described in which the finite-rate chemistry in thermal and chemical nonequilibrium air is fully and implicitly coupled with the fluid motion. Developed for use in the suborbital hypersonic flight speed range, the method accounts for nonequilibrium vibrational and electronic excitation and dissociation, but not ionization. The steady-state solution to the resulting system of equations is obtained by using a lower-upper factorization and symmetric Gauss-Seidel sweeping technique through Newton iteration. Inversion of the left-hand-side matrices is replaced by scalar multiplications through the use of the diagonal dominance algorithm. The code, named CENS2H (Compressible-Euler-Navier-Stokes Two-Dimensional Hypersonic), is fully vectorized and requires about 8.8×10 to the -5th sec per node point per iteration using a Cray X-MP computer. Converged solutions are obtained after about 2400 iterations. Sample calculations are made for a circular cylinder and a 10 percent airfoil at 5 deg angle of attack. The calculated cylinder flow field agrees with that obtained experimentally. The code predicts a 10 percent change in lift, drag, and pitching moment for the airfoil due to the thermochemical phenomena. Author

A89-41819*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

FINITE ELEMENT COMPUTATION OF HYPERSONIC FLOW PAST A COMPLETE BODY

MARK HOMMEL (NASA, Johnson Space Center, Houston, TX) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 450-454. refs (AIAA PAPER 89-1976)

The finite element method was applied to compressible flows past complete blunt bodies in a first attempt to use the method to model hypersonic flow past re-entry vehicles. A Runge-Kutta time marching scheme was utilized and was found to adequately handle the bow shock and downstream wake. Adaptive refinement was successively applied to the flow field grid, and improvement in solution accuracy was observed. The results reported in this paper include the flow past a circular cylinder at Mach 3, and the flow in the plane of symmetry for the flow past a sphere at Mach 10. Author

A89-41820#

SIMPLE IMPROVEMENTS OF AN UPWIND TVD SCHEME FOR HYPERSONIC FLOW

B. MUELLER (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 455-463. Research supported by CNES. refs (AIAA PAPER 89-1977)

A spatially second-order-accurate upwind TVD scheme is investigated using the Euler implicit method with approximate factorization. For inviscid flow, Roe's average leads to a simpler and more accurate solid-wall boundary treatment than the use of

the wall-normal momentum equation. The entropy function applied to the nonlinear fields to enforce the entropy condition is anisotropically scaled to handle highly stretched grid cells for viscous hypersonic flow. The modified scheme is applied to calculate inviscid and viscous supersonic and hypersonic flow over ramps and laminar hypersonic flow over a flared cone. Author

A89-41823*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CONSERVATIVE TREATMENT OF BOUNDARY INTERFACES FOR OVERLAID GRIDS AND MULTI-LEVEL GRID ADAPTATIONS

YOUNG J. MOON (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) and MENG-SING LIOU (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 480-494. refs (Contract NAS3-25266) (AIAA PAPER 89-1980)

Conservative algorithms for boundary interfaces of overlaid grids are presented. The basic method is zeroth order, and is extended to a higher order method using interpolation and subcell decomposition. The present method, strictly based on a conservative constraint, is tested with overlaid grids for various applications of unsteady and steady supersonic inviscid flows with strong shock waves. The algorithm is also applied to a multi-level grid adaptation in which the next level finer grid is overlaid on the coarse base grid with an arbitrary orientation. Author

A89-41825*# Old Dominion Univ., Norfolk, VA.

DYNAMIC GRID DEFORMATION USING NAVIER-DISPLACEMENT EQUATION FOR DEFORMING WINGS

OSAMA A. KANDIL and H. ANDREW CHUANG (Old Dominion University, Norfolk, VA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 502-511. refs (Contract NAG1-648) (AIAA PAPER 89-1982)

For dynamic and aeroelastic applications of maneuvering wings, the solid boundaries undergo rigid-body motion and aeroelastic deformation. For rigid-body motion, the conservative fluid dynamics equation, in terms of the Eulerian description, is written in terms of a moving frame of reference, and the problem is solved on a time-independent body-conformed grid. For both rigid-body motion and aeroelastic deformation, the Navier-displacement equation, in terms of the Lagrangian coordinates, is modified for fluid-flow problems. It is used along with the Eulerian description of the conservative fluid dynamics equations to account for the grid deformation. Author

A89-41826#

UNSTRUCTURED GRID GENERATION FOR NON-CONVEX DOMAINS

JIUNN FANG and STEPHEN R. KENNON (Texas, University, Arlington) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 512-524. refs (Contract F08635-89-C-0211) (AIAA PAPER 89-1983)

Two methods for generating unstructured grids about arbitrary, nonconvex domains are presented. The first method is based on the sweepline concept and the second is based on a novel generalization of the Voronoi diagram and rational treatment of the domain boundaries. A modification is made to the standard sweepline algorithm to handle nonconvex domains correctly. The second method is shown to enforce the boundary of the domain as part of the triangulation. Thus, both methods guarantee valid, boundary-conforming grids for arbitrary, nonconvex domains.

Example grids generated using each scheme are presented for generic test cases and a multiple-element airfoil configuration.

Author

A89-41832#

VORTICITY EQUATION SOLUTIONS FOR SLENDER WINGS AT HIGH INCIDENCE

A. DAGAN (Ministry of Defence, Scientific Dept., Haifa, Israel) and D. ALMOSNINO (Technion - Israel Institute of Technology, Haifa) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 579-587. refs

(AIAA PAPER 89-1989)

An approximate model for the viscous flow around slender wing or body shapes at high angles of attack is proposed. The Sychev (1960) geometric similarity parameter is shown to apply to the present viscous flow model. The feasibility of the method is tested using the examples of various delta wings with flat elliptical cross sections. Results for aerodynamic coefficients, surface pressure distributions, stream functions, and vorticity contours in cross-flow planes agree well with experimental data.

R.R.

A89-41835#

A TIME-ACCURATE ITERATIVE SCHEME FOR SOLVING THE UNSTEADY COMPRESSIBLE FLOW EQUATIONS

KENICHI MATSUNO (National Aerospace Laboratory, Chofu, Japan) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 602-611. refs

(AIAA PAPER 89-1992)

A second-order time-accurate scheme has been extended to an arbitrary kth-order time-accurate scheme with high-order accuracy in both time and space. The second-order scheme is shown to be suitable for unsteady flow computations. Although the kth-order form of the algorithm is essentially iterative at each time step, the scheme is theoretically kth-order accurate in time without any iteration. It is noted that the iterations at each time step improve the numerical accuracy and robustness of the algorithm.

R.R.

A89-41836#

A NEW FORMULATION FOR UNSTEADY COMPRESSIBLE EULER EQUATIONS

H. U. AKAY, A. ECER, and E. SPYROPOULOS (Purdue University, Indianapolis, IN) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 612-621. refs

(AIAA PAPER 89-1993)

A Clebsch formulation of the unsteady Euler equations is discussed. It is demonstrated that the modeling of the shock for transonic flows and the implementation of the Kutta condition for sharp trailing edges of airfoils can be accomplished with the desired level of accuracy. The circulation around an airfoil can be expressed in terms of the jump in entropy, the density, and two Clebsch variables at the trailing edge.

R.R.

A89-41837*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A TIME ACCURATE FINITE VOLUME HIGH RESOLUTION SCHEME FOR THREE DIMENSIONAL NAVIER-STOKES EQUATIONS

MENG-SING LIOU (NASA, Lewis Research Center, Cleveland, OH) and ANDREW T. HSU (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 622-633. refs

(AIAA PAPER 89-1994)

A time accurate, three-dimensional, finite volume, high resolution scheme for solving the compressible full Navier-Stokes

equations is presented. The present derivation is based on the upwind split formulas, specifically with the application of Roe's (1981) flux difference splitting. A high-order accurate (up to the third order) upwind interpolation formula for the inviscid terms is derived to account for nonuniform meshes. For the viscous terms, discretizations consistent with the finite volume concept are described. A variant of second-order time accurate method is proposed that utilizes identical procedures in both the predictor and corrector steps. Avoiding the definition of midpoint gives a consistent and easy procedure, in the framework of finite volume discretization, for treating viscous transport terms in the curvilinear coordinates. For the boundary cells, a new treatment is introduced that not only avoids the use of 'ghost cells' and the associated problems, but also satisfies the tangency conditions exactly and allows easy definition of viscous transport terms at the first interface next to the boundary cells. Numerical tests of steady and unsteady high speed flows show that the present scheme gives accurate solutions.

Author

A89-41838#

A FLUX-DIFFERENCE SPLIT ALGORITHM FOR UNSTEADY THIN-LAYER NAVIER-STOKES SOLUTIONS

L. BRUCE SIMPSON (USAF, Armament Laboratory, Eglin AFB, FL) and DAVID L. WHITFIELD (Mississippi State University, Mississippi State) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 634-642. refs

(AIAA PAPER 89-1995)

An efficient flux-difference split scheme for obtaining steady and unsteady thin-layer Navier-Stokes solutions for airfoils and wings has been developed. Steady solutions for a flat plate laminar boundary layer profile can be accurately modeled using only three grid cells internal to the boundary layer. An efficient Newtonian subiteration technique was employed to allow for larger time step sizes and second order temporal accuracy. The present results agree well with experimental data for NACA 0012 airfoils and for the Langley rectangular-planform supercritical wing.

R.R.

A89-41839*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

UNSTEADY AERODYNAMIC SIMULATION OF MULTIPLE BODIES IN RELATIVE MOTION

ROBERT L. MEAKIN (NASA, Ames Research Center, Moffett Field, CA) and NORMAN E. SUHS (Calspan Corp., Arnold AFB, TN) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 643-657. Research supported by USAF, U.S. Navy, and NASA. refs

(AIAA PAPER 89-1996)

A prototype method for time-accurate simulation of multiple aerodynamic bodies in relative motion is presented. The method is general and features unsteady chimera domain decomposition techniques and an implicit approximately factored finite-difference procedure to solve the time-dependent thin-layer Navier-Stokes equations. The method is applied to a set of two- and three-dimensional test problems to establish spatial and temporal accuracy, quantify computational efficiency, and begin to test overall code robustness.

Author

A89-41841#

ANALYSIS OF POTENTIAL AND VISCOUS FLOWS PAST GENERAL TWO-DIMENSIONAL BODIES WITH ARBITRARY TRAILING EDGE GEOMETRIES

G. A. OSSWALD, K. N. GHIA, and U. GHIA (Cincinnati, University, OH) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 668-677. Research supported by Science Applications International Corp. refs

(Contract AF-AFOSR-87-0074)

(AIAA PAPER 89-1969)

02 AERODYNAMICS

A two-dimensional unsteady Navier-Stokes (NS) analysis is extended to compute the separated viscous flow past arbitrary bodies. The conservation-law form of the governing NS equations is used in terms of the stream function and vorticity in generalized orthogonal coordinates. The conformal Schwarz-Christoffel mapping technique of Davis (1979) forms the basis of the present separable orthogonal grid-generation analysis. The analysis uses curved body elements to generate arbitrary two-dimensional profiles with sharp as well as rounded trailing edges. The dominant scales of the separated flow are resolved using one-dimensional clustering transformations based on cubic-spline functions. Eight flow configurations were planned; the results for five are included herein. The Reynolds number is fixed at 1,000 in all of these configurations, and the effect of cusped, wedge-shaped and rounded trailing-edge geometries is examined. Author

A89-41842#

UPWIND ALGORITHMS BASED ON A DIAGONALIZATION OF THE MULTIDIMENSIONAL EULER EQUATIONS

CH. HIRSCH and C. LACOR (Brussel, Vrije Universiteit, Brussels, Belgium) AIAA, Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989. 18 p. refs (AIAA PAPER 89-1958)

A new method for the solution of the multidimensional Euler equations is presented. As opposed to the classical schemes it is genuinely multidimensional in that the local characteristic directions into which information is propagated, are detected. Based on this approach a conservative cell-centered scheme has been formulated. The numerical fluxes are evaluated using MUSCL extrapolations along the characteristic directions. This leads to a family of first- and second-order accurate schemes with an improved resolution as compared to the classical schemes. Author

A89-41844#

A CENTRAL FINITE VOLUME TVD SCHEME FOR THE CALCULATION OF SUPERSONIC AND HYPERSONIC FLOW FIELDS AROUND COMPLEX CONFIGURATIONS

J. SCHOENE, N. KROLL, C. ROSSOW, H. LI, and TH. SONAR (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) AIAA, Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989. 18 p. refs (AIAA PAPER 89-1975)

A finite volume scheme based on the Euler equations is used to analyze three-dimensional supersonic and hypersonic flows. Numerical results for a blunted biconic configuration and for the Hermes reentry vehicle demonstrate the limitations of the dissipation model of Jameson et al. (1981). In comparison with results obtained with the Jameson et al. scheme, solutions obtained using a modified discretization having TVD properties in one dimension are shown to exhibit fewer oscillations in the flow variables in the vicinity of strong shocks. R.R.

A89-41903

LINEAR INSTABILITIES IN TWO-DIMENSIONAL COMPRESSIBLE MIXING LAYERS

SAAD A. RAGAB and J. L. WU (Virginia Polytechnic Institute and State University, Blacksburg, PA) Physics of Fluids A (ISSN 0899-8213), vol. 1, June 1989, p. 957-966. refs (Contract N00014-87-K-0168)

Linear instability waves in supersonic shear layers are analyzed. Both viscous and inviscid disturbances are considered. The basic state is obtained by solving the compressible laminar boundary-layer equations or is specified by the hyperbolic tangent profile. The effects of the velocity ratio and temperature ratio are determined. The numerical results show that the maximum growth rate depends nonlinearly on the velocity ratio. The results also substantiate the convective Mach number as a compressibility parameter for mixing layers. Author

A89-42009*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

OBSERVATION OF AIRPLANE FLOWFIELDS BY NATURAL CONDENSATION EFFECTS

JAMES F. CAMPBELL, JOSEPH R. CHAMBERS, and CHRISTOPHER L. RUMSEY (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 593-604. Previously cited in issue 07, p. 929, Accession no. A88-22139. refs

A89-42010*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

TRANSONIC UNSTEADY PRESSURE MEASUREMENTS ON A SUPERCritical AIRFOIL AT HIGH REYNOLDS NUMBERS

ROBERT W. HESS, DAVID A. SEIDEL, WILLIAM B. IGOE, and PIERCE L. LAWING (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 605-614. Previously cited in issue 08, p. 1032, Accession no. A87-22370. refs

A89-42011*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CAVITY DOOR EFFECTS ON AERODYNAMIC LOADS OF STORES SEPARATING FROM CAVITIES

A. B. BLAIR, JR. and R. L. STALLINGS, JR. (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 615-620. Previously cited in issue 07, p. 933, Accession no. A88-22244. refs

A89-42012*# Royal Aerospace Establishment, Farnborough (England).

VALIDATION OF AERODYNAMIC PARAMETERS FOR HIGH-INCIDENCE RESEARCH MODELS

A. JEAN ROSS, GERALDINE F. EDWARDS (Royal Aerospace Establishment, Farnborough, England), VLADISLAV KLEIN (George Washington University, Hampton, VA), and JAMES G. BATTERSON (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 621-628. Research supported by the Ministry of Defence Procurement Executive. Previously cited in issue 22, p. 3530, Accession no. A87-49608. refs

A89-42013*# Cambridge Acoustical Associates, Inc., MA.

LIFTING-SURFACE THEORY FOR PROPFAN VORTICES IMPINGING ON A DOWNSTREAM WING

R. MARTINEZ (Cambridge Acoustical Associates, Inc., MA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 629-633. refs (Contract NAS1-18020)

Retrofitment of commercial aircraft with propfans could introduce undesirable aerodynamic sources of structure-borne noise that are absent for current turbojet powerplants. This paper theoretically examines the whipping action of the vortex wake from a generic propeller on the downstream rigid wing that supports it. The model addresses the high-frequency/compressible regime of most anticipated propfan implementations and produces an analytic solution for the distributed wing airload due to the periodic vortex impingement. The analysis also yields an expression for the local unsteady lift obtained from integration over an arbitrary internal patch of wing surface, for the purpose of applying a practical number of such forces at the nodes of a finite-element model for the corresponding structure (wing response results are not included in the present paper). Reported estimates of induced wing loads for a conventional-propeller example of demonstration appear to be in the reasonable range of expectation. Author

A89-42014#

NUMERICAL SIMULATION OF THE NAVIER-STOKES EQUATIONS FOR AN F-16A CONFIGURATION

G. W. HUBAND, D. P. RIZZETTA, and J. J. S. SHANG (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p.

634-640. Previously cited in issue 16, p. 2592, Accession no. A88-40702. refs

A89-42015#**FLOW PAST TWO-DIMENSIONAL RIBBON PARACHUTE MODELS**

HIROSHI HIGUCHI and FUMIYUKI TAKAHASHI (Minnesota, University, Minneapolis) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 641-649. Research supported by Sandia National Laboratory. Previously cited in issue 16, p. 2592, Accession no. A88-40714. refs

A89-42016*# Vigyan Research Associates, Inc., Hampton, VA. HYPersonic PARABOLIZED NAVIER-STOKES CODE VALIDATION ON A SHARP NOSE CONE

LAWRENCE D. HUEBNER (Vigyan Research Associates, Inc., Hampton, VA), JAMES L. PITTMAN (NASA, Langley Research Center, Hampton, VA), and ARTHUR D. DILLEY (Analytical Services and Materials, Inc., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 650-656. Previously cited in issue 16, p. 2594, Accession no. A88-40739. refs

A89-42017#**INVESTIGATIONS ON THE VORTICITY SHEETS OF A CLOSE-COUPLED DELTA-CANARD CONFIGURATION**

HANS-CHRISTOPH OELKER and DIETRICH HUMMEL (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) (ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1, p. 649-662) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 657-666. Previously cited in issue 03, p. 257, Accession no. A89-13566. refs
(Contract DFG-HU-254/8)

A89-42020*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.**TRANSONIC AEROELASTICITY OF FIGHTER WINGS WITH ACTIVE CONTROL SURFACES**

GURU P. GURUSWAMY and EUGENE L. TU (NASA, Ames Research Center, Moffett Field, CA) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A, p. 16-30) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 682-684. Previously cited in issue 14, p. 2102, Accession no. A87-33657. refs

A89-42021*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.**EFFECTS OF CONTAMINATION ON RIBLET PERFORMANCE**

BARRY S. LAZOS (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 684-686. refs

Thin-element polymeric film riblet surfacing materials previously shown to behave similarly to v-groove riblets in the reduction of aerodynamic drag have been tested to ascertain the effects of groove contamination. Three different levels of contamination were simulated for each of two kinds of contamination. Such contaminants as oil drops and condensates have no significant effect on drag reduction. Atmospheric particulates may, however, degrade riblet performance. O.C.

A89-42023#**NUMERICAL PREDICTION OF AERODYNAMIC PERFORMANCE FOR LOW REYNOLDS NUMBER AIRFOILS**

FIE-BIN HSIAO (National Cheng Kung University, Tainan, Republic of China) and CHENG-CHAING HSU Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 689-692. Previously cited in issue 16, p. 2595, Accession no. A88-40744. refs

A89-42024*# San Diego State Univ., CA.**NUMERICAL SIMULATION OF AIRCRAFT ROTARY AERODYNAMICS**

JOSEPH KATZ (San Diego State University, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 692, 693.

Previously cited in issue 07, p. 934, Accession no. A88-22295. refs

(Contract NCC2-458)

A89-42026#**CALCULATION OF WIND-TUNNEL SIDE-WALL INTERFERENCE USING A THREE-DIMENSIONAL MULTIGRID NAVIER-STOKES CODE**

R. RADESPIEL (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 9 p. refs
(AIAA PAPER 89-1790)

A recently developed finite-volume code that applies a multistage time stepping scheme in conjunction with steady state acceleration techniques is used to solve the three-dimensional Navier-Stokes equations for flow over the CAST 10-2/Do A 2 airfoil mounted in a wind tunnel. Attention is given to various aspects of computing viscous side-wall effects on the flow around an airfoil. These include the extension of the Baldwin-Lomax turbulence model to compute flows in junctures and the treatment of the boundaries of the computational domain. Results for different angles of attack are compared to two-dimensional Navier-Stokes solutions and to measurements. It is shown that the effects of the viscous side wall can vary significantly depending on the size of the supersonic region on the upper side of the airfoil. Author

A89-42028#**GLOBAL MARCHING TECHNIQUE FOR PREDICTING FLOWS OVER AIRFOILS WITH LEADING AND TRAILING EDGE FLAPS**

AHMAD A. M. HALIM (USAF, Institute of Technology, Wright-Patterson AFB, OH) and F. HAFEEZ AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 16 p. refs
(AIAA PAPER 89-1793)

The purpose of this paper is to develop a code based on the approximate Navier Stokes (ANS) equations in the Vorticity Stream Function delta form. The current version of the code can be used to predict unsteady turbulent flow around nonsymmetric bodies. The code has been used to analyze low Reynolds number (100,000) flow around the Wortman FX 63-137 airfoil fitted with leading and trailing edge devices at various angles of attack and various deflection angles. Results are compared to the experimental data of Muller and Williams. The agreement is very good at small angles of attack. Overall, the present scheme produces reasonable results and has the potential of being developed into an effective design tool. Author

A89-42036*# Ohio State Univ., Columbus.**AN EXPERIMENTAL STUDY OF A REATTACHING SUPERSONIC SHEAR LAYER**

M. SAMIMY (Ohio State University, Columbus) and B. A./K. ABU-HIJLEH AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 6 p. refs
(Contract NAG3-764; N00014-87-K-0168)
(AIAA PAPER 89-1801)

A Mach 1.83 fully developed turbulent boundary layer was separated at a 25.4 mm backward step and formed a free shear layer. The incoming boundary layer thickness, momentum thickness, and Reynolds number were approximately 8 mm, 0.5 mm, and 52×10^6 to the 6th/m, respectively. A two-component coincident LDV system was used to take velocity measurements of the incoming boundary layer, the free shear layer, and the reattached shear layer. The results confirmed the existence of organized structures in both the free and the reattached shear layer which was reported earlier based on the authors dynamic pressure measurements and Schlieren photographs. Author

A89-42037#**A STRUCTURE OF LEADING-EDGE AND TIP VORTICES AT A DELTA WING**

SUSUMU SHIRAYAMA (Institute of Computational Fluid Dynamics,

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Tokyo, Japan) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 13 p. refs
(AIAA PAPER 89-1803)

An analysis of the rolling-up mechanism and core features of leading edge and tip vortices which is based on the mechanics of vortex loops is presented. The method involves solving the pressure equation and the Navier-Stokes equation. Flowfields have been computed for a thin full-span wing with a 20-deg semivertex angle and a thin semispan wing with a 14-deg semivertex angle. Although the present flowfields are unsteady, it is found that primary separation is stable and that vortex lift is obtained. R.R.

A89-42038#

NUMERICAL ANALYSIS ON AERODYNAMIC CHARACTERISTICS OF AN INCLINED SQUARE CYLINDER

TETSURO TAMURA (Shimizu Corp., Ohsaki Research Institute, Tokyo, Japan) and KUNIO KUWAHARA (Institute of Space and Astronautical Science, Sagami-hara, Japan) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 15 p. refs
(AIAA PAPER 89-1805)

Two- and three-dimensional unsteady flows with separation around a square cylinder with angle of attack are simulated by a direct finite difference computation of the incompressible Navier-Stokes equations. Any explicit turbulence models are not incorporated and the third order upwind scheme is used for the nonlinear convection terms. Computational vortex motions in the separation region and aerodynamic forces on the cylinder are investigated and their relations are clarified. The 3-D computational results are in good agreement with the previous experimental data. It is found that the 3-D flow structures in the separation-reattachment zone close to the upwind side surface have an important role in order to decide the aerodynamic behavior of an inclined square cylinder. Author

A89-42041#

NUMERICAL ANALYSIS OF SUPERSONIC TURBULENT MIXING LAYER

STEPHEN C. CHAN and RODNEY L. CLARK (Teledyne Brown Engineering, Huntsville, AL) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 6 p. refs
(AIAA PAPER 89-1811)

Numerical analysis of the supersonic turbulent mixing layer is presented by using the multi-dimensional Upwind Flux Difference Splitting (UFDS) implicit algorithm to solve the full compressible Navier-Stokes equations. An algebraic Baldwin and Lomax turbulent model is adapted for the presented turbulence analysis. The backward-facing step with a small amount of fluid blowing from the lower wall is considered. The objectives are to validate this algorithm with accurate experimental data and then to extend the computations to include an aero-optical interactions analysis. Both two-dimensional and three-dimensional solutions with the UFDS algorithm and with a central difference algorithm that employed artificial viscosity (AV) are presented. As expected, the UFDS algorithm yields better agreement with experimental data. Author

A89-42043*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

EXPERIMENTAL STUDY OF FREE-SHEAR LAYER TRANSITION ABOVE A CAVITY AT MACH 3.5

RUDOLPH A. KING, THEODORE R. CREEL, JR., and DENNIS M. BUSHNELL (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 14 p. refs
(AIAA PAPER 89-1813)

The transition behavior of a free-shear layer above a cavity with high and low levels of freestream acoustic disturbances has been studied at Mach 3.5. Optical techniques, mean pitot pressure measurements, and hot-wire measurements were employed to detect transition locations. Transition Reynolds numbers of between 363,000 and 530,000 were found, in agreement with previous

results. It is suggested that upstream convected disturbances may be at least partially responsible for the insensitivity of transition Reynolds numbers to the freestream acoustic disturbance field.

R.R.

A89-42044#

USE OF NAVIER-STOKES CODE TO PREDICT FLOW PHENOMENA NEAR STALL AS MEASURED ON A 0.658-SCALE V-22 TILTROTOR BLADE

J. C. NARRAMORE (Bell Helicopter Textron, Inc., Fort Worth, TX) and R. VERMELAND (Cray Research, Inc., Mendota Heights, MO) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 8 p. refs
(AIAA PAPER 89-1814)

A three-dimensional unsteady Navier-Stokes method is used to model the flowfield about an axial flow rotor at high thrust levels in order to study the marked increase in lift coefficients noted near the stall of rotating blades. Axial flow hovering flight is a critical operating condition for VTOL aircraft. The results show that the flow on the inboard end of the blade remains attached up to high angles of attack, and that flow separation in the inboard region is curtailed for a rotating blade. R.R.

A89-42045#

THREE DIMENSIONAL ANALYSIS OF A ROTOR IN FORWARD FLIGHT

R. GANESH RAJAGOPALAN (Iowa State University of Science and Technology, Ames) and SANJAY R. MATHUR AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 13 p. Research supported by Iowa State University of Science and Technology. refs
(AIAA PAPER 89-1815)

The steady, incompressible laminar Navier-Stokes equations in Cartesian coordinates are solved for the flow field and performance characteristics of a helicopter rotor in forward flight. The rotor is modelled as a distribution of momentum sources the strength of which is determined from implicit functional relations involving the flow field properties, the rotor geometry and the aerodynamic characteristics of the blade cross-section. These strengths are calculated along with the rest of the flow field in an iterative manner using a finite-volume based primitive variable algorithm. No assumptions about the wake structure are made. Blade-loads are obtained for a test case and compared with experimental results. Solutions for the surrounding flow field are also presented. Author

A89-42046*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

VORTEX-DOMINATED CONICAL-FLOW COMPUTATIONS USING UNSTRUCTURED ADAPTIVELY-REFINED MESHES

JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 14 p. refs
(AIAA PAPER 89-1816)

A conical Euler/Navier-Stokes algorithm is presented for the computation of vortex-dominated flows. The flow solver involves a multistage Runge-Kutta time stepping scheme which uses a finite-volume spatial discretization on an unstructured grid made up of triangles. The algorithm also employs an adaptive mesh refinement procedure which enriches the mesh locally to more accurately resolve the vortical flow features. Results are presented for several highly-swept delta wing and circular cone cases at high angles of attack and at supersonic freestream flow conditions. Accurate solutions were obtained more efficiently when adaptive mesh refinement was used in contrast with refining the grid globally. The paper presents descriptions of the conical Euler/Navier-Stokes flow solver and adaptive mesh refinement procedures along with results which demonstrate the capability. Author

A89-42047#

THE COMPUTATION OF NAVIER-STOKES SOLUTIONS EXHIBITING ASYMMETRIC VORTICES

M. J. SICLARI and F. MARCONI (Grumman Corporate Research

Center, Bethpage, NY) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 14 p. refs
(AIAA PAPER 89-1817)

An efficient Navier-Stokes solver is used to demonstrate the existence of asymmetric vortex flows on slender cones flying at supersonic speeds and at very high angles of attack. The iteration scheme is continued until the residual or error attains machine zero. The computations were carried out on very fine grids so that issues of unsteadiness in the solution or large truncation error are minimized. These types of asymmetries have been noted experimentally for years; in addition, analytical/computational models have indicated the existence of these types of solutions. This paper is the first to present Navier-Stokes solutions which firmly demonstrate that these flows exist and that they are not experimental or computational anomalies. Author

A89-42048#
MULTIGRID SOLUTION OF THE EULER EQUATIONS FOR THREE-DIMENSIONAL CASCADE FLOWS

J. S. LIU and S. V. SUBRAMANIAN (Textron Lycoming, Stratford, CT) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 7 p. Research supported by Textron Lycoming Independent Research and Development Program. refs
(AIAA PAPER 89-1818)

The performance of a computer code, developed for simulating three-dimensional flowfields in stationary and rotating turbo-machinery blade rows is described in this study. The code solves the time dependent, three-dimensional Euler equations in cylindrical coordinates including the effect of blade rotation using the multi-stage Runge-Kutta numerical integration scheme. The major feature of this study is the incorporation of the multigrid acceleration technique for improving solution convergence. In order to demonstrate the accuracy and effectiveness of this code as an efficient design tool, solutions were obtained for many test case geometries. Results are presented for a subsonic turbine stator and a transonic compressor rotor for the sake of brevity. Numerical predictions are compared with experimental data to illustrate that the multigrid code efficiently predicts many important flow features with very good accuracy. Author

A89-42049*# Vigyan Research Associates, Inc., Hampton, VA.
INNOVATIVE PYLON CONCEPTS FOR ENGINE-AIRFRAME INTEGRATION FOR TRANSONIC TRANSPORTS

DINESH A. NAIK (Vigyan Research Associates, Inc., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 13 p. refs
(Contract NAS1-17919)
(AIAA PAPER 89-1819)

Pylon cross-sectional geometries that are believed to reduce pylon/wing installation drag are analyzed. The basic design philosophy is to alleviate flow acceleration near the pylon/wing junction by aerodynamic means. This involves reshaping the pylon, particularly on the inboard side. In some instances this is achieved by moving the pylon trailing edge closure aft of the wing trailing edge. A three-dimensional Euler code was used for the analysis. Promising pylon shapes are identified for further investigation. Author

A89-42051*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
NEW MIXING-LENGTH MODEL FOR TURBULENT HIGH-SPEED FLOWS

M. SITU and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg, PA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 15 p. Research supported by Johns Hopkins University and NASA. refs
(AIAA PAPER 89-1821)

A modification of Prandtl's mixing-length model is presented which takes into account the effects of compressibility on turbulence for high speed flows. A parameter is introduced into

the turbulent transport formula which acts like an effective turbulent Schmidt number for mixtures of gases or a turbulent Prandtl number for a homogeneous gas. Results presented for such cases as high Mach number turbulent boundary layer flows over a flat surface, tangential slot injection problems, and shock/turbulent shear-layer and boundary-layer interactions agree well with experimental data. R.R.

A89-42052#
A COMPUTATIONAL ANALYSIS OF THE TRANSONIC FLOW FIELD OF TWO-DIMENSIONAL MINIMUM LENGTH NOZZLES
BRIAN M. ARGROW and GEORGE EMANUEL (Oklahoma, University, Norman) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 22 p. refs
(AIAA PAPER 89-1822)

The method of characteristics is used to generate supersonic wall contours for two-dimensional, straight sonic line (SSL) and curved sonic line (CSL) minimum length nozzles for exit Mach numbers of two, four and six. These contours are combined with subsonic inlets to determine the influence of the inlet geometry on the sonic-line shape and location and on the supersonic flow field. A modified version of the code VNAP2 is used to compute the inviscid and laminar flow fields for Reynolds numbers of 1,170, 11,700, and 23,400. Results indicate that the inlet geometry directly determines the sonic-line shape and location. Supersonic flow field phenomena, including boundary-layer separation and oblique shock waves, are observed to be a direct result of the inlet geometry. The sonic-line assumptions made for the SSL prove to be superior to those of the CSL. Author

A89-42056*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

CALCULATION OF WINGED-BODY-LIKE FLOW FIELDS USING AN IMPLICIT UPWIND SPACE-MARCHING CODE

SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 12 p. refs
(AIAA PAPER 89-1826)

The Mach-8 flow past a 60-deg swept fin mounted on a 12-degree ramp has been simulated using a parabolized Navier-Stokes solver employing an upwind algorithm in order to investigate the interference patterns that develop when a bow shock impinges on a wing shock. Good agreement with experimental data is found downstream of the interaction for each of three meshes of varying grid point density and computed surface pressure and heat transfer. In the wedge flow region, some disagreement with experimental data is noted for both pressure and heat transfer. R.R.

A89-42057#
PROGRESS IN THE DEVELOPMENT OF PARABOLIZED NAVIER-STOKES TECHNOLOGY FOR EXTERNAL AND INTERNAL SUPERSONIC FLOWS

W. J. KRAWCZYK, T. B. HARRIS, N. RAJENDRAN (Science Applications International Corp., Wayne, PA), and D. R. CARLSON (Science Applications International Corp., Dayton, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 17 p. refs
(AIAA PAPER 89-1828)

Renewed interest in supersonic/hypersonic flight conditions has rapidly advanced technology in Computational Fluid Dynamics. Recent innovations in algorithm development has greatly improved the reliability and robustness of Navier-Stokes and Parabolized Navier-Stokes solvers. This paper surveys the state of PNS technology, including innovations such as the use of upwind algorithms and local time-iterative PNS algorithms, which have greatly improved the robustness and reliability of PNS codes over the original central difference based formulations. Several applications are presented for a spectrum of flight and wind tunnel simulations, for both external and internal flows. The implications of PNS upgrades for the numerical algorithm and for physical modeling is discussed for these applications. Author

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A89-42058*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

NUMERICAL SIMULATION OF FLOW OVER A HYPERSONIC AIRCRAFT USING AN EXPLICIT UPWIND PNS SOLVER

JOHN J. KORTE (NASA, Langley Research Center, Hampton, VA) and D. SCOTT MCRAE (North Carolina State University, Raleigh) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 13 p. Research supported by USAF and U.S. Navy. refs

(Contract NAGW-1072)

(AIAA PAPER 89-1829)

A hypersonic flow field over a generic airplane configuration is simulated by solving the Parabolized Navier-Stokes (PNS) equations. The finite difference solution of the PNS equations is calculated using a noniterative space marching, explicit, upwind scheme recently developed by the authors. Special gridding techniques are used which allowed the sharp changes in surface geometry of the airplane configuration to be modelled without smoothing of corners. Comparisons of the PNS results to a solution of the Navier-Stokes equations demonstrates a good agreement of the numerical results in approximately 1/6 of the cpu time. This paper demonstrates that the explicit upwind algorithm for solving the PNS equations is an efficient method for simulating hypersonic flow fields about complete airplane configurations and should be considered as an alternative to solving the Navier-Stokes equations for flow fields where the PNS equations are valid.

Author

A89-42060#

EXPERIMENTAL/COMPUTATIONAL STUDY OF A TRANSONIC AIRCRAFT WITH STORES

J. H. FOX and E. G. ALLEE (Calspen Arnold Engineering Development Center, Arnold AFB, TN) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 14 p. refs

(AIAA PAPER 89-1832)

An experimental and computational investigation of the flow field around an F-15E aircraft with stores at a Mach number of 0.98 is presented. Flowfield measurements, surface static pressure measurements, and Euler flowfield solutions were obtained for three aircraft configurations. The results for the configuration which included the addition of a finned store to the forward outboard conformal fuel tank pylon showed the dominant flow experienced by the store to be a crossflow resulting from the displacement of the oncoming airstream by the vehicle.

R.R.

A89-42061#

AN EXPERIMENTAL INVESTIGATION OF THE PARALLEL VORTEX-AIRFOIL INTERACTION AT TRANSONIC SPEEDS

IRAJ M. KALKHORAN, DONALD R. WILSON, and DONALD D. SEATH (Texas, University, Arlington) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 11 p. refs

(AIAA PAPER 89-1833)

Unsteady vortex-airfoil interaction experiments were conducted in a transonic wind tunnel in order to simulate the two-dimensional blade-vortex interaction problem frequently encountered in rotorcraft applications. The results show a substantial change in the pressure distribution over the leading 30 percent of the interacting airfoil. At supercritical Mach numbers, a strong interaction of the vortex and the shock wave is found, while with stronger vortices at supercritical Mach numbers, forward propagation of the shock wave was noted.

R.R.

A89-42062#

TRANSONIC FLOW AROUND AIRFOILS WITH RELAXATION AND ENERGY SUPPLY BY HOMOGENEOUS CONDENSATION

GUENTER H. SCHNERR and URLICH DOHRMANN (Karlsruhe, Universitaet, Federal Republic of Germany) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 10 p. Research supported by the Klein, Schanzlin und Becker Stiftung. refs

(Contract DFG-ZI-18-31)

(AIAA PAPER 89-1834)

A theoretical and experimental study of the steady two-dimensional flow of vapor/carrier gas mixtures with nonequilibrium condensation is presented. Numerical calculations using a diabatic time-dependent explicit finite volume code show that the variation of the pressure drag coefficient due to heating is the sum of three connected processes: (1) the reduction of the wave drag in the local supersonic area; (2) the shock shifting; and (3) the pressure decrease in the rear section due to evaporation. Both the circular arc and NACA-0012 airfoils considered reveal the same tendency with respect to shock shifting.

R.R.

A89-42063#

3D-EULER FLOW ANALYSIS OF FANJET ENGINE AND TURBINE POWERED SIMULATOR WITH EXPERIMENTAL COMPARISON IN TRANSONIC SPEED

NAOKI HIROSE, KEISUKE ASAI (National Aerospace Laboratory, Chofu, Japan), RYUMA KAWAMURA (Nihon University, Funabashi, Japan), and KATUYA IKAWA AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 10 p. refs

(AIAA PAPER 89-1835)

A transonic three-dimensional flow analysis code for the wind tunnel testing of a fan-jet engine and a turbine powered simulator has been developed which uses MacCormack's (1969) scheme in the finite volume form. The pressure distributions on the inlet cowl and core-jet cowl surface obtained by the code agree well with experimental observations. The results reveal the angle-of-attack effects on the inlet flow field and exhaust-jet plume, and have identified a pair of longitudinal vortices in the shear layer between the jet and the external flows.

R.R.

A89-42064*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

COMPUTATION OF TURBULENT FLOWS ON A CAST 10 WING USING AN UPWIND SCHEME

YVES P. MARX (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 12 p. refs

(AIAA PAPER 89-1836)

Two and three dimensional turbulent calculations around RAE2822, CAST 10 airfoils and a wing side-wall configuration are presented. A finite volume, cell-center method based on flux difference splitting schemes is used to solve the steady state thin-layer Navier-Stokes equations. Comparisons between the performances of different Riemann solvers and reconstruction schemes are also presented. The influence of a side-wall on the symmetry plane of a cylindrical CAST 10 wing is found to be highly sensitive to the turbulence modeling in the vicinity of the wing side-wall juncture.

Author

A89-42065*# Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH.

3-D COMPOSITE VELOCITY SOLUTIONS FOR SUBSONIC/TRANSONIC FLOW OVER AFTERBODIES

RAYMOND E. GORNIER (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) and STANLEY G. RUBIN (Cincinnati, University, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 11 p. refs

(Contract F49620-85-C-0027; NAG1-8)

(AIAA PAPER 89-1837)

A composite velocity procedure for the three-dimensional reduced Navier-Stokes equations is developed. The velocity components are written as a combined multiplicative and additive composite of viscous like velocities and pseudo-potential or inviscid velocities. The solution procedure is then consistent with both asymptotic inviscid flow and boundary layer theory. For transonic flow cases, the Enquist-Osher flux biasing scheme developed for the full potential equation is used. A quasi-conservation form of the governing equations is used in the shock region to capture

the correct rotational behavior. The composite velocity procedure is applied for the solution of three-dimensional afterbody problems. Author

A89-42066*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A VALIDATION STUDY OF FOUR NAVIER-STOKES CODES FOR HIGH-SPEED FLOWS

DAVID H. RUDY, JAMES L. THOMAS, AJAY KUMAR, PETER A. GNOFF (NASA, Langley Research Center, Hampton, VA), and SUKUMAR R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 13 p. refs (AIAA PAPER 89-1838)

A code validation study has been conducted for four different codes for solving the compressible Navier-Stokes equations. Computations for a series of nominally two-dimensional high-speed laminar separated flows were compared with detailed experimental shock-tunnel results. The shock wave-boundary layer interactions considered were induced by a compression ramp in one case and by an externally-generated incident shock in the second case. In general, good agreement was reached between the grid-refined calculations and experiment for the incipient- and small-separation conditions. For the most highly separated flow, three-dimensional calculations which included the finite-span effects of the experiment were required in order to obtain agreement with the data. The finite-span effects were important in determining the extent of separation as well as the time required to establish the steady-flow interaction. The results presented provide a resolution of discrepancies with the experimental data encountered in several recent computational studies. Author

A89-42067*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

DEVELOPMENT AND VALIDATION OF CNS (COMPRESSIBLE NAVIER-STOKES) FOR HYPERSONIC EXTERNAL FLOWS

JOLEN FLORES, CHUEN-YEN CHOW (NASA, Ames Research Center, Moffett Field, CA), and JAMES S. RYAN AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 9 p. refs (Contract NCC2-440) (AIAA PAPER 89-1839)

CNS, a new computational fluid dynamics procedure, has been developed to aid in hypersonic vehicle design. The code can be used to model the entire external flow around hypersonic vehicle shapes, from the captured shock at the nose to the beginning of the wake. Unlike space-marching codes, the technique allows axially separated flow regions to be modeled. Validation trials using sphere-cone data reveal good solution accuracy for the surface pressure and flowfield temperature. R.R.

A89-42068#
NUMERICAL SIMULATION OF LAMINAR HYPERSONIC FLOW PAST A DOUBLE-ELLIPSOID

S. RIEDELBAUCH, G. BRENNER, B. MUELLER, and W. KORDULLA (DFVLR, Goettinger, Federal Republic of Germany) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 12 p. refs (Contract DFG-RU-334/1-6) (AIAA PAPER 89-1840)

Three-dimensional laminar hypersonic flow of perfect gas past a double-ellipsoid at angles of attack varying between 0 and 40 deg and axisymmetric flow of air in chemical equilibrium past a hemisphere and a hyperboloid are simulated. The thin-layer Navier-Stokes equations are solved by a semiimplicit finite-difference method. The robustness of the shock-fitting procedure has been enhanced. Shock-shock and shock-boundary layer interactions as well as flow separation are observed for the double ellipsoid. The results are compared with experimental flow visualizations. The implementation of an equilibrium air model has been validated for the flow past a hemisphere. Author

A89-42070#

EXPERIMENT AND COMPUTATION IN HYPERSONIC CAVITY FLOWS

M. P. NETTERFIELD and R. HILIER (Imperial College of Science, Technology and Medicine, London, England) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 10 p. Research supported by the Ministry of Defence, Royal Commission for the Exhibition of 1851, and Overseas Research Scheme. refs (AIAA PAPER 89-1842)

Axisymmetric hypersonic cavity flow experiments have been conducted at high Reynolds numbers with a nominal boundary layer edge Mach number at separation of 8.0. Pressure and heat transfer distributions were recorded for cavities with length to depth ratios of 0.8-2.4 and with relatively-thick, turbulent boundary layers at separation ($\delta/D=0.25$). Distinct Reynolds number effects were noticed in the region of shear layer reattachment on the rear face where the highest pressures and heat transfer rates were recorded. Evidence of flow unsteadiness was also found. Simple semiempirical relations were found to give realistic estimates of peak pressure. Initial work is also reported on the development of a Navier-Stokes code from a second order Godunov-type method. Author

A89-42071#

INTERACTION OF A COMPRESSION RAMP WITH A HYPERSONIC LAMINAR BOUNDARY LAYER

A. RANGWALLA and G. R. INGER (Iowa State University of Science and Technology, Ames) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 17 p. refs (AIAA PAPER 89-1843)

This paper analyzes the weakly-hypersonic interaction of a 2-D compression-ramp shock with an adiabatic laminar boundary layer using a non-asymptotic triple deck approach that extends Lighthill's work for supersonic flow to include second order effects. The disturbance flow field is obtained analytically for a range of free stream Mach numbers and Reynolds numbers. In particular, the first and second order wall pressure and skin friction perturbations are obtained and their far upstream and downstream asymptotic behavior are deduced as a function of Mach number and Reynolds number. The relative importance of the hypersonic effects to supersonic flow are then obtained as a function of both Mach number and Reynolds number. Also, the onset of separation is predicted. Author

A89-42072#

MEASUREMENT AND COMPUTATION OF THE VELOCITY FIELD OF A CYLINDER IN THE WAKE OF A ROTOR IN FORWARD FLIGHT

D. N. MAVRIS, S. G. LIOU, N. M. KOMERATH, and H. M. MCMAHON (Georgia Institute of Technology, Atlanta) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 10 p. refs (Contract DAAG29-82-K-0084) (AIAA PAPER 89-1844)

The problem of predicting the flowfield around a rotorcraft in low-speed forward flight is studied using a potential-flow code, whose results are compared with surface pressure measurements and flow velocity measurements. The test case used is a 2-bladed teetering rotor above a hemisphere-cylinder airframe in a wind tunnel. The dominant features of this problem are modeled by a lifting line/lifting surface rotor model with a free wake distorting in the presence of the airframe. The airframe flowfield is modeled using a source/doublet panel method. The instantaneous flowfield is computed at specified intervals of rotor azimuth, with the effects of blade motion added to the formulation. Modeling the energy addition at the rotor using actuator segments leads to successful prediction of the time-averaged pressure field. The periodic velocity variations along the spine of the airframe are predicted successfully. When a fully unsteady potential formulation is used, however, large differences appear between measured and computed periodic velocity at the sides of the airframe. These are attributed to the

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inadequate understanding of interaction of the rotor tip vortices with the airframe surface, as well as to inadequate modeling of the flowfield around the rotor hub. Author

A89-42073*# Textron Bell Helicopter, Fort Worth, TX.
COMPUTATIONAL AND EXPERIMENTAL EVALUATION OF HELICOPTER ROTOR TIPS FOR HIGH SPEED FORWARD FLIGHT

DAVE SIGL (Bell Helicopter Textron, Fort Worth, TX) and ROGER C. STRAWN (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 11 p. refs (AIAA PAPER 89-1845)

A computational and experimental method for the evaluation of helicopter rotor tips in high-speed forward flight is presented which uses an unsteady full-potential solver on the advancing side of the rotor disk. Forces and moments measured during angle-of-attack sweeps reveal the soft-stall phenomenon of the double-swept planforms as well as the delayed stall of the single-swept hyperbolic tip. Double-swept planforms are shown to exhibit the most favorable performance, creating counter-rotating vortices that augment the lifting capabilities of the blade at high angles of attack and delay the onset of stall. R.R.

A89-42074*# Rockwell International Science Center, Thousand Oaks, CA.

NUMERICAL SOLUTIONS OF FORWARD-FLIGHT ROTOR FLOW USING AN UPWIND METHOD

C. L. CHEN (Rockwell International Science Center, Thousand Oaks, CA), W. J. MCCROSKEY, and S. OBAYASHI (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 9 p. refs (AIAA PAPER 89-1846)

A finite-volume upwind algorithm for solving the 3-D Euler equations with a moving grid has been developed for computing helicopter forward-flight rotor flows. The computed pressure distributions and shock positions of high-speed rotor flow are compared with various experimental data as well as with other numerical results, and the agreement is encouraging. A comparison of quasi-steady solutions with unsteady solutions reveals that when a shock occurs in the flowfield, the assumption of quasi-steady flow may fail due to the time-lag of the shock motion. Similarly, three-dimensional effects cannot be neglected. Sufficient subiterations for each time step are required to avoid numerical lag effects in using the present method. The redistribution of the residual due to the coordinate transformation is discussed. For high-order MUSCL-type schemes, a coordinate-independent solution can be obtained by interpolating primitive variables. Author

A89-42075*# McDonnell-Douglas Helicopter Co., Mesa, AZ.

SIMULATION OF REALISTIC ROTOR BLADE-VORTEX INTERACTIONS USING A FINITE-DIFFERENCE TECHNIQUE

AHMED A. HASSAN and BRUCE D. CHARLES (McDonnell Douglas Helicopter Co., Mesa, AZ) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 15 p. refs (Contract NAS1-17145)

(AIAA PAPER 89-1847)

A numerical finite-difference code has been used to predict helicopter blade loads during realistic self-generated three-dimensional blade-vortex interactions. The velocity field is determined via a nonlinear superposition of the rotor flowfield. Data obtained from a lifting-line helicopter/rotor trim code are used to determine the instantaneous position of the interaction vortex elements with respect to the blade. Data obtained for three rotor advance ratios show a reasonable correlation with wind tunnel data. R.R.

A89-42076*# JAI Associates, Mountain View, CA.
UNSTEADY INTERACTION OF A ROTOR WITH A VORTEX

G. R. SRINIVASAN (JAI Associates, Inc., Sunnyvale, CA) and W. J. MCCROSKEY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 20 p. refs (Contract DAAL03-88-C-0006) (AIAA PAPER 89-1848)

The unsteady, three-dimensional flow field of a helicopter rotor blade encountering a passing vortex is calculated by solving the Euler/thin layer Navier-Stokes equations by a finite-difference numerical procedure. A prescribed vortex method is adopted to preserve the structure of the interacting vortex. The cases considered for computation correspond to the experimental model rotor test conditions of Caradonna, et al. and consist of parallel and oblique interactions. Comparison of the numerical results with test data show good agreement for both parallel and oblique interactions at subsonic and transonic tip speeds. Author

A89-42077#
MEASUREMENTS OF SWEEPED SHOCK WAVE/TURBULENT BOUNDARY-LAYER INTERACTIONS BY HOLOGRAPHIC INTERFEROMETRY

J. C. HSU and G. S. SETTLES (Pennsylvania State University, University Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 11 p. refs (Contract AF-AFOSR-86-0082)

(AIAA PAPER 89-1849)

The flowfield structure of swept shock wave/turbulent boundary layer interactions generated by a fin mounted on a flat plate at Mach 2.43 and 2.97 has been visualized and measured by pulsed-laser holographic interferometry. The interactions studied range from moderate strength (Mach 2.43, $\alpha = 10$ deg) to a strong case (Mach 2.97, $\alpha = 20$ deg) with obvious flow separation. A conical holographic object beam, focused at the virtual origin of the interaction and aimed along the swept wave, was required to view these quasicircular interactions properly. Shadowgram images were also produced. The results have revealed the characteristic lambda-shock structure, the boundary-layer separation vortex, and the transonic jet which emerges from the lambda-shock and impinges just ahead of the fin/plate intersection. An improved physical model of the interaction structure has been proposed based on these results. Detailed comparisons of the results have been made with both flowfield surveys and computational simulations by other investigators. Author

A89-42078*# Texas Univ., Arlington.
INCEPTION LENGTH TO A FULLY-DEVELOPED FIN-GENERATED SHOCK WAVE BOUNDARY-LAYER INTERACTION

FRANK K. LU (Texas, University, Arlington) and GARY S. SETTLES (Pennsylvania State University, University Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 12 p. refs (Contract AF-AFOSR-86-0082; NCA2-192) (AIAA PAPER 89-1850)

An experimental study of fin-generated shock wave turbulent boundary-layer interactions confirmed previous observations that, sufficiently far from the fin apex, such interactions become conical. The inception length to conical symmetry was found to increase weakly with Mach number for Mach numbers from 2.5 to 4 and fin angles from 4 to 22 deg. For the range of interactions examined, the inception length was found to depend primarily upon the inviscid shock angle, this angle ranging from 21 to 40 deg. The behavior of the inception length with shock angle can be broadly divided into two categories. For 'weak' interactions with shock angles less than about 35 deg, the inception length decreased as the shock angle increased. For 'strong' interactions with shock angles greater than about 35 deg, the inception region was small and was approximately constant at three boundary-layer thicknesses in length. In the latter, strong interaction case, the inception length

was an order of magnitude smaller than that found in the weakest interactions examined, to the extent that strong interactions were practically fully-developed from the apex. Author

A89-42079#
NAVIER-STOKES SIMULATION OF A SHOCK
WAVE-TURBULENT BOUNDARY LAYER INTERACTION IN A
THREE-DIMENSIONAL CHANNEL

L. CAMBIER and B. ESCANDE (ONERA, Chatillon-sous-Bagneux, France) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 10 p. Research supported by DRET. refs (AIAA PAPER 89-1851)

The paper deals with the numerical simulation of a shock wave-turbulent boundary layer interaction in a three-dimensional channel, by solution of the Reynolds averaged Navier-Stokes equations with a mixing-length turbulence model. The numerical method is characterized by an explicit centered finite difference scheme associated with a multigrid convergence acceleration. The computed configuration is well suited to the validation of a 3-D Navier-Stokes solver since the flow has a very complex 3-D structure although the channel geometry is simple. Comparison with experiment shows that the numerical results obtained in a mesh containing about 600,000 points are satisfactory. Author

A89-42080#
COMPUTATION OF SHARP FIN AND SWEEPED COMPRESSION
CORNER SHOCK/TURBULENT BOUNDARY LAYER
INTERACTIONS

DOYLE D. KNIGHT (Rutgers University, New Brunswick, NJ) and YAN ZANG AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 13 p. refs (AIAA PAPER 89-1852)

A numerical computation has been carried out to investigate three-dimensional shock wave/turbulent boundary layer interactions generated by the sharp fin and the swept compression corner. The upstream flow is at Mach number 3 and Reynolds number 1.06×10^6 to the 6th based on the upstream boundary-layer thickness. Reynolds averaged compressible Navier-Stokes equations were solved with turbulence represented by an algebraic eddy viscosity model. The two geometries investigated were three-dimensional sharp fin with fin angle $\alpha = 17.5$ deg (17.5 deg fin) and the swept compression corner at an angle of attack $\lambda = 30$ deg and with a sweep angle of 60 deg (30, 60) corner. Overall, good agreement has been achieved between computation and experiment. Both interaction flowfields were dominated by a large vortical structure aligned with the corner. Computation tends to support the quasi-conical free similarity principle proposed previously from experiments. Author

A89-42081#
SEPARATION SHOCK MOTION AND ENSEMBLE-AVERAGED
WALL PRESSURES IN A MACH 5 COMPRESSION RAMP
INTERACTION

D. S. DOLLING (Texas, University, Austin) and M. E. ERENGIL AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 16 p. refs (Contract AF-AFOSR-86-0112) (AIAA PAPER 89-1853)

Simultaneous fluctuating wall pressure measurements have been made under the unsteady separation shock and the separated shear layer in a Mach 5 compression ramp induced turbulent boundary layer interaction. The freestream unit Reynolds number was 48.7×10^6 to the 7th/m, and the turbulent boundary layer developed on the tunnel floor under approximately adiabatic wall temperature conditions. Conditional sampling algorithms and a 'variable-window' ensemble averaging technique have been used to determine ensemble-averaged pressure distributions corresponding to different separation shock wave positions. The results show that: (1) significant unsteadiness is largely confined to the intermittent region, (2) the intermittent region is characterized by a shock wave and compression system whose strength is a function of shock position, (3) pressure distributions for

'shock-upstream' and 'shock-downstream' conditions have the features of large- and small-scale separated flows respectively, indicative of an expanding and contracting bubble, and (4) ensemble-averaged pressure histories under the separated shear layer rise and fall as the separation shock translates downstream and upstream respectively. Author

A89-42082#
THE STRUCTURE OF AERODYNAMIC HEATING IN
THREE-DIMENSIONAL SHOCK WAVE/TURBULENT
BOUNDARY LAYER INTERACTIONS INDUCED BY SHARP
AND BLUNT FIN

SHIGERU ASO (Kyushu University, Fukuoka, Japan), MASANORI HAYASHI (Nishinippon Institute of Technology, Japan), and ANZHONG TAN AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 10 p. refs (AIAA PAPER 89-1854)

A method employing a thin-film heat transfer gage with high spatial resolution is used to study the detailed structure of aerodynamic heating in a three-dimensional shock wave/turbulent boundary layer induced by sharp and blunt fins. Experiments have been performed using a Mach number of 4 and a total pressure of 1.2 MPa. The results reveal a drastic change in the heat transfer rate in the interaction region, along with the strong relationship between peak heating and flow reattachment. R.R.

A89-42083#
DETERMINATION OF COMPUTATIONAL TIME STEP FOR
CHEMICALLY REACTING FLOWS

TING-LUNG CHIANG and KLAUS A. HOFFMANN (Texas, University, Austin) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 15 p. refs (AIAA PAPER 89-1855)

A numerical algorithm for determining the marching time step of chemically reacting flows is presented. A Von Neumann stability analysis has been included in the chemistry equations in order to obtain a criteria for the selection of a time step that provides a stable solution. The Euler equations and the chemistry species equations have been discretized using an implicit flux-splitting finite difference formulation. The scheme has been validated by the numerical simulation of a quasi-one-dimensional nozzle problem. R.R.

A89-42084#
PARAMETRIC STUDY OF THERMAL AND CHEMICAL
NONEQUILIBRIUM NOZZLE FLOW

PH. SAGNIER and L. MARRAFFA (ONERA, Chatillon-sous-Bagneux, France) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 13 p. refs (AIAA PAPER 89-1856)

A numerical analysis of a thermochemical nonequilibrium inviscid nozzle flow was made for two types of wind tunnel facility. The first was a French project of continuously arc heated wind tunnel. The second was a generic wind tunnel, similar to a future European facility. Its stagnation pressure and enthalpy are higher than in the first wind tunnel. These nozzles are supplied with equilibrium air. Equilibrium is assumed up to the throat. Downstream, calculation is carried out with a pseudo-one-dimensional method, taking into account nonequilibrium thermochemistry, with possible vibration-dissociation coupling. There, the air is quickly expanded and departure from equilibrium and then freezing are observed. Different models of chemical, electronic and vibrational kinetics and different coupling models are studied. Their global influences are analyzed for one test condition for each wind tunnel. Furthermore, for the first nozzle, the computed frozen Mach number compares pretty well with experimental results. Author

A89-42092#
TURBULENT FLOW PREDICTIONS FOR AFTERBODY/NOZZLE
GEOMETRIES INCLUDING BASE EFFECTS

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A. J. PEACE (Aircraft Research Association, Ltd., Bedford, England) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 10 p. Research supported by the Ministry of Defence Procurement Executive. refs

(AIAA PAPER 89-1865)

A numerical method for solving the Reynolds-averaged Navier-Stokes equations around axisymmetric afterbody/nozzle configurations, with sharp trailing edges or finite bases, is presented. Turbulence closure is achieved through either a simple algebraic turbulence model or a low Reynolds number form of the k-epsilon two-equation differential model. The solution procedure uses an explicit time-marching finite-volume method. The performance of each of the turbulence models is assessed through comparisons with experimental data on three series of geometries, including both attached and separated flow cases. Author

A89-42093#

AN EXPERIMENTAL STUDY OF HYPERSONIC TURBULENCE ON A SHARP CONE

J. HARVEY (Imperial College of Science and Technology, London, England), R. C. BERGMAN, and M. S. HOLDEN (Calspan Corp., Buffalo, NY) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 11 p. refs (AIAA PAPER 89-1866)

A preliminary experimental study has been conducted in which an electron beam, and pitot and total temperature probes were used to measure the mean and fluctuating density, and mean static temperature across a Mach 7.5 turbulent boundary layer over a 4-ft long 6 deg sharp cone. The experimental studies were conducted in a 96-in Tunnel at a free stream Mach number of 8.5 and unit Reynolds number of 5×10 to the 6th. The initial use of this technique has demonstrated a potential to obtain fluctuation measurements up to frequencies approaching 1 MHz. Additional improvement is expected when more advanced optics are used. The mean rotational temperature through the boundary layer can be determined from spectra obtained using an Optical Multichannel Analyzer. The electron gun has proven highly reliable and has the potential to work at equivalent densities up to over 100 torr. Further developments are anticipated employing an electron beam to stimulate a gas which is examined using a resonant laser technique. Author

A89-42094#

PREDICTION OF TURBULENT MIXING AND FILM-COOLING EFFECTIVENESS FOR HYPERSONIC FLOWS

JONG H. WANG (Rockwell International Corp., Los Angeles, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 12 p. Research supported by the U.S. Army. refs (AIAA PAPER 89-1867)

An efficient boundary layer code that solves both streamwise and lateral momentum equations has been applied to the prediction of wall heat flux and flowfields for film-cooling problems with front slot injection. The code is shown to be capable of handling subsonic, supersonic, and hypersonic flow regimes. Predicted surface pressures and heat transfer rates are found to agree well with experimental data. R.R.

A89-42095#

TURBULENCE MEASUREMENTS FOR HEATED GAS SLOT INJECTION IN SUPERSONIC FLOW

C. R. HYDE, B. R. SMITH, J. A. SCHETZ, and D. A. WALKER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 15 p. Research supported by Johns Hopkins University. refs (AIAA PAPER 89-1868)

Detailed profile measurements of the flow created by heated, supersonic, tangential air injection into a supersonic air flow are presented. In comparison with the unheated slot flow, the heated slot flow did not significantly change the location of the merging of the freestream boundary layer with the slot flow. The results

show some increase in absolute turbulence levels in the heated flow, along with shifts in the location of the maximum turbulence. Shock interaction with the shear layer was found to generally result in elevated turbulence. R.R.

A89-42099#

AN ANALYTICAL APPROACH TO THE PREDICTION OF SHOCK PATTERNS IN BOUNDED HIGH-SPEED FLOWS

C. S. LIU (New York, State University, Amherst) and D. J. AZEVEDO AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 13 p. refs (AIAA PAPER 89-1874)

A control-volume analysis of a two-dimensional symmetric wedge configuration representative of a simple high-speed intake in steady flow is presented. Special attention is given to the complex reflection patterns that develop when the leading-edge shocks intersect at angles above a certain critical value that is less than the wedge attachment angle. It is found that the predicted stem heights are consistently lower than the mean experimental values, and that the viscosity-related phenomena have only a minor influence on stem height for the freestream Mach number range considered. R.R.

A89-42100*# California Univ., Davis.

CONVERGENCE ACCELERATION OF VISCOUS AND INVISCID HYPERSONIC FLOW CALCULATIONS

A. CHEER, M. HAFEZ (California, University, Davis), S. CHEUNG, and J. FLORES (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 11 p. refs (AIAA PAPER 89-1875)

The convergence of inviscid and viscous hypersonic flow calculations using a two-dimensional flux-splitting code is accelerated by applying a Richardson-type overrelaxation method. Successful results are presented for various cases; and a 50 percent savings in computer time is usually achieved. An analytical formula for the overrelaxation factor is derived, and the performance of this scheme is confirmed numerically. Moreover, application of this overrelaxation scheme produces a favorable preconditioning for Wynn's epsilon-algorithm. Both techniques have been extended to viscous three-dimensional flows and applied to accelerate the convergence of the compressible Navier-Stokes code. A savings of 40 percent in computer time is achieved in this case. Author

A89-42101#

HYPERSONIC FLOW IN A COMPRESSION CORNER IN 2D AND 3D CONFIGURATIONS

AMER CHPOUN AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 10 p. refs (AIAA PAPER 89-1876)

This paper presents results relative to wall pressure and heat transfer distributions in high Reynolds number ramp flows with emphasis on transitional interaction. A fine Reynolds number variation shows clearly the modification of wall pressure distribution according to the location of transition in the separation region. Three dimensional effects on wall pressure and heat flux distributions are also investigated by means of sweep angle variation. In addition, a previously validated 2D laminar numerical code, based on Mac Cormack's two step scheme for solving full Navier-Stokes equations is used to check the quality of experimental procedure. Author

A89-42103*# Oklahoma Univ., Norman.

PERFORMANCE OF AN AERO-SPACE PLANE PROPULSION NOZZLE

GEORGE EMANUEL (Oklahoma, University, Norman) and YOON-YEONG BAE AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 19 p. refs

(Contract NAG1-886)

(AIAA PAPER 89-1878)

An inviscid and viscous analysis is provided for an exposed

half nozzle that is used with a scramjet for thrust generation. The analysis is based on the inviscid theory of a two-dimensional, minimum length nozzle with a curved inlet surface, where the flow may be sonic or supersonic. Inlet conditions are prescribed and the gas is assumed to be perfect. Viscous, and when appropriate inviscid, nondimensional parametric results are provided for the thrust, lift, heat transfer, pitching moment, and a variety of boundary-layer thicknesses. In addition to global results, wall distributions of pressure, heat transfer, etc., are provided. The analysis demonstrates that the nozzle produces a considerable lift force whose magnitude may exceed the thrust and a significant pitching moment. The thrust is quite sensitive to the inlet Mach number; it rapidly decreases as the inlet Mach number increases. There is little loss in the thrust as the nozzle's downstream wall is truncated. The corresponding decrease in lift and the pitching moment is moderate. Author

A89-42114* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CROSSFLOW-VORTEX INSTABILITY AND TRANSITION ON A 45 DEG SWEEP WING

J. RAY DAGENHART, J. PETER STACK (NASA, Langley Research Center, Hampton, VA), WILLIAM S. SARIC, and MARC C. MOUSSEUX (Arizona State University, Tempe) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 16 p. refs (Contract NAG1-805; NAG1-937) (AIAA PAPER 89-1892)

A crossflow vortex experiment on a 45 deg swept wing is currently being conducted in the Arizona State University Unsteady Wind Tunnel. The experimental apparatus is designed to produce crossflow-dominated transition by simulating infinite swept wing flow using contoured end liners in a closed throat wind tunnel. Stationary fixed-wavelength crossflow vortices are observed at several chord Reynolds numbers. The vortex wavelength which is fixed for a given Reynolds number varies with Reynolds number approximately as predicted by linear stability theory, but with the predicted wavelengths about 30 percent larger than the observed wavelengths. Travelling waves are observed both in the frequency range predicted by linear stability theory and at higher frequencies. These higher frequency waves may be harmonics of the primary crossflow waves generated by a nonlinear parametric resonance phenomena. Author

A89-42115* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

TRANSITION FLIGHT EXPERIMENTS ON A SWEEP WING WITH SUCTION

D. V. MADDALON, C. K. LAND (NASA, Langley Research Center, Hampton, VA), F. S. COLLIER (High Technology Corp., Hampton, VA), and L. C. MONTROYA (NASA, Flight Research Center, Edwards, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 25 p. refs (AIAA PAPER 89-1893)

Flight experiments were conducted on a 30 degree swept wing with a perforated leading edge by systematically varying the location and amount of suction over a range of Mach number and Reynolds number. Suction was varied chordwise ahead of the front spar from either the front or rear direction by sealing spanwise perforated strips. Transition from laminar to turbulent flow was due to leading edge turbulence contamination or crossflow disturbance growth and/or Tollmien-Schlichting disturbance growth, depending on the test configuration, flight condition, and suction location. A state-of-the-art linear stability theory which accounts for body and streamline curvature and compressibility was used to study the boundary layer stability as suction location and magnitude varied. N-factor correlations with transition location were made for various suction configurations. Author

A89-42116*

EFFECT OF WALL TEMPERATURE DISTRIBUTION ON THE STABILITY OF THE COMPRESSIBLE BOUNDARY LAYER

G. GASPERAS (Calspan Corp., Arnold AFB, TN) AIAA, Fluid

Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 9 p. refs (AIAA PAPER 89-1894)

The response of a hypersonic boundary layer to various wall temperature distributions is studied. The stability of the Mach 6.84 flat plate boundary layer over an adiabatic wall, a constant temperature cooled wall, and a wall which experiences a steep linear temperature decrease is evaluated by the use of spatial viscous compressible linear stability theory and the $\epsilon(N)$ method. The stability of a sharp cone boundary layer in a Mach 8.00 free stream is obtained from the flat plate results by a transformation. It is found that the constant temperature cooled wall shows the largest amplification rates, as well as the largest N-factors. In the vicinity of the linear surface temperature decrease, the amplification rates and N-factors are less than those for the adiabatic wall. Farther downstream, however, amplification rates and N-factors approach those found for the constant temperature cooled wall. Author

A89-42117*

LAMINAR BOUNDARY LAYER STABILITY EXPERIMENTS ON A CONE AT MACH 8. V - TESTS WITH A COOLED MODEL

KENNETH F. STETSON (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH), ELTON R. THOMPSON, JOSEPH C. DONALDSON, and LEO G. SILER (Calspan Corp., Arnold Engineering Development Center, Arnold AFB, TN) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 31 p. refs (AIAA PAPER 89-1895)

Hot-wire anemometry techniques were used to study the stability of the laminar boundary layer on a water-cooled, sharp, 7-deg half-angle cone at a Mach number of 8. Cooling the surface was found to stabilize the first mode disturbances (Tollmien-Schlichting or vorticity disturbances) and to destabilize the second mode disturbances (the high frequency acoustic disturbances that are unique to high Mach number boundary layers). The corresponding transition Reynolds numbers were shown to change from about 4.8×10 to the 6th (uncooled) to 3.2×10 to the 6th (cooled). R.R.

A89-42139*

PERIODIC VORTEX SHEDDING OVER DELTA WINGS

D. P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg), H. STAPOUNTZIS (Salonika, University, Greece), and O. K. REDINIOTIS AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 9 p. refs (Contract AF-AFOSR-89-0283; NATO-0441/87)

(AIAA PAPER 89-1923)

Experiments with delta wings at high angles of attack are carried out. It is found that periodic vortices are shed for angles of attack larger than 35 deg. At or below this angle, the two leading edge vortices remain attached on the wing all the way from the apex to the trailing edge. An alternate and simultaneous shedding mode are discovered. K.K.

A89-42460

SUPERSONIC FLOW STAGNATION IN A DUCT DURING COMBUSTION [O TORMOZHENII SVERKHZVUKOVOGO POTOKA V KANALE PRI GORENII]

S. I. ROZHITSKII and V. N. STROKIN IN: *Pioneers of space and the present age*. Moscow, Izdatel'stvo Nauka, 1988, p. 57-61. In Russian. refs

During combustion in supersonic air flow in a duct, the separation of the boundary layer at the walls may lead to the formation of an extended stagnation zone propagating from the heat release region in the direction opposite to that of the flow. The objective of the experimental study reported here, in which various amounts of a gaseous fuel (hydrogen) were burned in supersonic air flow (M 2.6) in a water-cooled duct simulating a simple combustion chamber, was to investigate the relationship between the dimensions of the stagnation zone and heat release

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within the duct. The possibility of calculating the maximum possible heat removal based on the the duct length is demonstrated.

V.L.

A89-42464

THREE-DIMENSIONAL EFFECTS IN HIGH-INTENSITY VORTICES [TREKHMERNYE EFEKTY V INTENSIVNYKH VIKHRIAKH]

G. F. GLOTOV IN: Pioneers of space and the present age. Moscow, Izdatel'stvo Nauka, 1988, p. 77-90. In Russian. refs

The paper reports the results of an experimental study of flow parameters on the wall under an air intake (M_{tau} less than 1) and under a vortex on the leeside of a delta wing (free-stream M 0.1-1.0, angle of attack 15 deg). Flow in the wall layer of both vortices is three-dimensional and characterized by the formation of a stationary vortex sheet with pairs of longitudinal counterrotating vortices due to stability loss at concave flow lines. The presence of these vortices in the wall layer leads to a nonuniform flow parameter distribution on the wall.

V.L.

A89-42465

STABILITY OF COMPRESSION SHOCKS IN DUCTS IN THE PRESENCE OF EXTERNAL EFFECTS [USTOICHIVOST' SKACHKOV UPLOTNENIYA V KANALAKH PRI NALICHII VNESHNIKH VOZDEISTVII]

F. A. SLOBODKINA IN: Pioneers of space and the present age. Moscow, Izdatel'stvo Nauka, 1988, p. 90-97. In Russian. refs

The stability of transonic quasi-one-dimensional flows of an ideal inviscid gas in ducts in the presence of external effects, such as mass, momentum, and energy transfer, is investigated analytically. Supersonic flow is assumed at the duct inlet and subsonic flow at the exit, with the supersonic transition occurring in the compression shock. It is demonstrated that the stability of flow with a compression shock is largely determined by the duct shape at the site of the shock in stationary flow, on the nature of external effects, gas properties, and the type of boundary conditions at the duct exit.

V.L.

A89-42496

THE SHAPE OF THIN BODIES WITH MINIMAL DRAG [PRO FORMU TONKIKH TIL MINIMAL'NOGO OPORU]

I. G. NESTERUK (Chernivets'kii Derzhavnii Universitet, Chernovtsy, Ukrainian SSR) Akademiia Nauk Ukrain's'koi RSR, Dopovidy, Seriya A - Fiziko-Matematichni ta Tekhnichni Nauki (ISSN 0002-3531), April 1989, p. 56-58. In Ukrainian. refs

A necessary condition for the minimum of the total resistance of a thin body moving with a constant velocity in a liquid or gas at large Reynolds numbers is presented. The condition is the ensurance of a negative value for the value of the pressure gradient on the suppressing part of the surface. Examples of planar and axisymmetric optimal shapes are presented.

K.K.

A89-42519

CALCULATION OF STATIONARY SUBSONIC AND TRANSONIC NONPOTENTIAL FLOWS OF AN IDEAL GAS IN AXISYMMETRIC CHANNELS [RASCHET STATSIONARNYKH DO- I TRANZVUKOVYKH NEPOTENTIAL'NYKH TECHENII IDEAL'NOGO GAZA V OSESIMMETRICHNYKH KANALAKH]

IU. S. KOSOLAPOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, May 1989, p. 765-774. In Russian. refs

A generalization of a method for calculating stationary subsonic and transonic nonpotential flows of an ideal gas is proposed. The method is based on the numerical solution of a current function equation written in arbitrary coordinates. To determine density in transonic flow calculations, a marching procedure is proposed for solving one of the Euler equation projections. Results of calculations are presented.

V.L.

A89-42521

SUPERSONIC FLOW PAST A SPHERE IN A GAS WITH A PERIODIC DENSITY FIELD STRUCTURE [SVERKHZVUKOVOE OBTEKANIE SFERY V GAZE S PERIODICHESKOI STRUKTUROI POLIA PLOTNOSTI]

IU. P. GOLOVACHEV and N. V. LEONT'EVA Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, May 1989, p. 791-793. In Russian. refs

Axisymmetric supersonic flow past the front surface of a sphere moving in a gas with a constant-pressure and a periodically varying density is investigated numerically. The problem is solved in the context of a viscous shock layer model. Results of the calculations demonstrate the significant role of nonstationary effects.

V.L.

A89-42567

EFFECT OF THE ADIABATIC EXPONENT ON THE STABILITY AND TURBULENT TRANSITION OF A SUPERSONIC LAMINAR BOUNDARY LAYER [VLIANIE POKAZATELIA ADIABATY NA USTOICHIVOST' I PEREKHOD SVERKHZVUKOVOGO LAMINARNOGO POGRANICHNOGO SLOIA V TURBULENTNYI]

V. I. LYSENKO Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Mar.-Apr. 1989, p. 179-183. In Russian. refs

The effect of the adiabatic exponent on the laminar-turbulent transition of a boundary layer is investigated analytically and experimentally for a supersonic flow of a compressible heat-conducting gas in a two-dimensional boundary layer. It is shown that a decrease in the adiabatic exponent leads to a substantial decrease in the Reynolds number of the laminar-turbulent transition.

V.L.

A89-42569

NONSTATIONARY SUPERSONIC FLOW PAST A SPHERE MOVING THROUGH A THERMAL INHOMOGENEITY [NESTATSIONARNOE SVERKHZVUKOVOE OBTEKANIE SFERY PRI DVIZHENII CHEREZ TEPLOVIU NEODNORODNOST']

IU. P. GOLOVACHEV and N. V. LEONT'EVA Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Mar.-Apr. 1989, p. 186-189. In Russian. refs

Supersonic flow past a sphere moving in a layer of a variable-temperature gas is analyzed in the context of a viscous shock layer model. The sphere velocity is assumed to be constant and the gas velocity sufficient for the formation of a head shock wave. The flow between the head shock and the sphere surface is described by simplified Navier-Stokes equations. The problem is solved using a two-layer implicit finite difference scheme. Calculations are carried out for flow of a diatomic gas past a sphere with an adiabatic exponent of 1.4, and the results are compared with experimental data.

V.L.

A89-42572

EFFECT OF GAS DISSOCIATION AND IONIZATION ON THE TRANSITION OF A SUPERSONIC BOUNDARY LAYER [VLIANIE DISSOTSIIATSII I IONIZATSII GAZOV NA PEREKHOD SVERKHZVUKOVOGO POGRANICHNOGO SLOIA]

V. I. LYSENKO (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskie Nauki (ISSN 0002-3434), April 1989, p. 45-49. In Russian. refs

The effect of gas dissociation and ionization on the laminar-turbulent transition of the boundary layer was investigated experimentally in an impulse wind tunnel and a shock tube using air and nitrogen as the working gases. The free-stream Mach number varied from 5 to 7; the flow stagnation temperature ranged from 1100 to 3600 K. It is found that, at moderate Mach numbers (about M 5), external flow dissociation lowers the Reynolds number of the turbulent transition. External flow ionization at Mach numbers equal to or greater than 8 does not reduce the Reynolds number of the boundary layer transition.

V.L.

A89-42837

NUMERICAL SOLUTION OF TRANSONIC POTENTIAL FLOW IN 2D COMPRESSOR CASCADES USING MULTI-GRID TECHNIQUES

M. HUNEK, K. KOZEL, and M. VAVRINCOVA (Ceskomoravska Kolben Danek; Ceske Vysoke Ucení Technické, Prague, Czechoslovakia) IN: Robust multi-grid methods; Proceedings of the Fourth GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 22-24, 1988. Wiesbaden, Federal Republic of Germany, Friedr. Vieweg & Sohn, 1989, p. 145-154. refs

A multigrid method is presented to numerically solve transonic potential flow in two-dimensional compressor cascades using the full potential equation in nonconservative form. A modified Jameson (1976) rotated difference scheme is used for the solution. The periodical conditions are simplified with the local disturbance form of the governing equation. The resulting algebraic system is solved using the SLOR method, line relaxation in three grid levels, and the full approximation scheme and correction scheme algorithm. The methods are applied to transonic cascade flows and the results are compared to experimental data. R.B.

A89-42931

APPLICATION OF HISSS PANEL CODE TO A FIGHTER-TYPE AIRCRAFT CONFIGURATION AT SUBSONIC AND SUPERSONIC SPEEDS

LUCIANO FORNASIER and STEFAN HEISS (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) IN: Research and development: Technical and scientific publications 1988 (A89-42926 18-99). Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, p. 81-94. refs

(AIAA PAPER 87-2619; MBB-FE-122/S/PUB/304)

The paper reports the application of a higher-order panel code, HISSS, to an advanced fighter-type airplane configuration. The goals of the study were manifold. The range of problems for which the code yields adequate solution has been investigated by comparing lift and pitching moment predictions with experimental data. At the same time, the method has been faced up with a realistic benchmark, giving the opportunity to exercise and check out a large variety of modeling options. Finally, interface procedures for interactive preprocessing of the geometrical data and graphic postprocessing of the results have been set up and tested. An account of the most significant outcomes of the investigation together with a description of the numerical procedures are the subject of the paper. Author

A89-42950#

FLOW VISUALIZATION STUDIES OF THE TIP VORTEX SYSTEM OF A SEMI-INFINITE WING

ALLEN E. WINKELMANN (Maryland, University, College Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 23 p. refs (AIAA PAPER 89-1807)

Results are presented on flow visualization studies of the vortex system development on the tip of a semiinfinite square wing, which was tested in the Glenn L. Martin Wind Tunnel. The model employed in these studies had a removable tip section, making it possible to test various tip shapes. TiCl₄-smoke was used to visualize the flow. I.S.

A89-43094

AERODYNAMIC DESIGN VIA CONTROL THEORY

ANTONY JAMESON (Princeton University, NJ) Journal of Scientific Computing (ISSN 0885-7474), vol. 3, Sept. 1988, p. 233-260. refs

The application of control theory to design problems is addressed. The design of two-dimensional profiles for compressible potential flow when the profile is generated by conformal mapping is discussed. The same problem when the flow is governed by the inviscid Euler equations is examined. Finally, the three-dimensional design problem for a wing is considered, assuming the flow to be governed by the inviscid Euler equations. C.D.

A89-43108

COMPUTATION OF FLOW AND LOSSES IN TRANSONIC TURBINE CASCADES

W. RODI and K. SRINIVAS (Karlsruhe, Universitaet, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 13, Mar.-Apr. 1989, p. 101-119. Research sponsored by the Bundesministerium fuer Wirtschaft. refs

A computer code for calculating both inviscid and viscous flow in transonic turbomachinery cascades is described. The calculation procedure is basically two-dimensional but can take account of three-dimensional effects due to a variation of the stream-tube height. Viscous flow can be calculated for either fully laminar or partly turbulent conditions, in which case a modified version of the Baldwin-Lomax turbulence model is selected when the boundary layer separates and in the wake. Results of the application of the computer program to four typical transonic cascades are presented for a wide Mach-number range. There is generally good agreement with pressure distribution measurements along the blade surfaces and between calculated and observed shock patterns. The pressure distribution deviates significantly from experiment only in cases with fairly large separation regions. Author

A89-43113#

SIMULATION OF THE FLOW AROUND A COUNTERROTATING SHROUDED PROPFAN [STROEMUNGSSIMULATION UM EINEN GEGENLAEUFIG ROTIERENDEN UMMANTELTEN PROPFAN]

PAUL LUECKING, PETRA WEHLITZ (MTU Motoren- und Turbinen-Union, Muenchen, GmbH, Munich, Federal Republic of Germany), and STEFAN LEICHER Dornier Post (ISSN 0012-5563), no. 3, 1988, p. 21-23. In German.

Three-dimensional numerical simulations of the flow around counterrotating integrated shrouded propfan (CRISP) configurations are described. The CRISP studies are being undertaken as part of a development program for future civilian transport aircraft to operate at speeds up to about Mach 0.8; primary design goals are reduced cruising drag and the elimination of separation in critical flight regimes. In the simulations, a Runge-Kutta solution scheme is applied to finite-volume formulations of the Euler or Navier-Stokes equations. The principles and implementation of the computations are discussed, and typical results are presented graphically. It is shown that the nose profile of the proposed shroud design can induce separation in the extreme case of takeoff with full thrust and strong rotation. T.K.

A89-43114#

NUMERICAL SIMULATION AND EXPERIMENTS ON LEADING-EDGE VORTICES ON MODERN WINGS, WITH EUROPEAN COOPERATION [NUMERISCHE SIMULATION UND EXPERIMENTE FUER VORDERKANTENWIRBEL AN MODERNEN FLUEGELN IN EUROPAEISCHER ZUSAMMENARBEIT]

STEPHAN M. HITZEL Dornier Post (ISSN 0012-5563), no. 3, 1988, p. 24-27. In German.

The aerodynamic design of advanced fighter-aircraft wings is discussed, with a focus on leading-edge vortices (LEVs). The basic physical principles involved in the formation and evolution of LEVs are reviewed and illustrated with diagrams; the important role of numerical simulations as a complement to wind-tunnel testing is explained; and particular attention is given to a joint research effort being undertaken in the FRG, the Netherlands, the UK, and Italy under the control of the Independent European Programme Group. These studies involve both the generation of detailed experimental flowfield data and simulations of the effects of LEV breakup and LEV interference in complex wing, wing-fuselage, and wing-fuselage-canard configurations. T.K.

A89-43147

REAL-TIME SOLUTION OF THE AIRFLOW CONTINUITY EQUATIONS FOR A HOVERCRAFT SIMULATION

LAWRENCE A. KAHN and JOSEPH E. WHALEN (ORI, Inc.,

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Rockville, MD) IN: 1988 Annual Summer Computer Simulation Conference, 20th, Seattle, WA, July 25-28, 1988, Proceedings. San Diego, CA, Society for Computer Simulation International, 1988, p. 786-791. refs

The development of a real-time computer program that simulates the motions of a hovercraft during overland operations is discussed. Particular attention is given to algorithms for predicting the pressures in the cushion chambers supporting the craft. The present method uses several approximation algorithms that significantly improve run times, yet guarantee a sufficiently accurate solution of the various chamber pressures to correctly model the craft motions over a wide range of operating scenarios. K.K.

A89-43178# ADAPTIVE GRID EMBEDDING IN NONEQUILIBRIUM HYPERSONIC FLOW

MICHAEL J. AFTOSMIS and JUDSON R. BARON (MIT, Cambridge, MA) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 18 p. refs
(Contract F33615-87-C-3004)
(AIAA PAPER 89-1652)

An adaptive grid algorithm using local grid embedding was applied to two dimensional and axisymmetric blunt bodies subject to real gas conditions in hypersonic flow. The modeling considers inviscid and viscous air mixtures with up to five species undergoing uncoupled and coupled nonequilibrium chemical reactions. Attention was given to the influence of numerical smoothing terms on the stagnation region and to applying unstructured mesh adaptation in a moving (adjusting) domain. Perfect gas, dissociating gas and multiple reaction comparisons demonstrated good agreement with both experiment and computation. The adaptive technique provided considerable savings in computation time relative to solutions on globally refined grids. Author

A89-43187*# University of Southern California, Los Angeles.
**'HYPERSONIC SLIP FLOWS' AND ISSUES ON EXTENDING
CONTINUUM MODEL BEYOND THE NAVIER-STOKES LEVEL**
H. K. CHENG, C. J. LEE, E. WONG, and H. T. YANG (Southern California, University, Los Angeles, CA) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 18 p. refs
(Contract AF-AFOSR-88-0146; NAGW-1061)
(AIAA PAPER 89-1663)

Results of a direct simulation Monte Carlo method for a hypersonic flow about a flat plate at a 40 deg angle of attack have been compared with corresponding results from a theory for fully viscous shock layers (FVSLs). Using the 13-moment equations for a Maxwell gas, it is demonstrated that nonequilibrium and equilibrium FVSL flows can be correlated. With the exception of the pressure density, most of the flow properties along a streamline (including heat flux and shear and normal stresses) are correctly predicted to leading order by the Navier-Stokes model. R.R.

A89-43188*# Stanford Univ., CA.
**APPLICATION OF A VECTORIZED PARTICLE SIMULATION IN
HIGH-SPEED NEAR-CONTINUUM FLOW**
MICHAEL S. WORONOWICZ and JEFFREY D. MCDONALD (Stanford University, CA) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 12 p. refs
(Contract AF-AFOSR-88-0139; NCA2-313; NAGW-965)
(AIAA PAPER 89-1665)

An efficient particle simulation technique, developed for use on vector architecture based supercomputers for studying hypersonic rarefied gas flows is employed to simulate the complex wake generated by Mach six flow over a 10 deg half-angle wedge for freestream Reynolds numbers of 1780 and 3560. Data obtained are compared against higher Reynolds number experimental results. Simulations utilized as many as 10 to the 5th computational cells and 10 to the 7th simulated particles having power-law interaction potentials. A code performance of 1.8-2.4 microsec of Cray-2 CPU time to process a single particle per timestep is achieved. Diffuse adiabatic and isothermal wedge surface models are used in this investigation. Although the wedge geometry is

two-dimensional, the simulation incorporates a width-wise direction, resulting in a three-dimensional computation. Author

A89-43194#
**ACCURATE NAVIER-STOKES RESULTS FOR THE
HYPERSONIC FLOW OVER A SPHERICAL NOSETIP**
FREDERICK G. BLOTTNER (Sandia National Laboratories, Albuquerque, NM) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 13 p. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 89-1671)

The unsteady thin-layer Navier-Stokes equations for a perfect gas are solved with a linearized block Alternating Direction Implicit finite-difference solution procedure. Solution errors due to numerical dissipation added to the governing equations are evaluated. Errors in the numerical predictions on three different grids are determined where Richardson extrapolation is used to estimate the exact solution. Accurate computational results are tabulated for the hypersonic laminar flow over a spherical body which can be used as a benchmark test case. Predictions obtained from the code are in good agreement with inviscid numerical results and experimental data. Author

A89-43195*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
**TOWARD A CFD NOSE-TO-TAIL CAPABILITY - HYPERSONIC
UNSTEADY NAVIER-STOKES CODE VALIDATION**
THOMAS A. EDWARDS and JOLEN FLORES (NASA, Ames Research Center, Moffett Field, CA) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 16 p. refs
(AIAA PAPER 89-1672)

Computational fluid dynamics (CFD) research for hypersonic flows presents new problems in code validation because of the added complexity of the physical models. This paper surveys code validation procedures applicable to hypersonic flow models that include real gas effects. The current status of hypersonic CFD flow analysis is assessed with the Compressible Navier-Stokes (CNS) code as a case study. The methods of code validation discussed to beyond comparison with experimental data to include comparisons with other codes and formulations, component analyses, and estimation of numerical errors. Current results indicate that predicting hypersonic flows of perfect gases and equilibrium air are well in hand. Pressure, shock location, and integrated quantities are relatively easy to predict accurately, while surface quantities such as heat transfer are more sensitive to the solution procedure. Modeling transition to turbulence needs refinement, though preliminary results are promising. Author

A89-43212*# North Carolina State Univ., Raleigh.
**AN APPROXIMATE VISCOUS SHOCK LAYER METHOD FOR
CALCULATING THE HYPERSONIC FLOW OVER
BLUNT-NOSED BODIES**
A. C. GRANTZ, F. R. DEJARNETTE (North Carolina State University, Raleigh), and R. A. THOMPSON (NASA, Langley Research Center, Hampton, VA) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 17 p. refs
(Contract NCC1-100)
(AIAA PAPER 89-1695)

The approximate axisymmetric method presented for accurately calculating the surface and flowfield properties of fully viscous hypersonic flow over blunt-nosed bodies incorporates the turbulence model of Cebeci-Smith (1970) and the equilibrium air tables of Hansen (1959). The method is faster than the parabolized Navier-Stokes or viscous shock layer solvers that it could replace for preliminary design determinations. Surface heat transfer and pressure predictions for the present method are comparable with the more accurate viscous shock layer method as well as flight test and wind tunnel data. A starting solution is not required. O.C.

A89-43215#

NUMERICAL SIMULATION OF HYPERSONIC VISCOUS PERFECT GAS FLOW FOR THE AEROTHERMODYNAMIC DESIGN OF SPACE PLANES AT LOW ANGLES OF ATTACK

YUKIMITSU YAMAMOTO (National Aerospace Laboratory, Chofu, Japan), HARUHIKO ARAKAWA, and RYUJI YOSHIDA (Mitsubishi Heavy Industry Corp., Nagoya, Japan) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 22 p. refs (AIAA PAPER 89-1699)

In the present numerical simulation of hypersonic aerothermodynamic heating along the wing leading edge of a reentry-glide spacecraft, with a view to preliminary aerothermal structural design that must be conditioned by localized heating due to recompression or shock impingement at low angles-of-attack, attention is given to this phenomenon in three different vehicle configurations proposed by Japan's NAL. These three designs differ with respect to wing leading-edge sweep angles. The numerical computations were conducted at Mach 7 and Reynolds number of 4.4 million, at zero, 10, and 20 deg angles-of-attack; the results obtained are compared with experimental heat-transfer measurements. O.C.

A89-43228*# North Carolina State Univ., Raleigh.

STUDY OF HYPERSONIC FLOW PAST SHARP CONES

JEFF C. TAYLOR, H. A. HASSAN (North Carolina State University, Raleigh), and JAMES N. MOSS (NASA, Langley Research Center, Hampton, VA) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 10 p. Research supported by USAF and U.S. Navy. refs

(Contract NCC1-112; NAGW-1022; NAGW-1331)

(AIAA PAPER 89-1713)

Calculations using the direct simulation Monte Carlo (DSMC) method of Bird for flow past sharp cones in the near continuum to free molecule flow regime are presented and compared with experiment. It is found that results are sensitive to the grid and the interaction potential. Moreover, the time counter method was found to be as accurate as other methods when the solution is grid independent. Finally, the results show that the effects of the wake on the forebody surface properties are minimal. Author

A89-43230#

NUMERICAL SIMULATION OF 3D RAREFIED HYPERSONIC FLOWS

T. C. LIN, R. D. MCGREGOR, J. L. WONG, and W. R. GRABOWSKY (TRW, Inc., Ballistic Missiles Div., San Bernardino, CA) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 12 p. refs

(Contract F04704-88-C-0017)

(AIAA PAPER 89-1715)

Rigorous models are formulated to estimate the flow properties around hypersonic vehicles. The flow conditions range from the continuum to free molecule flow. The Navier-Stokes/Merged Layer Equation/Parabolized Navier-Stokes (NS/ML/PNS) codes are used to predict flowfields in the continuum regime while the free molecule models are employed in the rarefied flow limit. In the transitional flow regime, TRW's Direct Simulation Monte Carlo (DSMC) code is applied. This paper is intended to illustrate the validity of various state-of-the-art codes as they are used in the various flow domains. The effects of angle-of-attack and flow rarefaction on the aerodynamic coefficient and heat transfer rate are demonstrated through comparison with ground test measurements. Engineering methods deduced from DSMC/NS/ML/PNS models are developed to estimate the flow properties in the transitional flow regime. Author

A89-43537

THE UNSTEADY FLOW IN THE FAR FIELD OF AN ISOLATED BLADE ROW

J. M. VERDON (United Technologies Research Center, East Hartford, CT) Journal of Fluids and Structures (ISSN 0889-9746), vol. 3, March 1989, p. 123-149. refs

(Contract N00014-85-C-0702)

Analytic solutions are derived to represent the unsteady flow

in the far field of an isolated two-dimensional cascade operating at subsonic, transonic or supersonic inlet and exit Mach numbers. These solutions describe the velocity potential and rotational velocity fluctuations associated with irrotational pressure disturbances, rotational velocity disturbances and the vorticity shed from blade trailing edges and convected along blade wakes. They thus provide the inlet and exit information needed for a proper understanding and numerical resolution of the unsteady flow through a blade row. As part of this investigation a method for classifying unsteady excitations, based on the acoustic response that they produce in the far field, is developed, and analytical results are presented to illustrate subsonic and supersonic far-field acoustic response behavior. Numerical calculations of unsteady flows through subsonic compressor-type cascades are also carried out to demonstrate the link between unsteady flow behavior in the far-field and the aerodynamic loads acting at a vibrating blade surface. Author

N89-23408# National Aerospace Lab., Tokyo (Japan).

TRANSONIC OPERATIONAL CHARACTERISTICS AND PERFORMANCE

AKIRA KOIKE, KEISUKE ASAI, NOBUYUKI HOSOE, TOSHIO KARASAWA, HISASHI SUENAGA, SUSUMU MITSUBORI, and KOICHI SUZUKI Mar. 1988 33 p In JAPANESE; ENGLISH summary

(NAL-TR-968; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

Two turbine-powered simulators (TPSs) manufactured by Tech Development Inc. (Model 1079A), clad with nacelles of a generic configuration, are subjected to test in the NAL 2 x 2 m Transonic Wind Tunnel up to a Mach number of 0.8 in order to obtain data needed for use of the TPSs in a high-speed wind tunnel test of the NAT STOL research airplane ASKA. The TPSs are placed on top of a strut erected on the balance turn-table of the test-section floor so that the aerodynamic forces acting on the nacelle-strut system can be measured. Operational characteristics are obtained by measuring the TPS fan rotational speed as a function of the turbine-drive air pressure, and by observing the variation of the temperatures at the bearings supporting the TPS rotational part. Acceleration levels due to vibration are also measured. Instrumentation includes the total pressure-and temperature distributions within the fan and turbine nozzle flows to derive the TPS/nacelle performance represented by the fan pressure ratio, the mass flow through the fan and the magnitude of the thrust generated by the TPS/nacelle system. Author

N89-23409# National Aerospace Lab., Tokyo (Japan).

NUMERICAL SIMULATION OF HYPERSONIC FLOW AROUND A SPACE PLANE. 1: BASIC DEVELOPMENT

YUKIMITSU YAMAMOTO and SHIN KUBO May 1988 23 p In JAPANESE; ENGLISH summary

(NAL-TR-976T; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

Thomas and Van Leer's flux-split upwind TVD scheme was applied to the hypersonic flow around a space plane proposed by National Aerospace Laboratory (NAL). Thin-layer Navier-Stokes equations in a finite volume formulation are solved by using an implicit approximately factored ADI algorithm. Numerical computations are performed for a Mach number of 7.0 and Reynolds number of 1.3×10^7 at angles of attack up to 30 degrees. Numerical results are compared with experimental data obtained from the hypersonic wind tunnel tests at NAL. Through these comparisons, it is demonstrated that the present TVD Navier-Stokes code has excellent capabilities for evaluating total aerodynamic performance and investigating severe aerodynamic heating, which are of great significance in the design of a space plane configuration. In the analysis, a modified Yee-Harten's TVD scheme is also developed and applied. Numerical calculations were carried out by using two schemes for free stream $\alpha = 10.0$ at $\alpha = 0$ deg and almost the same pressure contours were obtained. Author

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N89-23410*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPUTING INDUCED VELOCITY PERTURBATIONS DUE TO A HELICOPTER FUSELAGE IN A FREE STREAM

JOHN D. BERRY and SUSAN L. ALTHOFF Jun. 1989 65 p
(Contract DA PROJ. 1L1-62211-A-47-A)
(NASA-TM-41113; L-16533; NAS 1.15:4113;
AVSCOM-TR-89-B-001) Avail: NTIS HC A04/MF A01 CSCL 01/1

The velocity field of a representative helicopter fuselage in a free stream is computed. Perturbation velocities due to the fuselage are computed in a plan above the location of the helicopter rotor (rotor removed). The velocity perturbations computed by a source-panel model of the fuselage are compared with experimental measurements taken with a laser velocimeter. Three paneled fuselage models are studied: fuselage shape, fuselage shape with hub shape, and a body of revolution. The velocity perturbations computed for both fuselage shape models agree well with the measured velocity field except in the close vicinity of the rotor hub. In the hub region, without knowing the extent of separation, modeling of the effective source shape is difficult. The effects of the fuselage perturbations are not well-predicted with a simplified ellipsoid fuselage. The velocity perturbations due to the fuselage at the plane of the measurements have magnitudes of less than 8 percent of free-stream velocity. The velocity perturbations computed by the panel method are tabulated for the same locations at which previously reported rotor-inflow velocity measurements were made. Author

N89-23411*# Old Dominion Univ., Norfolk, VA.

EXPERIMENTAL STUDY OF PRESSURE AND HEATING RATE ON A SWEEP CYLINDRICAL LEADING EDGE RESULTING FROM SWEEP SHOCK WAVE INTERFERENCE M.S. Thesis

CHRISTOPHER E. GLASS Apr. 1989 164 p Sponsored by NASA
(NASA-CR-185326; NAS 1.26:185326) Avail: NTIS HC A08/MF A01 CSCL 01/1

The effects of cylindrical leading edge sweep on surface pressure and heat transfer rate for swept shock wave interference were investigated. Experimental tests were conducted in the Calspan 48-inch Hypersonic Shock Tunnel at a nominal Mach number of 8, nominal unit Reynolds number of 1.5×10 to the 6th power per foot, leading edge and incident shock generator sweep angles of 0, 15, and 30 deg, and incident shock generator angle-of-attack fixed at 12.5 deg. Detailed surface pressure and heat transfer rate on the cylindrical leading edge of a swept shock wave interference model were measured at the region of the maximum surface pressure and heat transfer rate. Results show that pressure and heat transfer rate on the cylindrical leading edge of the shock wave interference model were reduced as the sweep was increased over the range of tested parameters. Peak surface pressure and heat transfer rate on the cylinder were about 10 and 30 times the undisturbed flow stagnation point value, respectively, for the 0 deg sweep test. A comparison of the 15 and 30 deg swept results with the 0 deg swept results showed that peak pressure was reduced about 13 percent and 44 percent, respectively, and peak heat transfer rate was reduced about 7 percent and 27 percent, respectively. Author

N89-23413*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NUMERICAL SOLUTION OF PERIODIC VORTICAL FLOWS ABOUT A THIN AIRFOIL

JAMES R. SCOTT and HAFIZ M. ATASSI (Notre Dame Univ., IN.) 1989 12 p Presented at the 24th Thermophysics Conference, Buffalo, NY, 12-14 Jun. 1989; sponsored by the AIAA
(NASA-TM-101998; E-4703; NAS 1.15:101998) Avail: NTIS HC A03/MF A01 CSCL 01/1

A numerical method is developed for computing periodic, three-dimensional, vortical flows around isolated airfoils. The unsteady velocity is split into a vortical component which is a known function of the upstream flow conditions and the Lagrangian coordinates of the mean flow, and an irrotational field whose

potential satisfies a nonconstant-coefficient, inhomogeneous, convective wave equation. Solutions for thin airfoils at zero degrees incidence to the mean flow are presented in this paper. Using an elliptic coordinate transformation, the computational domain is transformed into a rectangle. The Sommerfeld radiation condition is applied to the unsteady pressure on the grid line corresponding to the far field boundary. The results are compared with a Possio solver, and it is shown that for maximum accuracy the grid should depend on both the Mach number and reduced frequency. Finally, in order to assess the range of validity of the classical thin airfoil approximation, results for airfoils with zero thickness are compared with results for airfoils with small thickness. Author

N89-23414*# Continuum Dynamics, Inc., Princeton, NJ.

ENHANCEMENTS TO A NEW FREE WAKE HOVER ANALYSIS

TODD R. QUACKENBUSH and DANIEL A. WACHSPRESS Apr. 1989 41 p
(Contract NAS2-12810)
(NASA-CR-177523; NAS 1.26:177523) Avail: NTIS HC A03/MF A01 CSCL 01/1

The results of three distinct efforts whose common goal was to enhance the applicability and utility of the EHPIC (Evaluation of Hover Performance using Influence Coefficients) free wake hover performance prediction program are summarized. The primary task in this three-part effort revolved around the addition of an image wake to the original version of the EHPIC analysis to permit exploration of the effect of ground proximity on rotor performance. Representative calculations were carried out to test the adequacy of the current ground effect model and the comparisons obtained with existing full-scale helicopter performance data was encouraging. The second task undertaken involved exploiting a capability that has been latent in the influence coefficient solution method since the original work on this topic. The modified EHPIC code can now undertake wake stability analyses for converged solutions using an existing eigensystem analysis package. Sample calculations are shown that illustrate some of the many possible applications of this capability. Finally, the EHPIC code was extensively rewritten to take advantage of the vector processing capabilities of CRAY-type supercomputers. Test runs on the NASA CRAY X-MP have shown that the modified version of the EHPIC code runs four to five times faster than the original version designed for serial processing machines. Author

N89-23415*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STATUS OF SONIC BOOM METHODOLOGY AND UNDERSTANDING

CHRISTINE M. DARDEN, CLEMANS A. POWELL, WALLACE D. HAYES, ALBERT R. GEORGE, and ALLAN D. PIERCE (Pennsylvania State Univ., University Park.) Washington Jun. 1989 32 p Presented at the Sonic Boom Workshop, Hampton, VA, Jan. 1988
(NASA-CP-3027; L-16567; NAS 1.55:3027) Avail: NTIS HC A03/MF A01 CSCL 01/1

In January 1988, approximately 60 representatives of industry, academia, government, and the military gathered at NASA-Langley for a 2 day workshop on the state-of-the-art of sonic boom physics, methodology, and understanding. The purpose of the workshop was to assess the sonic boom area, to determine areas where additional sonic boom research is needed, and to establish some strategies and priorities in this sonic boom research. Attendees included many internationally recognized sonic boom experts who had been very active in the Supersonic Transport (SST) and Supersonic Cruise Aircraft Research Programs of the 60's and 70's. Summaries of the assessed state-of-the-art and the research needs in theory, minimization, atmospheric effects during propagation, and human response are given. Author

N89-23417*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THE LOW FREQUENCY OSCILLATION IN THE FLOW OVER A NACA0012 AIRFOIL WITH AN ICED LEADING EDGE

K. B. M. Q. ZAMAN and M. G. POTAPCZUK 1989 16 p

Presented at the Conference on Low Reynolds Number Aerodynamics, Notre Dame, IN, 5-7 Jun. 1989; sponsored by Notre Dame Univ.

(NASA-TM-102018; E-4727; NAS 1.15:102018) Avail: NTIS HC A03/MF A01 CSCL 01/1

The unusually low frequency oscillation in the wake of an airfoil is explored experimentally as well as computationally for a NACA0012 airfoil with a glaze ice accretion at the leading edge. Experimentally, flow oscillations were observed at low frequencies that correspond to a Strouhal number of about 0.02. This occurred in the angle of attack range of 8 to 9 deg, near the onset of static stall for this airfoil. With a Navier-Stokes computation, limit-cycle oscillations in the flow and in the aerodynamic forces were also observed at low Strouhal numbers. However, the occurrence of the oscillation is found to depend on the turbulence model in use as well as the Reynolds number. Author

N89-23418*# California Univ., Davis. Div. of Aeronautical Science and Engineering.

HIGH ANGLE-OF-ATTACK AERODYNAMIC CHARACTERISTICS OF CRESCENT AND ELLIPTIC WINGS Final Report

C. P. VANDAM May 1989 38 p

(Contract NAG1-732)

(NASA-CR-184992; NAS 1.26:184992) Avail: NTIS HC A03/MF A01 CSCL 01/1

Static longitudinal and lateral-directional forces and moments were measured for elliptic- and crescent-wing models at high angles-of-attack in the NASA Langley 14 by 22-Ft Subsonic Tunnel. The forces and moments were obtained for an angle-of-attack range including stall and post-stall conditions at a Reynolds number based on the average wing chord of about 1.8 million. Flow-visualization photographs using a mixture of oil and titanium-dioxide were also taken for several incidence angles. The force and moment data and the flow-visualization results indicated that the crescent wing model with its highly swept tips produced much better high angle-of-attack aerodynamic characteristics than the elliptic model. Leading-edge separation-induced vortex flow over the highly swept tips of the crescent wing is thought to produce this improved behavior at high angles-of-attack. The unique planform design could result in safer and more efficient low-speed airplanes. Author

N89-23420# Stanford Univ., CA. Thermosciences Div.

AN EXPERIMENTAL STUDY OF THE EFFECT OF STREAMWISE VORTICES ON UNSTEADY TURBULENT BOUNDARY-LAYER SEPARATION

W. W. HUMPHREYS and W. C. REYNOLDS 9 Dec. 1988 273 p

(Contract F49620-86-K-0020)

(AD-A205462; TF-42; AFOSR-89-0275TR) Avail: NTIS HC A12/MF A01 CSCL 01/3

This experiment studied the effect of streamwise vortices on unsteady turbulent boundary-layer separation. The objectives were to document the flow field, to characterize the time response of the boundary layer, and to understand the actual mechanisms by which the streamwise vortices modify boundary-layer behavior. A new configuration for non-obtrusive three-component Laser Doppler Anemometry (LDA) determined the phase averaged velocity and Reynolds stress components, in an unsteady water tunnel, at a momentum thickness Reynolds number of 1840. The streamwise vortices were created by three pairs of half-delta wing vortex generators, while the boundary-layer separation was controlled through impulsively initiated opposite-wall suction, which created a strong adverse pressure gradient. The time response of the freestream velocity demonstrates that convection is the primary mechanism by which vortex generators modify the response of the boundary layer. There is an initial fast response throughout the boundary layer which is unaffected by the presence of vortex generators, followed by a slow or convective response, the magnitude of which is substantially modified by the presence of the vortex generators. GRA

N89-23423# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.

DEVELOPMENT OF HARMONIC PANEL METHODS FOR AEROELASTIC APPLICATIONS TO ELASTIC BODIES AND BODY-FIN COMBINATIONS IN SUPERSONIC FLOW Final Report, Jan. 1984 - Dec. 1988

D. D. LIU and PABLO GARCIA-FOGEDA Jan. 1989 201 p

(Contract DAAG29-84-K-0004)

(AD-A205739; ASU-CR-R-89021; ARO-20928.6-EG) Avail: NTIS HC A10/MF A01 CSCL 20/4

Recent development of several unsteady supersonic methods for computations of airloads for elastic bodies of revolution, asymmetric bodies and body wing configurations are reported. These methods include the Harmonic Potential Panel (HPP) method, the Bundle Triplet Method (BTM) and the combined method of BTM and the Harmonic Gradient Method (HGM) for body wing combinations. All methods are based on the generic Harmonic Gradient (H-G) model, which is essential in providing accurate solutions in the full frequency domain and the low Mach number range. Extensive comparisons of computed results obtained from these methods show good correlations with existing data. Comparison examples range from simple cones and ogive bodies to Saturn SA-1 configuration, to the cylindrical panel membrane and to the NACA wing-body combinations. Cases computed yield steady and unsteady pressures, generalized forces, stability derivatives, aerodynamic dampings and divergence and flutter boundaries for these configurations. The developed methods have been validated with existing theories or measured data. For supersonic aeroelastic analysis, these methods yield results that are accurate and cost-effective, thus rendering them very favorable for technology transfer and industry applications. GRA

N89-23424# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

NAVIER-STOKES SOLUTION FOR A NACA 0012 AIRFOIL WITH MASS FLUX (FAN) M.S. Thesis

PAUL D. BOYLES Dec. 1988 140 p

(AD-A205771; AFIT/GAE/AA/88D-02) Avail: NTIS HC A07/MF A01 CSCL 01/1

STOL aircraft use a variety of mechanisms to augment lift. Small fans with vectored exhaust imbedded in an aircraft wing could increase lift and reduce drag. The aim of this thesis is to investigate the two-dimensional effect of a small fan in wing on the flow field and on the lift and drag behavior of a NACA 0012 airfoil. Numerical solutions are obtained for a Mach number of 0.3 and a Reynolds number of one million. The parameters examined are angle of attack, fan ejection angle and suction velocity. The numerical code used is based on the Beam-Warming implicit factorization algorithm for solving the two-dimensional mass-averaged compressible Navier-Stokes equations for viscous, unsteady flows. GRA

N89-23425# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

INVESTIGATION OF THE FLOWFIELD CREATED BY THE INTERACTION OF A SONIC JET AND A CO-FLOWING SUPERSONIC STREAM M.S. Thesis

BENOIT J. DURAND Dec. 1988 142 p

(AD-A205823; AFIT/GAE/AA/88D-11) Avail: NTIS HC A07/MF A01 CSCL 20/4

Flowfield characteristics created by a sonic flow expanding freely between two supersonic streams were investigated experimentally using optical and pressure instrumentation. The base flow produced by the expansion of the streams around the base regions is compared to experimental data and theory by Chow. The shear layer created between the sonic and supersonic stream was also studied using Schlieren photographs is examined in an effort to explain the observed flow phenomenon. It was observed that a shear layer crossing a shock wave spreads and increases its turbulence level. However, an undesirable loss in total pressure results which could be undesirable. It appears that Chow's theory on base pressure approximates the characteristics of the flow near the end of the nozzle assembly where the two flows initially

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interact. The same trends were observed in the behavior of base pressure with increasing secondary total pressure as Chow observed during his experiment. The convective Mach number concept was successfully applied to the sonic injection geometry and it was demonstrated that the convective Mach number decreases drastically as the secondary pressure is increased. This is an indication that the growth rate of the shear layer increases, giving a faster mixing rate. GRA

N89-23426# Stanford Univ., CA.
FLOW CONTROL FOR UNSTEADY AND SEPARATED FLOWS AND TURBULENT MIXING Annual Report, 1 Oct. 1987 - 30 Sep. 1988

J. K. EATON, LAMBERTUS HESSELINK, J. P. JOHNSTON, I. M. KROO, J. D. POWELL, L. ROBERTS, and W. C. REYNOLDS 31 Oct. 1988 51 p
(Contract F49620-86-K-0020)
(AD-A205989; AFOSR-89-0232TR) Avail: NTIS HC A04/MF A01 CSCL 01/1

A coordinated set of experimental research projects on flow control is being conducted by a team with experience in fluid mechanics and automatic control. The primary objective of this work is to develop new ways to control flows of technical interest and a generic approach to the design of flow control systems. Included are studies of mixing enhancement by excitation of jets, active control of unsteady turbulent boundary layers and separated flows, and active control of the vortical flow over delta wings using leading-edge blowing. GRA

N89-23427# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

EJECTOR EFFECTS ON A SUPERSONIC NOZZLE AT LOW ALTITUDE AND MACH NUMBER M.S. Thesis

CHRISTOPHER A. SEAVER Dec. 1988 105 p
(AD-A206049; AFIT/GAE/AA/88D-33) Avail: NTIS HC A06/MF A01 CSCL 01/1

This research involves the study of ejector effects on a supersonic nozzle. A blowdown wind tunnel was used to simulate the launch of an ejector rocket to determine possible thrust augmentation capabilities of such a design. Pressure measurements were made along the mixing chamber during the 42 separate runs which were used to select a specified profile to study the effects the flow has on wall pressures and rocket thrust. Primary airflow was directed to the primary rocket nozzle designed for Mach 3.09. Secondary airflow was directed to a sonic ejector which was adjusted to simulate vehicle Mach number. A vacuum tank was used to provide the environment simulating a reverse trajectory of a launch. GRA

N89-23428# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

NUMERICAL STUDY OF THE INFLUENCE OF LEADING AND TRAILING EDGE FLAPS ON THE PERFORMANCE OF AIRFOILS M.S. Thesis

FARAN HAFEEZ Mar. 1989 164 p
(AD-A206138; AFIT/GAE/AA/89M-2) Avail: NTIS HC A08/MF A01 CSCL 01/1

The purpose of this study is to develop a code based on the Approximate Navier Stokes (ANS) equations (in the Vorticity Stream Function delta form). The Wortman FX 63-137 airfoil fitted with leading and trailing edge devices has been analyzed at low Reynolds Number (100,000) at various angles of attack and various deflection angles. Results are compared to the experimental data. The agreement is very good at small angles of attack. However, at large angles of attack the disparity is larger, and improvements have been recommended which will resolve this disparity. Overall the present scheme produces very reasonable results, with good repeatability and fast convergence, and has the potential of being developed into an effective design tool. GRA

N89-23429# Bolt, Beranek, and Newman, Inc., Canoga Park, CA.

NOISE AND SONIC BOOM IMPACT TECHNOLOGY. PCBOOM COMPUTER PROGRAM FOR SONIC BOOM RESEARCH, VOLUME 1 Final Report, May 1987 - Oct. 1988

DWIGHT E. BISHOP Oct. 1988 56 p
(Contract F33615-86-C-0530)
(AD-A206290; BBN-6741-VOL-1; HSD-TR-88-014-VOL-1) Avail: NTIS HC A04/MF A01 CSCL 20/1

The PCBOOM computer program, described in this technical report, calculates the location and magnitude of sonic boom overpressures on the ground due to supersonic flight under standard atmosphere and no wind propagation conditions. The program is intended for environmental planners and engineers who may need to estimate the noise impact from individual flights of supersonic military aircraft. The program runs on a Zenith Z-248 personal computer and also should run on most similarly configured IBM-compatible computers. The program contains information for all current military aircraft and allows updating for additional aircraft. The user can select either Quick look computations which assume steady-state flight or detailed ray-tracing calculations which can handle non-steady flight and sonic boom focus conditions. Several types of simple maneuvers can be selected for computations; the program will also handle up to ten connected straight line segments. Flight segments from the MOAOPS library of supersonic combat training flights may also be selected. User-specified output for printer, plotter or screen includes tables of overpressures and graphic display of the sonic boom overpressure footprints on the ground. GRA

N89-23430# Bolt, Beranek, and Newman, Inc., Canoga Park, CA.

NOISE AND SONIC BOOM IMPACT TECHNOLOGY. PCBOOM COMPUTER PROGRAM FOR SONIC BOOM RESEARCH. VOLUME 2: PROGRAM USERS/COMPUTER OPERATIONS MANUAL Final Report, May 1987 - Oct. 1988

AUGUSTINE SALVETTI and HARRY SEIDMAN Oct. 1988 58 p
(Contract F33615-86-C-0530)
(AD-A206291; BBN-6742-VOL-2; HSD-TR-88-014-VOL-2) Avail: NTIS HC A04/MF A01 CSCL 20/1

This report contains the information for both the user and for computer operations. The report provides the user with the information necessary to effectively use PCBOOM. In addition, it provides the computer operations personnel with a description of the computer system and its associated environment. Two other reports provide a technical discussion of the algorithms used and a program maintenance manual. GRA

N89-23433*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

TRANSONIC NAVIER-STOKES SOLUTIONS OF THREE-DIMENSIONAL AFTERBODY FLOWS

WILLIAM B. COMPTON, III, JAMES L. THOMAS, WILLIAM K. ABEYOUNIS, and MARY L. MASON Jul. 1989 62 p
(NASA-TM-4111; L-16516; NAS 1.15:4111) Avail: NTIS HC A04/MF A01 CSCL 01/1

The performance of a three-dimensional Navier-Stokes solution technique in predicting the transonic flow past a nonaxisymmetric nozzle was investigated. The investigation was conducted at free-stream Mach numbers ranging from 0.60 to 0.94 and an angle of attack of 0 degrees. The numerical solution procedure employs the three-dimensional, unsteady, Reynolds-averaged Navier-Stokes equations written in strong conservation form, a thin layer assumption, and the Baldwin-Lomax turbulence model. The equations are solved by using the finite-volume principle in conjunction with an approximately factored upwind-biased numerical algorithm. In the numerical procedure, the jet exhaust is represented by a solid sting. Wind-tunnel data with the jet exhaust simulated by high pressure air were also obtained to compare with the numerical calculations. Author

N89-24264*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF ADVANCED ROTORCRAFT AIRFOIL SECTIONS ON THE HOVER PERFORMANCE OF A SMALL-SCALE ROTOR MODEL

SUSAN L. ALTHOFF (Army Aviation Systems Command, Hampton, VA.) Sep. 1988 35 p
 (Contract DA PROJ. 1L1-61102-AH-45-A)
 (NASA-TP-2832; L-16407; NAS 1.60:2832;
 AVSCOM-TP-88-B-001) Avail: NTIS HC A03/MF A01 CSCL 01/1

A hover test was conducted on a small scale rotor model for two sets of tapered rotor blades. The baseline rotor blade set used a NACA 0012 airfoil section, whereas the second rotor blade set had advanced rotorcraft airfoils distributed along the radius. The experiment was conducted for a range of thrust coefficients and tip speeds, and the data were compared to the predictions of three analytical methods. The data show the advantage of the advanced airfoils at the higher rotor thrust levels; two of the analyses predicted the correct data trends. Author

N89-24265*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

THERMAL ANALYSIS OF A HYPERSONIC WING TEST STRUCTURE Final Report, Oct. 1986 - Apr. 1989

DORAL R. SANDLIN and NEIL J. SWANSON, JR. Apr. 1989 54 p
 (Contract NCC2-433)
 (NASA-CR-185319; NAS 1.26:185319) Avail: NTIS HC A04/MF A01 CSCL 01/1

The three-dimensional finite element modeling techniques developed for the thermal analysis of a hypersonic wing test structure (HWTS) are described. The computed results are compared to measured test data. In addition, the results of a NASA two-dimensional parameter finite difference local thermal model and the results of a contractor two-dimensional lumped parameter finite difference local thermal model will be presented. B.G.

N89-24266*# West Virginia Univ., Morgantown. Dept. of Mechanical and Aerospace Engineering.

COMPUTATIONAL DESIGN OF LOW ASPECT RATIO WING-WINGLET CONFIGURATIONS FOR TRANSONIC WIND-TUNNEL TESTS Final Report

JOHN M. KUHLMAN and CHRISTOPHER K. BROWN May 1989 115 p
 (Contract NAG1-625)
 (NASA-CR-185016; NAS 1.26:185016) Avail: NTIS HC A06/MF A01 CSCL 01/1

Computational designs were performed for three different low aspect ratio wing planforms fitted with nonplanar winglets; one of the three configurations was selected to be constructed as a wind tunnel model for testing in the NASA-Langley 7 x 10 high speed wind tunnel. A design point of $M = 0.8$, CL approximately equal to 0.3 was selected, for wings of aspect ratio equal to 2.2, and leading edge sweep angles of 45 and 50 deg. Winglet length is 15 percent of the wing semispan, with a cant angle of 15 deg, and a leading edge sweep of 50 deg. Winglet total area equals 2.25 percent of the wing reference area. The design process and the predicted transonic performance for each configuration is summarized. In addition, a companion low-speed design study was conducted, using one of the transonic design wing-winglet planforms but with different camber and thickness distributions. A low-speed wind tunnel model was constructed to match this low-speed design geometry, and force coefficient data were obtained for the model at speeds of 100 to 150 ft/sec. Measured drag coefficient reductions were of the same order of magnitude as those predicted by numerical subsonic performance predictions. Author

N89-24267 Rensselaer Polytechnic Inst., Troy, NY.
AERODYNAMICS OF A LIFTING ROTOR DUE TO NEAR FIELD

UNSTEADY EFFECTS Ph.D. Thesis

ROBERT LOWELL MILLIKEN 1988 210 p
 Avail: Univ. Microfilms Order No. DA8905209

Lift deficiency functions to aid in the prediction of oscillatory loadings due to near field wake effects on a three-dimensional rotor blade in forward flight were obtained. The Pulse Transfer Function (PTF) technique was used in obtaining the lift deficiency functions. A discrete vortex model of the circulatory flow field was employed to obtain the time domain lift response to a pulse shaped transient input. The frequency domain response was then obtained by inverting the time domain response using fast Fourier transforms (FFT), from which the lift deficiency functions could be determined. To demonstrate the validity of the PTF technique, the analytical lift deficiency functions of Theodorsen and Loewy were compared with numerical representations of these functions. These lift deficiency functions and their PTF numerical counterparts agreed well in magnitude, but the error in the phase shift was large and increased with increasing reduced frequency. Lift deficiency functions for rotor blades of aspect ratios 6, 12, and 18 were plotted for advance ratios 0, 0.2, and 0.4 for each 45 degree increment about the azimuth. The results show that the effect of three dimensions is to produce a lower lift loss than calculated on the basis of two-dimensional results. The difference between the magnitude of the unsteady lift predicted by the lift deficiency functions and Theodorsen's function can be as much as 25 percent. Author

N89-24270# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

USE OF NAVIER-STOKES METHODS TO PREDICT CIRCULATION CONTROL AIRFOIL PERFORMANCE M.S. Thesis

STEVEN L. WILLIAMS Mar. 1989 84 p
 (AD-A206242; AFIT/GAE/AA/89M-4) Avail: NTIS HC A05/MF A01 CSCL 01/1

The predictive capability of the two-dimensional compressible mass-averaged Navier-Stokes equations was investigated for a typical circulation control air-foil. The governing equations were solved using the implicit approximate factorization algorithm of Beam-Warming with the turbulence model of Baldwin-Lomax. To account for the unique characteristics of circulation control airfoils, an empirical turbulence model correction due to Bradshaw was used. This thesis is unique in that the predictive capability of the computational method is explored by examining the importance of the empirical Bradshaw curvature correction constant on the computed results. Using a generic value of the curvature constant at various blowing coefficient levels, the computational method was able to accurately predict airfoil pitching moment and lift curve slope due to blowing. Predicted levels of airfoil lift coefficient, although reasonable, were found to be consistently low compared with experiment due to the generic curvature constant providing premature jet detachment from the Coanda surface. Computed and measured airfoil drag results followed the same trends, but lack of overall drag coefficient agreement was disappointing. Lift coefficient was found to be quite sensitive, pitching moment not sensitive, and drag coefficient moderately sensitive to the value of the curvature constant used. GRA

N89-24271# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

WATER TUNNEL INVESTIGATION OF THE VORTEX DYNAMICS OF PERIODICALLY PITCHED WINGS M.S. Thesis

MICHAEL DAVID Dec. 1988 125 p
 (AD-A206359; AFIT/GAE/AA/88D-06) Avail: NTIS HC A06/MF A01 CSCL 01/1

The vortex structure above semi-span wings was investigated in the AFFDL's 24-inch water tunnel to determine the effects of periodic pitching using a saw-tooth motion. Each of the six wings was pitched about the mid-chord at nondimensional upstroke rates ranging from 0.05 to 0.30 and down-stroke rates from 0.025 to 0.600 at tunnel flow rates of 0.6 to 3.6 in/sec. Visualization of the vortices obtained through dye injection from the models was recorded using both high speed and 3/4-in. standard speed video

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systems. Digitized data from the high speed system provided trend data which showed the saw-tooth motion caused a hysteresis effect on the vortex breakdown location for the swept wings where during the upstroke the vortex would burst further aft than during the down-stroke. In addition, comparison of two 65-deg sweep wings with different cross sections (flat plate and NACA 0012-34) showed a smaller hysteresis effect for the thicker wing. For the rectangular wing, increasing down-stroke rates resulted in higher dynamic stall vortex convection rates. Information was also gathered on the oscillation of static breakdown location and the effects of vortex breakdown of tunnel flow velocity. GRA

N89-24272# Flow Research, Inc., Kent, WA.
AN INVESTIGATION OF V/STOL JET INTERACTIONS IN A CROSSFLOW Final Report, 26 Sep. 1988 - 30 Mar. 1989
SURESH MENON Feb. 1989 72 p Revised Sponsored by DARPA
(Contract DAAH01-88-C-0865)
(AD-A206360; FLOW-RR-470) Avail: NTIS HC A04/MF A01
CSCL 01/1

Recently, a numerical simulation code was developed to study the interaction of the effects of a row of normal impinging jets. This model essentially simulates the hovering configuration of a V/STOL aircraft. The code solves unsteady, 3-D incompressible Navier-Stokes equations using the technique of large-eddy simulations which resolves all the length scales above the grid resolution and models the contribution of the small scales by a subgrid eddy viscosity model. The present study extends this code to include other realistic V/STOL configurations such as an obliquely impinging jet and an impinging jet in crossflow with and without a moving ground plane. These configurations model the V/STOL aircraft in pitch and in forward motion. These modifications were successfully achieved and preliminary simulations using axisymmetric forcing of the impinging jet were carried out to demonstrate the capability of the numerical code. Even with coarse mesh simulations, the results show good qualitative agreement with experimental observations. Simulation of the impinging jet in crossflow showed the formation of counterrotating streamwise vortices which has been observed in many experiments. However, it was shown that the presence of the adjacent impinging jet (which is absent in all experiments) can significantly modify the dynamics of the vortical motion in the flow field. Significant 3-dimensional vortex stretching occurs in this flow and redistribution of the total vorticity in the flow field. GRA

N89-24273# Naval Postgraduate School, Monterey, CA. Dept. of Aeronautics and Astronautics.
BOUNDARY LAYER RESPONSE TO AN UNSTEADY TURBULENT ENVIRONMENT M.S. Thesis
ROBERT W. RENOUD Dec. 1988 123 p
(AD-A206578) Avail: NTIS HC A06/MF A01 CSCL 01/1

An experimental investigation of a wing boundary layer subjected to periodic turbulent flow at a Reynolds number of 500,000 was conducted. Non-thrusting turbulence pulses were generated at a rate of 50 pulses/s with a turbulence intensity near 10 percent. Time-varying velocity measurements were made at representative chord locations (laminar, transitional/turbulent, fully turbulent) at one angle of attack using single-element hot-wire anemometry. Characteristics of the boundary layer velocity profiles, turbulence intensity profiles, and velocity spectra and total spectral power were documented. The time-varying boundary layer response could be characterized by undisturbed flow, turbulence pulse, and recovery period. The boundary layer exhibited a cyclic transition response varying from the undisturbed flow regime to the turbulence pulse regime back to the undisturbed flow regime. The turbulence pulse penetrated into the entire boundary layer. The turbulence pulse prompted flow laminarization during the recovery period. Laminarization apparently resulted from rapid acceleration of near-surface flow within the boundary layer due to turbulence induced momentum transfer down through the boundary layer and local flow acceleration following velocity deficit of the turbulence pulse. Effects of the periodic turbulence pulse were most noticeable

in the recovery period at the transitional/turbulent and fully turbulent regions of the wing. Recovery was generally characterized by lowered turbulence. GRA

N89-24274# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.

ANALYSIS OF THE BOUNDARY LAYER OF A DELTA WING IN INCIDENCE [ANALYSE DE LA COUCHE LIMITE A L'INTRADOS D'UNE AILE EN FLECHE ET EN INCIDENCE]

G. PAILHAS Apr. 1988 61 p
(Contract STPA-8595-004)
(CERT-RT-OA-26/5025-AYD; DERAT-26/5025-14; ETN-89-94522)
Avail: NTIS HC A04/MF A01

A 60 deg delta wing at 15 deg incidence is tested in a wind tunnel. The wing is an ONERA D 200 mm chord. The flow velocity is 30 m/s. The model is equipped with five arrays of pressure measuring points. A representation of the isobars shows lines parallel to the leading edge. Graphics showing the velocity profiles, transversal velocities, and turbulences are presented. ESA

N89-24278# Technische Hochschule, Aachen (Germany, F.R.). Lehrstuhl fuer Stahlbau.

UNSTEADY AERODYNAMIC EFFECTS ON BLUFF BODIES

H. P. RUSCHEWEYH *In* VKI, Unsteady Aerodynamics, Volume 1 72 p 1988
Avail: NTIS HC A20/MF A01

The physical background of aerodynamic vibration excitation phenomena is explained, including gust response, vortex resonance, galloping, interference galloping, and flutter. The mathematical models describing vibration induction are presented. Possible measures against dangerous flow induced vibrations are discussed. ESA

N89-24282# Ecole Nationale Supérieure de Mécanique, Nantes (France).

NUMERICAL METHODS FOR UNSTEADY FLOWS

Y. LECOINTE and J. PIQUET *In* VKI, Unsteady Aerodynamics, Volume 2 217 p 1988
Avail: NTIS HC A16/MF A01

Physical flow models are described in order of decreasing complexity, and typical results illustrating progress for the various flow modelling levels are discussed. Significant efforts are devoted to understanding the effects of equational level, computational grid, boundary conditions, and interactive viscous modeling. Progress in solution algorithms is detailed. Computational aeroelastic analysis shows its capability to predict complete transonic flutter boundaries for wings, including significant transonic dip features. ESA

N89-24285*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

EXPERIMENTAL AERODYNAMIC CHARACTERISTICS OF A JOINED-WING RESEARCH AIRCRAFT CONFIGURATION

STEPHEN C. SMITH and RONALD K. STONUM Apr. 1989 100 p
(NASA-TM-101083; A-89074; NAS 1.15:101083) Avail: NTIS HC A05/MF A01 CSCL 01/1

A wind-tunnel test was conducted at Ames Research Center to measure the aerodynamic characteristics of a joined-wing research aircraft (JWRA). This aircraft was designed to utilize the fuselage and engines of the existing NASA AD-1 aircraft. The JWRA was designed to have removable outer wing panels to represent three different configurations with the interwing joint at different fractions of the wing span. A one-sixth-scale wind-tunnel model of all three configurations of the JWRA was tested in the Ames 12-Foot Pressure Wind Tunnel to measure aerodynamic performance, stability, and control characteristics. The results of these tests are presented. Longitudinal and lateral-directional characteristics were measured over an angle of attack range of -7 to 14 deg and over an angle of sideslip range of -5 to +2.5 deg at a Mach number of 0.35 and a Reynolds number of 2.2×10^6 /ft. Various combinations of deflected control surfaces

were tested to measure the effectiveness and impact on stability of several control surface arrangements. In addition, the effects on stall and post-stall aerodynamic characteristics from small leading-edge devices called vortilons were measured. The results of these tests indicate that the JWRA had very good aerodynamic performance and acceptable stability and control throughout its flight envelope. The vortilons produced a profound improvement in the stall and post-stall characteristics with no measurable effects on cruise performance. Author

N89-24286 Virginia Polytechnic Inst. and State Univ., Blacksburg.

ANALYSIS OF THE WAKE BEHIND A PROPELLER USING THE FINITE ELEMENT METHOD WITH A TWO-EQUATION TURBULENCE MODEL Ph.D. Thesis

SEUNG JOO KIM 1988 219 p

Avail: Univ. Microfilms Order No. DA8904992

The finite element in the form of the weak Galerkin formulation with the penalty function method was applied to several problems of axisymmetric turbulent flows including flow through a sudden pipe expansion, the stern region flow of a slender body, and flows past ducted and nonducted propellers in action. The coupled set of the Reynolds time-averaged Navier-Stokes equations and two turbulence transport equations for the turbulent kinetic energy and its rate of dissipation was solved by L/U decomposition and successive substitution with relaxation. An existing finite element code was modified with a low Reynolds number form for an appropriate treatment of wall influences on turbulence transport, which produces a better solution and provides an easier imposition of boundary conditions by solving up to wall with no slip boundary conditions. The two-equation turbulence model with the wall modification was first successfully tested by solving the turbulent flow through a sudden pipe expansion. The numerical simulation of the stern region flow of a streamlined body resulted in an excellent agreement with the measured data in terms of the mean-flow and turbulence quantities. Turbulent shear flow past a propeller at the rear end of the same slender body, modeled by an actuator disk, were successfully solved at two rotational speeds, self-propelled and 100 percent over-thrusted, using the same two-equation model. And finally, comparisons of the wake behind a propeller were made for the self-propelled conditions of a ducted and nonducted propeller on the same streamlined body. Author

03

AIR TRANSPORTATION AND SAFETY

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

A89-39859

**SAFETY PHILOSOPHIES IN AIR TRANSPORT
[SICHERHEITSPHILOSOPHIEN IM LUFTVERKEHR]**

GUNTHER SCHAENZER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) Braunschweig, Technische Universitaet, Mitteilungen, vol. 24, no. 1, 1989, p. 9-19. In German. refs

Theoretical, technological, and design aspects of aircraft safety and reliability are examined in a general overview. Topics addressed include statistical measures comparing the safety of air travel to that of automobiles and trains, the downward trend in aviation accidents (per distance or time flown), the basic principles of design for safety, the definition of acceptable risk, and the redundant design of essential components. Particular attention is given to the frequency of occurrence of air turbulence, pilot workloads and the role of human error in accidents, the failure probability of autopilot systems, the increasing number of cockpit displays and controls, the problem of parallel redundancy, and software errors. Extensive diagrams and graphs are provided. T.K.

A89-42151

HAZARDS OF MOUNTAIN FLYING - CRASHES IN THE COLORADO ROCKIES

SUSAN P. BAKER and MARGARET W. LAMB (Johns Hopkins University, Baltimore, MD) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 60, June 1989, p. 531-536. refs

(Contract PHS-R49-CCR-302486-01)

Between 1964 and 1987, 232 airplanes crashed within 50 nautical miles of Aspen, Colorado; a total of 202 people died and 69 were seriously injured. Most pilots were experienced and many were flight instructors, but 44 percent had flown less than 100 hours in the type of plane in which they crashed. Airplanes with three or four occupants and low-powered four-seater aircraft were over-represented among crashes involving failure to outclimb rising terrain. In a subset of crashes examined for restraint use, 50 percent of the front-seat occupants using only lap belts were killed, compared to 13 percent of those who also wore shoulder restraints. Preventive recommendations include shoulder restraint use and better training in mountain flying with incentives provided by the FAA and insurance companies. Author

A89-42536

AIRCRAFT FLIGHT SAFETY: METHODOLOGICAL PRINCIPLES [BEZOPASNOST' POLETOV LETATEL'NYKH APPARATOV: METODICHESKIE OSNOVY]

ANATOLII I. STARIKOV, VIKTOR IA. ZACHESA, and NIKOLAI N. ZINKOVSKII Moscow, Izdatel'stvo Transport, 1988, 160 p. In Russian. refs

The fundamental principles of aircraft flight safety and methods of flight safety evaluation are reviewed. In particular, attention is given to the modeling of the states of aircraft and their systems; models of the interval and instantaneous states and models of state changes in flight are described. The discussion also covers method of analysis of special flight situations and quantitative estimation of flight safety characteristics on the basis of mathematical models. V.L.

A89-42811

PROBING BOEING'S CROSSED CONNECTIONS

KAREN FITZGERALD IEEE Spectrum (ISSN 0018-9235), vol. 26, May 1989, p. 30-35.

The causes and consequences of the misconnected circuits and hoses found in the fire protection systems of 94 in-service Boeing aircraft are examined. The problems were discovered during the massive worldwide inspections of fire protection systems in Boeing aircraft following the crash in England of a British Midland Airways Boeing 737 en route to Belfast in January 1989. These problems, of which there were a number of reports during 1988, did not cause the crash, which was attributed to human error. I.E.

N89-23434# National Transportation Safety Board, Washington, DC. Bureau of Safety Programs.

ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA, US AIR CARRIER OPERATIONS: CALENDAR YEAR 1986

3 Feb. 1989 101 p

(PB89-151021; NTSB/ARC-89/01) Avail: NTIS HC A06/MF A01 CSCL 01/3

The record of aviation accidents involving revenue operations of U.S. Air Carriers including Computer Air Carriers and On Demand Air Taxis for calendar year 1986 is presented. The report is divided into three major sections according to the Federal regulations under which the flight was conducted - 14 CFR 121, 125, 127, Scheduled 14 CFR 135, or Nonscheduled 14 CFR 135. In each section tables describe the losses and characteristics of 1986 accidents to enable comparison with prior years. Author

N89-23435# Computer Resource Management, Inc., Vienna, VA.

NATIONAL AIRSPACE SYSTEM SEARCH AND RESCUE OPERATIONAL CONCEPT (NAS-SR-1329)

WILLIAM TRENT, RODNEY KUHN, and THOMAS PICKERELL

03 AIR TRANSPORTATION AND SAFETY

Feb. 1989 50 p
(Contract DTFA01-88-Y-01073)
(DOT/FAA/DS-89/07) Avail: NTIS HC A03/MF A01

A requirement for the National Airspace System (NAS) is to provide for detecting the need for initiating and assisting in search and rescue activities, as identified in the NAS System Requirement Specification. A concept of operations for search and rescue is presented. It describes search and rescue assistance capabilities and shows the relationships between subsystems, facilities, information, and operators/users. It is intended to provide a common perspective for personnel involved in search rescue activities, assist in determining whether the search and rescue procedures meet formal requirements, and support coordination among the organizations involved with search and rescue assistance. Author

N89-23436# National Transportation Safety Board, Washington, DC. Bureau of Accident Investigation.

AIRCRAFT ACCIDENT REPORT: AVAIR INC., FLIGHT 3378, FAIRCHILD METRO 3, SA227 AC, N622AV, CARY, NORTH CAROLINA, FEBRUARY 19, 1988

13 Dec. 1988 73 p
(PB88-910412; NTSB/AAR-88/10) Avail: NTIS HC A04/MF A01; HC also available on subscription, North American Continent price \$70.00/year, all others write for quote CSCL 01/3

On February 19, 1988, an AVAir Inc. Fairchild Metro 3, N622AV, operating as Air Virginia (AVAir) flight 3378, crashed in Cary, North Carolina shortly after it departed runway 23R at Raleigh Durham International Airport (RDU), Morrisville, North Carolina, with 2 flightcrew members and 10 passengers on board. The airplane struck water within 100 feet of the shoreline of a reservoir, about 5,100 feet west of the midpoint of runway 23R. The airplane was destroyed and all 12 persons on board were killed. The National Transportation Safety Board determines that the probable cause of this accident was the failure of the flightcrew to maintain a proper flightpath because of the first officer's inappropriate instrument scan, the captain's inadequate monitoring of the flight, and the flightcrew's response to a perceived fault in the airplane's stall avoidance system. Contributing to the accident was the lack of company response to documented indications of difficulties in the first officer's piloting, and inadequate Federal Aviation Administration surveillance of AVAir. Author

N89-24288# Federal Aviation Administration, Atlantic City, NJ. Technical Center.

A COMPUTER SIMULATION STUDY OF LIQUID WATER CONTENT ADJUSTMENT BASED ON ICING CLOUD HORIZONTAL EXTENT

JAMES T. RILEY, JAMES BOOTH, and DOUGLAS FERGUSON
Dec. 1988 117 p
(DOT/FAA/CT-TN89/3) Avail: NTIS HC A06/MF A01

The analytical airfoil ice accretion prediction code LEWICE was used to determine resultant ice shapes on an airfoil when the cloud horizontal extent (CHE) - liquid water content (LWC) factor curve, as given in the Federal Aviation Regulations (FAR's), is applied for related icing conditions of LWC and CHE extent. LEWICE predicts the shape of an ice accretion that would form on an unprotected airfoil (or other 2-dimensional geometry) when exposed to icing conditions. Although LEWICE is not validated for all purposes, it can be usefully employed in a comparative study of this type to study trends in ice accretion shape as ambient conditions are systematically varied. Results must be interpreted carefully in the context of the limitations of the ice accretion model assumed by LEWICE. For the conditions included in this study, LEWICE predicts that as LWC is decreased and CHE is increased by application of the CHE-LWC factor curve of the FAR's, a larger and more severe ice shape will accrete on an unprotected airfoil. Author

N89-24289# Army Aviation Engineering Flight Activity, Edwards AFB, CA.

PRELIMINARY AIRWORTHINESS EVALUATION OF MODIFIED SECOND-GENERATION PNEUMATIC BOOT DEICING SYSTEM ON A JUH-1H Final Report, 26 Oct. 1987 - 7 Apr. 1988

JAMES D. BROWN, CHARLES E. CASSIL, and MICHAEL K. HERBST Oct. 1988 62 p
(AD-A206255; USAAEFA-87-08) Avail: NTIS HC A04/MF A01 CSCL 08/12

The U.S. Army Aviation Engineering Flight Activity conducted a Preliminary Airworthiness Evaluation of a modified second-generation Pneumatic Boot Deicing System (PBDS) on a JUH-1H helicopter. This consisted of a structural loads survey, level flight performance evaluation, and a qualitative handling qualities evaluation. Twelve flights were conducted for a total of 7.8 productive flight hours. Rotor system structural loads were generally lower than those reported for the unmodified second-generation PBDS. With the PBDS inflated, main rotor pitch link load reached the endurance limit at 100 knots indicated airspeed in level flight. Power required in level flight was less than or equal to power required by the unmodified second-generation PBDS. Inflating the PBDS generated moderate right yaw rates and engine torque rises as great as eight pounds per square inch. One previously identified shortcoming, the aircraft response to PBDS activation during level flight, still exists. GRA

N89-24290*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

DESIGN OF AUTOMATED SYSTEM FOR MANAGEMENT OF ARRIVAL TRAFFIC

HEINZ ERZBERGER and WILLIAM NEDELL (San Jose State Univ., CA.) Jun. 1989 50 p Original contains color illustrations (NASA-TM-102201; A-89116; NAS 1.15:102201) Avail: NTIS HC A03/MF A01 CSCL 17/7

The design of an automated air traffic control system based on a hierarchy of advisory tools for controllers is described. Compatibility of the tools with the human controller, a key objective of the design, is achieved by a judicious selection of tasks to be automated and careful attention to the design of the controller system interface. The design comprises three interconnected subsystems referred to as the Traffic Management Advisor, the Descent Advisor, and the Final Approach Spacing Tool. Each of these subsystems provides a collection of tools for specific controller positions and tasks. The design of two of these tools, the Descent Advisor, which provides automation tools for managing descent traffic, and the Traffic Management Advisor, which generates optimum landing schedules is focused on. The algorithms, automation modes, and graphical interfaces incorporated in the design are described. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A89-40446

AIRCRAFT NAVIGATION USING I.R. IMAGE ANALYSIS

R. A. SAMY and A. LUCAS (Societe Anonyme des Telecommunications, Paris, France) IN: Applications of digital image processing XI; Proceedings of the Meeting, San Diego, CA, Aug. 15-17, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 310-314.

Recent IR image-analysis techniques can be used to enhance the accuracy of aircraft navigation systems. Scene matching is one of the most promising techniques that can be combined with an inertial navigation system to give very-high-accuracy autonomous navigation. APARS segment detection using an optimal edge operator is used to select points in an IR image.

Matching of reference map with APARS is achieved by prediction and evaluation algorithms which include a Kalman estimation for image-to-map transformation refinements. Author

A89-40802

PRACTICAL EXPERIMENTAL EXAMPLES OF LAND, SEA, AND AIR NAVIGATION USING THE NAVSTAR/GPS SYSTEM [EXEMPLES D'EXPERIMENTATIONS PRATIQUES DE NAVIGATION TERRESTRE, MARITIME ET AERIENNE AVEC L'AIDE DU SYSTEME NAVSTAR/GPS]

JEAN FOURNIER, PIERRE MANNEVY, and JEAN-PIERRE CAILLETAUD (Istituto Italiano di Navigazione, Convegno Nazionale sul le Utilizzazioni Civili del Sistema di Posizionamento Globale Navstar/GPS, Rome, Italy, Mar. 7, 8, 1989) Navigation (Paris) (ISSN 0028-1530), vol. 37, April 1989, p. 177-192. In French.

The GPS/Navstar system is described, and experimental results for land and sea navigation (using a Trimble-type TANS GPS receiver) and for air navigation (using a Trimble-type 400 GPS receiver) are presented. The land experiments were performed near Caen-Ouistreham (Normandy), the sea experiments on the Caen canal, and the air experiments on a B-17 over agricultural sites in the Netherlands. The test data show a scatter of + or - 10 meters and a repeatability of 17 meters. R.R.

A89-40803

POSSIBILITY OF USING GPS FOR PRECISION APPROACHES [POSSIBILITE D'UTILISATION DU GPS POUR LES APPROCHES DE PRECISION]

LAWRENCE HOGLE (Mitre Corp., McLean, VA) Navigation (Paris) (ISSN 0028-1530), vol. 37, April 1989, p. 204-224. refs

The potential application of GPS for precision approach landing operations is explored. Although the horizontal accuracy of GPS is shown to be within the requirement specified for a precision approach to 200 ft altitude above the runway, the GPS does not achieve the required vertical accuracy, even when operating in a differential mode. It is noted that the coverage reliability and integrity of the system will also require further improvement in order for GPS to be used as a precision approach system. R.R.

A89-40895#

A STUDY ON THE AIR TRAFFIC MANAGEMENT - THE EFFECT OF DEPARTURE REGULATION

MORIYUKI MIZUMACHI (Tokyo, University, Japan) Tokyo, University, Faculty of Engineering, Journal, Series A (ISSN 0563-7945), no. 26, 1988, p. 36, 37. In Japanese, with abstract in English.

Simulation is used to investigate the effect of departure regulation on one-way air traffic flow. The regulation is performed by on-off gating, depending upon different thresholds of a clearance parameter. Two kinds of clearance parameters are adopted: (1) the number of aircraft en-route; and (2) the number of aircraft departed within an hour. On evaluation of results, such parameters as the waiting time on the ground, the flight time, the total trip time, etc., are obtained. Author

A89-41030

STATE AND PERSPECTIVES OF SATELLITE USE IN CIVIL AVIATION. I [STAND UND PERSPEKTIVEN DER SATELLITENNUTZUNG IN DER ZIVILEN LUFTFAHRT. I]

GUSTAV WESTPHAL (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, German Democratic Republic) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol 25, no. 1, 1989, p. 37-41. In German.

The development and state of the art in the use of satellites for civil aviation are addressed. The bases of satellite technology are reviewed, and the aspects involving radio technology are discussed. Satellite radio technology is examined, including systems for communication, passive systems for navigation, and active systems for navigation. C.D.

A89-41043

INTRODUCTION OF MLS - EFFECTS ON AIRSPACE AND AIRPORT CAPACITY

RICHARD P. ARNOLD (FAA, MLS Programme Office, Washington, DC) ICAO Bulletin (ISSN 0018-8778), vol. 44, Jan. 1989, p. 30-32.

The advantages of the microwave landing system (MLS) in dealing with today's air-traffic capacity problem are reviewed. As an example, it is pointed out what improvements in capacity could be achieved at La Guardia airport by utilizing an MLS. It is argued that a demonstration program covering all elements of the development of MLS should be carried out now. C.D.

A89-42652

ADVANCED TECHNOLOGY ULTRA RELIABLE RADAR (URR)

D. E. LINGLE, D. P. MIKSZAN (Westinghouse Electric Corp., Electronics Systems Group, Baltimore, MD), and DENNIS MUKAI (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: 1989 IEEE National Radar Conference, 4th, Dallas, TX, Mar. 29, 30, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1-6.

The authors describe the URR (ultrareliable radar) system, subsystems, software architecture, and reliability and maintainability design. Objectives of the current URR program, which is scheduled to be completed in early FY 1990, are also discussed. As originally conceived, the URR program was to develop next-generation radar technology that would exhibit an order of magnitude improvement in reliability over existing radar systems. Since existing systems were exhibiting a mean time between failures (MTBF) of approximately 40 hours, the URR reliability goals was established at 400 hours for a system serial MTBF. The URR program has developed technology applicable to the advanced tactical fighter and F-15/F-16/B-1B updates by integrating advanced receiver/STALO (stable local oscillator) technology with solid-state phased-array active aperture technology and very-high-speed integrated circuit common signal processor technology. I.E.

A89-42655

FUTURE TERRAIN FOLLOWING RADARS

CHARLES W. CHAPOTON, JR. (Texas Instruments, Inc., McKinney) IN: 1989 IEEE National Radar Conference, 4th, Dallas, TX, Mar. 29, 30, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 20-23.

After examining current terrain-following radars (TFRs) as well as factors forcing change in TFR systems, the author describes the projected characteristics of future TFRs. He predicts that future TFRs will be multipurpose and short-range systems, transmit low-power pulses and a complex waveform, have an electronically scanned antenna and an irregular scan pattern, operate intermittently, and process large amounts of data. Each of these features is examined. I.E.

A89-42661

ANALOG-TO-DIGITAL CONVERTER EFFECTS ON AIRBORNE RADAR PERFORMANCE

B. N. SURESH BABU and C. M. SORRENTINO (Mitre Corp., Bedford, MA) IN: 1989 IEEE National Radar Conference, 4th, Dallas, TX, Mar. 29, 30, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 56-61. Research supported by USAF.

In order to evaluate A/D (analog/digital) converter effects on airborne radar performance, a polynomial A/D converter model based on measured harmonic levels of a 14-bit A/D converter has been developed. The model has been validated by comparing the measured spurious-free dynamic range of the A/D converter at different amplitude levels and frequencies with the simulated data from the model. The comparison shows that the model captures the roll-off in spurious-free dynamic range due to increasing input frequency and causes small ripples across frequency and input power levels. The model has been included in an airborne radar simulation to evaluate the effect of internal noise and nonlinearities of the A/D converter on the radar performance. It is concluded from 50 Monte Carlo simulation runs

04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

for two cases-ideal A/D converter and A/D converter with nonlinearities-that the number of false alarms and subclutter visibility are not significantly degraded by nonlinearities for this 14-bit A/D converter for the case of mainbeam land clutter at broadside. I.E.

A89-42666

TECHNIQUES FOR ROBUST TRACKING IN AIRBORNE RADARS

LAWRENCE W. NELSON and TAGE A. CARLSON (General Electric Co., Utica, NY) IN: 1989 IEEE National Radar Conference, 4th, Dallas, TX, Mar. 29, 30, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 80-84. refs

The authors describe the techniques used in an advanced multimode radar to achieve robust tracking in a package that weighs only 189 lb, occupies only 2.0 cu ft and consumes only 2000 W of power. A combination of advanced hardware and postdetection processing on a judicious choice of selected data is used to provide robust tracking. Recent advances in technology have allowed a very high degree of digital signal processing to be performed on the received signal. Two MIL-STD-1750 computers are used for the postdetection processing, the heart of which is an adaptive, nine-state Kalman filter used to estimate target position, velocity, and acceleration. Additional postdetection processing is used to support the Kalman filter in extracting target information from the data and providing immunity to various sources of interference. I.E.

A89-42676

IMPROVED BANDWIDTH MICROSTRIP ANTENNA DESIGN FOR AIRBORNE PHASED ARRAYS

SHASHI SANZGIRI, BILL POWERS, and JIM HART (Texas Instruments Antenna Laboratory, McKinney) IN: 1989 IEEE National Radar Conference, 4th, Dallas, TX, Mar. 29, 30, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 135-140.

A microstrip radiating element design for a 10 percent bandwidth, wide-scan-angle, phased-array antenna is described. The radiating element consists of a single probe-fed circular patch on a thick substrate. The element match is optimized using a waveguide array simulator. A finite array of 108 elements was fabricated to evaluate the array's scan-angle performance. Mutual coupling data were used to compute the element reflection coefficient as a function of frequency and scan angle. The scan angle performance was compared with that obtained using the theoretically computed mutual coupling coefficients of a similar array. Both analytical and measured results showed high voltage standing-wave ratio (VSWR) at wide scan angles. The array is performance with a dielectric cover on the top has been evaluated both analytically and experimentally. The results show improvement in the scan angle performance over 10 percent bandwidth. I.E.

A89-42680

SYNTACTIC CLASSIFICATION OF RADAR MEASUREMENTS OF COMMERCIAL AIRCRAFT

O. S. SANDS and F. D. GARBER (Ohio State University, Columbus) IN: 1989 IEEE National Radar Conference, 4th, Dallas, TX, Mar. 29, 30, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 158-163. refs (Contract N00014-86-K-0202)

A syntactic pattern recognition system for applications to radar signal identification is designed, and the performance of the resulting classification system is evaluated. Two different techniques for generating symbolic patterns from radar backscatter signals are considered. The classification utility of the symbolic patterns is assessed in terms of the performance of maximum-likelihood classification of the observed symbol strings. A syntax analysis algorithm that makes use of symbolic patterns derived from radar backscatter measurements is developed from the likelihood function classifier. Performance results obtained from simulated classification experiments for both maximum-likelihood and language-theoretic classifiers are presented. I.E.

A89-42938

CIDS- CABIN INTERCOMMUNICATION DATA SYSTEM

FRED HILDEBRANDT and JOERG REITMANN (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, Federal Republic of Germany) (Walter-Blohm-Stiftung, Festakt, Hamburg, Federal Republic of Germany, July 28, 1987) IN: Research and development: Technical and scientific publications 1988. Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, p. 151-158. In German. (MBB-UT-020-87-PUB)

The development of The Cabin Intercommunication Data System (CIDS) is reviewed. Cockpit design and the problems that the design poses for communication are discussed. The CIDS concept as a solution for these problems is explained, and the design of CIDS and its mode of functioning are described. The advantages of CIDS are outlined. C.D.

A89-43148

AN OVERVIEW OF THE DIRECT SIMULATION OF AN INTEGRATED AIRCRAFT NAVIGATION SYSTEM ON A PC

STEVEN KARELS (Analytic Sciences Corp., Reading, MA) and WILLARD HOLMES (U.S. Army, Missile Command, Huntsville, AL) IN: 1988 Annual Summer Computer Simulation Conference, 20th, Seattle, WA, July 25-28, 1988, Proceedings. San Diego, CA, Society for Computer Simulation International, 1988, p. 792-797.

A large-scale, direct (Monte Carlo) simulation of an integrated aircraft navigation system, implemented on a Personal Computer (PC), is described in terms of its features, architecture, and performance. The simulation was written to permit investigations of the integration of GPS technology into cruise missile avionics. The navigation system includes a gimbaled Inertial Navigation System (INS); a five-channel, adaptive-bandwidth Global Positioning System (GPS) receiver, and a baro-altimeter. This development focused on providing an analysis tool based on an existing main-frame computer simulation and on re-hosting it to a Government-furnished PC. A realistic dynamic environment is provided by a five-DOF trajectory generator, driven by DTED maps for terrain-following flight. A complex jamming environment, coordinated with the terrain features, is also simulated. An 11-state Kalman filter integrates the INS and radio navigation system measurements. A variety of navigation performance results are described, and PC throughput timing, partitioning, and data flow issues are addressed. Author

A89-43573#

FUTURE AIR NAVIGATION SYSTEMS (FANS)

JENS-UWE KOCH (Deutsche Lufthansa AG, Frankfurt am Main, Federal Republic of Germany) *Ortung und Navigation* (ISSN 0474-7550), vol. 30, no. 1, 1989, p. 73-82.

Current development trends in aircraft communication, navigation, and surveillance (CNS) are reviewed, summarizing the recommendations of the ICAO Special Committee on Future Air Navigation Systems (FANS). The history of FANS and organizational aspects of its operations are discussed; the limitations of current CNS systems are outlined; and global all-attitude coverage, digital data-exchange capability, and service for non-MLS airfields are identified as key objectives for the future. Particular attention is given to digital modulation techniques, system architectures, flexible performance-based standards for onboard CNS equipment, utilization of satellite navigation systems, secondary and primary surveillance radars, navigation systems for ground traffic, collision-avoidance systems, system validation procedures, and the role of the ICAO in establishing standards and coordinating implementation. T.K.

N89-23438# Federal Aviation Administration, Atlantic City, NJ. INSTRUMENT LANDING SYSTEM MATHEMATICAL MODELING STUDY FOR ORLANDO INTERNATIONAL AIRPORT RUNWAY 35L LOCALIZER, ORLANDO, FLORIDA. FINAL AIRSIDE DOCKING PLAN (SCHEME 3A)

JAMES D. RAMBONE and JOHN E. WALLS Dec. 1988 30 p (AD-A205351; DOT/FAA/CT-TN89/4) Avail: NTIS HC A03/MF A01 CSCL 17/7

This Technical Note describes the instrument landing system (ILS) math modeling performed by the Federal Aviation Administration (FAA) Technical Center at the request of the Southern Region. Computed data are presented showing the effects of airside terminals with simulated docked and taxiing aircraft on the performance of an ILS localizer proposed for runway 35L at the Orlando International Airport. The Southern Region is concerned that reflections from two proposed airside terminals with docked and taxiing aircraft may degrade the localizer course beyond category II/III tolerances. Modeled course structure results indicate that category II/III localizer performance should be obtained with the Wilcox Mark II, 14-element, dual-frequency log periodic antenna and both airside terminals with docked and taxiing aircraft at the currently proposed locations. Computed clearance orbit results indicate satisfactory linearity, course crossover, and signal clearance levels. GRA

N89-23440# Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.

GENERATION OF ARCHITECTURES FOR DISTRIBUTED INTELLIGENCE SYSTEMS

ALEXANDER H. LEVIS Feb. 1989 22 p
(Contract N00014-85-K-0519)
(AD-A205783; LIDS-P-1849) Avail: NTIS HC A03/MF A01
CSCL 12/9

An approach to the modeling of discrete event distributed intelligence system is presented that uses ordinary Petri Nets for fixed structure architectures. The model leads to the precise formulation of the problem of generating the complete set of architectures that satisfy a number of resource and design constraints. Two algorithms are presented: The first one (the DFS algorithm) starts with the specification of the desired functionality and generates data flow structures with prescribed redundancy and complexity; then the various functions are allocated to resources; the second one (the Lattice algorithm) starts with a given set of decision making units and obtains the partially ordered sets that contain all the feasible architectures. The resulting architectures can be analyzed to evaluate their performance characteristics. GRA

N89-23443# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

DEVELOPMENT OF THE EXTENDED KALMAN FILTER FOR THE ADVANCED COMPLETELY INTEGRATED REFERENCE INSTRUMENTATION SYSTEM (CIRIS) M.S. Thesis

JOSEPH K. SOLOMON Mar. 1989 160 p
(AD-A206083; AFIT/GE/ENG/89M-8) Avail: NTIS HC A08/MF A01
CSCL 17/7

The Completely Integrated Reference Instrumentation System (CIRIS) was developed by the Central Inertial Guidance Test Facility (CIGTF) at Holloman AFB, NM. The CIRIS system is an inertial navigation system (INS) aided with line-of-sight range and range-rate measurements from surveyed ground transponders. The information from the measurement and INS data is combined using an extended Kalman filter to produce an accurate estimate of the INS position and velocity errors. The accurate CIRIS aircraft position and velocity data is used as a baseline reference to determine the performance capabilities of proposed aircraft navigation systems. The new aircraft navigation systems projected in the next five years will attain accuracies approaching the level of the current CIRIS system. In order to test these systems, the accuracy of CIRIS will be increased through the addition of aiding measurements from the Global Positioning System (GPS). GRA

N89-23444# Royal Signals and Radar Establishment, Malvern (England).

COMPARISON OF INTERPOLATION ALGORITHMS FOR SPEED CONTROL IN AIR TRAFFIC MANAGEMENT

A. J. BUDD 17 Aug. 1988 21 p
(AD-A206314; RSRE-MEMO-4131; DRIC-BR-109213) Avail:
NTIS HC A03/MF A01 CSCL 17/7

With air traffic movements at a high level, techniques to assist air traffic management using computers are being investigated.

One technique in particular being studied is the early adjustment of the speed of arriving aircraft so that the rate of flow near to the airports is closely matched to landing capacity. A Speed Control Adviser has been developed which allocates a landing time to each inbound aircraft. Once the estimated landing time is known, the speed the aircraft must fly needs to be calculated. This cannot be done directly and interpolation using a suitable polynomial approximation is used. This memorandum investigates four polynomials and examines their effectiveness at providing a good estimate with minimum computations. GRA

N89-24291# Federal Aviation Administration, Washington, DC. Technical Center.

AN OPERATIONAL DEMONSTRATION AND ENGINEERING FLIGHT TEST OF THE MICROWAVE LANDING SYSTEM ON RUNWAY 22L AT CHICAGO'S MIDWAY AIRPORT Technical Note, Sep. 1988

CLIFFORD W. MACKIN, EDMUND ZYZYS, and ROBERT H. PURSEL Oct. 1988 41 p
(Contract FAA-T0604-F)
(DOT/FAA/CT-TN88/42) Avail: NTIS HC A03/MF A01

At the request of the Great Lakes Region, the Federal Aviation Administration (FAA) Technical Center conducted an operational demonstration of Microwave Landing System (MLS) on runway 22L at Chicago's Midway Airport. The MLS test bed installed at the FAA Technical Center was transported to, and temporarily installed at Chicago's Midway Airport. Three engineering flighttests were conducted on August 27, 28, and 29, 1988, to verify and characterize system operation. On August 30, three demonstration flights were conducted for the aviation industry, the media, and FAA personnel. Three profiles were designed for these flights to demonstrate the operational capabilities of MLS. The operational capability of MLS was successfully demonstrated and the MLS signal in space met Category 2 instrument landing system (ILS) tolerances. Author

N89-24292# Federal Aviation Administration, Atlantic City, NJ. **CONTROLLER EVALUATION OF INITIAL DATA LINK AIR TRAFFIC CONTROL SERVICES. VOLUME 1: MINI STUDY 2 Final Report**

NICHOLAS J. TALOTTA, CLARK SHINGLEDECKER, THOMAS ZURINSKAS, KAROL KERNS, and HENRY R. MAREK Mar. 1989 37 p
(DOT/FAA/CT-89/14-VOL-1) Avail: NTIS HC A03/MF A01

The results of Mini Study 2 are detailed. This Mini Study was conducted at the Federal Aviation Administration (FAA) Technical Center utilizing the Data Link test bed. Initial Data Link air traffic control services were evaluated under part task simulation conditions in order to identify service delivery methods which optimize controller acceptance, performance, and workload. Author

N89-24293*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

B-737 FLIGHT TEST OF CURVED-PATH AND STEEP-ANGLE APPROACHES USING MLS GUIDANCE Technical Report, Apr. 1982 - Feb. 1986

J. R. BRANSTETTER (Federal Aviation Administration, Hampton, VA.) and W. F. WHITE Apr. 1989 188 p
(NASA-TM-101521; NAS 1.15:101521; FAA-PM-86/20) Avail:
NTIS HC A09/MF A01 CSCL 17/7

A series of flight tests were conducted to collect data for jet transport aircraft flying curved-path and steep-angle approaches using Microwave Landing System (MLS) guidance. During the test, 432 approaches comprising seven different curved-paths and four glidepath angles varying from 3 to 4 degrees were flown in NASA Langley's Boeing 737 aircraft (Transport Systems Research Vehicle) using an MLS ground station at the NASA Wallops Flight Facility. Subject pilots from Piedmont Airlines flew the approaches using conventional cockpit instrumentation (flight director and Horizontal Situation Indicator (HSI)). The data collected will be used by FAA procedures specialists to develop standards and criteria for designing MLS terminal approach procedures (TERPS). The

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use of flight simulation techniques greatly aided the preliminary stages of approach development work and saved a significant amount of costly flight time. This report is intended to complement a data report to be issued by the FAA Office of Aviation Standards which will contain all detailed data analysis and statistics. Author

N89-24294# Federal Aviation Administration, Washington, DC. Office of Aviation Medicine.

A COMPARISON OF DETECTION EFFICIENCY ON AN AIR TRAFFIC CONTROL MONITORING TASK WITH AND WITHOUT COMPUTER AIDING

RICHARD I. THACKRAY and R. M. TOUCHSTONE Jan. 1989 12 p
(AD-A206422; DOT/FAA/AM-89/1) Avail: NTIS HC A03/MF A01 CSCL 17/7

Future levels of air traffic control automation plan to incorporate computer aiding features designed to alert the controller to upcoming problem situations by displaying information that will identify the situation and suggest possible solutions. Concerns have been expressed that reliance on such aids may lead to a reduced capacity to detect and respond to infrequent failures of the automation. The present study employed a simulated ATC monitoring task with a computer-aiding feature designed to detect possible aircraft conflict situations. The ability of subjects to detect occasional failures of the computer-aiding feature in detecting problem situations was compared with detection efficiency for these same situations when no computer aiding was provided. The hypothesis that alertness would be lower and detection less efficient with computer aiding than when no aiding was employed was not supported. Applications and limitations of the findings to the problem of complacency in automated systems are discussed.

GRA

N89-24295# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuehrung.

IMAGE SIGNAL PROCESSING FOR FLIGHT GUIDANCE

Sep. 1988 315 p Partly in ENGLISH and GERMAN Colloquium held in Brunswick, Fed. Republic of Germany, 30-31 May 1988; sponsored by DFVLR

(DFVLR-MITT-88-32; ISSN-0176-7739; ETN-89-94645) Avail: NTIS HC A14/MF A01; DFVLR, VB-PL-DO, Postfach 40 60 58, 5000 Cologne, Fed. Republic of Germany, DM 108

Scene reconstruction for image sequences, and aspects of image communication in air-to-ground systems are discussed. A displacement-estimation technique for aerial video scenes, and a parametric displacement estimation scheme for aerial images were studied. Terrain-aided flight navigation in near-Earth sections, and landscape-related position finding for flying systems are outlined. The determination of reference trajectories for testing navigation aids using an onboard CCD camera was investigated. The transformation of real and virtual objects into a virtual, visual environment, and the display of flight guidance information in the aircraft cockpit are discussed. Status and trends of technological image processing possibilities are outlined. A versatile flight experiment system for image processing is presented.

ESA

N89-24296# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuehrung.

IMAGE SIGNAL PROCESSING FOR FLIGHT GUIDANCE: OVERVIEW AND INTRODUCTION TO THE MAIN TOPICS [BILDSIGNALVERARBEITUNG FUER AUFGABEN DER FLUGFUEHRUNG. UEBERBLICK UND EINFUEHRUNG IN DIE THEMENSCHWERPUNKTE]

A. BECKER *In its* Image Signal Processing for Flight Guidance p 9-24 Sep. 1988 In GERMAN; ENGLISH summary Avail: NTIS HC A14/MF A01; DFVLR, VB-PL-DO, Postfach 40 60 58, 5000 Cologne, Fed. Republic of Germany, DM 108

The main applications of image signal processing in flight guidance are introduced, the main topics are defined, and connections between these topics are pointed out. Image signal

coding for perturbation-resistant air-to-ground communication; image aided navigation; image synthesis; and stationary and flight-fit experimental arrangements are discussed. ESA

N89-24303# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuehrung.

DETERMINATION OF REFERENCE TRAJECTORIES FOR TESTING NAVIGATION AIDS USING AN ONBOARD CCD CAMERA

ULRICH BROKOF and H.-D. SCHWIND (Bundesanstalt fuer Flugsicherung, Klosterlechfeld, Germany, F.R.) *In its* Image Signal Processing for Flight Guidance p 181-215 Sep. 1988 In GERMAN; ENGLISH summary Avail: NTIS HC A14/MF A01; DFVLR, VB-PL-DO, Postfach 40 60 58, 5000 Cologne, Fed. Republic of Germany, DM 108

A flight inspection system was developed. A solid state camera onboard the test aircraft was used to make the flight inspection system independent of ground stations. In testing an instrument landing system the camera detects the field of white stripes on both ends of the runway. The flight trajectory generated by velocity data of an inertial navigation system is aided by distance data and additionally updated with the precise position information of the video system. Since this information is only available at the end of a measuring flight, the final computation is performed offline (but during the flight) by backward smoothing. The obtainable results are demonstrated by simulation calculations. ESA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A89-39836#

BO108 - AN ULTRAMODERN GERMAN HELICOPTER [BO108 - EIN DEUTSCHER HUBSCHRAUBER MODERNSTER TECHNOLOGIE]

VOLKER VON TEIN and CLAUS SCHICK (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) DGLR, Jahrestagung, Darmstadt, Federal Republic of Germany, Sept. 20-23, 1988, Paper. 12 p. In German. refs

(MBB-UD-530-88-PUB)

The development of the ultramodern German helicopter BO108 is discussed. The concept and goals of the BO108 are outlined, and examples of the way that selected components of the aircraft are being developed are described. These include the rotor system, main engines, main hydraulic system, tail rotor and engine, and fully integrated vibration isolation system. The design of the tail structure is addressed, as are the electrical system and radio navigation system. The status of the program is briefly addressed. C.D.

A89-39840#

THE DEVELOPMENT OF A COMPOSITE HELICOPTER FUSELAGE AS EXEMPLIFIED ON THE BK 117

ALEXANDER ENGLER and WOLFRAM KOLETZKO (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Associazione Industrie Aerospaziali and Associazione Italiana di Aeronautica ed Astronautica, European Rotorcraft Forum, 14th, Milan, Italy, Sept. 20-23, 1988, Paper. 20 p. (MBB-UD-534-88-PUB)

A West German technology program to develop a composite fuselage for the BK 117 helicopter is described. The design philosophy is discussed, including models, tools, and parts. Consideration is given to structural joints, electrical effects, and stress analysis. The process of manufacturing and integrating the

lower fuselage and cockpit assemblies is examined. Results are presented from testing and analysis of the fuselage. R.B.

A89-39844#
BO 108 - TECHNOLOGY FOR NEW LIGHT TWIN HELICOPTERS

VOLKER VON TEIN and CLAUS SCHICK (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Associazione Industrie Aerospaziali and Associazione Italiana di Aeronautica ed Astronautica, European Rotorcraft Forum, 14th, Milan, Italy, Sept. 20-23, 1988, Paper. 18 p. refs (MBB-UD-529-88-PUB)

The technology used in the development of the BO 108 helicopter is discussed. The BO 105 helicopter is described and the characteristics of the BO 105 which have been improved for the BO 108 are outlined. The BO 108 rotor system, main transmission, hydraulic system, tail rotor and tail rotor drive system, fully integrated vibration isolation system, and airframe are described in detail. In addition, the electrical system, the engines, and the radio and navigation systems are examined. The status of the BO 108 development program is evaluated and the basic performance data for the helicopter are given. R.B.

A89-39845#
DESIGN AND DEVELOPMENT TESTS OF A FIVE-BLADED HINGELESS HELICOPTER MAIN ROTOR

DIETER BRAUN and HELMUT HUBER (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Associazione Industrie Aerospaziali and Associazione Italiana di Aeronautica ed Astronautica, European Rotorcraft Forum, 14th, Milan, Italy, Sept. 20-23, 1988, Paper. 17 p. refs (MBB-UD-531-88-PUB)

To evaluate the effects of a higher number of blades on main rotors, an experimental program was conducted with a five-bladed rotor system. For that, the four-bladed hingeless rotor system of the BO 105 helicopter was fitted with an additional fifth blade resulting in 25 percent more blade area. The five-bladed hub design is very similar to that of the four-bladed production version. An essential difference, however, is represented by changing the inclination of the blade pitch axis to 0 deg which was expected to affect positively the lead-lag/torsion coupling and in-plane damping. In the present paper, a survey of the rotor design rationale, the main characteristics, and the most important results from whirl tower and flight testing in the fields, performance, handling qualities, rotor loads, aeroelastic stability, and vibrations is given. Author

A89-40083
FATIGUE DAMAGE TO AN AIRCRAFT FROM GUSTS [UNAVOVE POSKOZENI LETOUNU OD PORYVU]

JOSEF VLACHYNSKY Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1989, p. 17-24. In Czech. refs

Three methods for calculating the fatigue damage to an aircraft from gusts are presented. Two involve the hypothesis of the linear accumulation of fatigue damage; one of the methods considers the dynamic behavior of the aircraft, whereas the other does not. The third method involves the hypothesis of the spectral accumulation of loading energy, taking the dynamic behavior of the aircraft into account. The results obtained by these methods are compared. B.J.

A89-40261
AIRBORNE POD STRUCTURES

HAROLD MALM (Sargent-Fletcher Co., El Monte, CA) IN: Airborne reconnaissance XII; Proceedings of the Meeting, San Diego, CA, Aug. 16, 17, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 80-83.

Military aircraft external fuel tanks, which have been designed for large-volume production, may follow the USAF preference for three-sectioned structures with low assembly time characteristics or that of the USN for a monocoque structure with access doors for the servicing of internal components; either type can readily be converted to house 'special purpose' photographic reconnaissance equipment, countermeasures, etc. Attention is

presently given to a reconnaissance-instrument pod designed to MIL-A-8591 ('External Stores Suspension Criteria') in all matters affecting pod/tank interface load reactions. O.C.

A89-40814#
ROUGH DESIGN CRITERION FOR GROUND AND AIR RESONANCE OF HELICOPTER ROTOR WITH THREE OR MORE BLADES

SHIGENORI ANDO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 37, no. 422, 1989, p. 155-158. In Japanese, with abstract in English.

The rough criterion for the ground or air resonance of helicopter rotor with three or more blades, which was presented by Donham et al. (1966) is simple and useful. The theoretical basis, is however, not so clear. It is the purpose of this paper to assign some theoretical reasons for the criterion. Coleman's (1956) theory is reviewed, and then a concept of 'Quasi-Resonance-Center' is defined. Then it is found that the 'Resonance Region' designated by Donham et al. is the above 'Quasi-Resonance-Center' and nothing but. Author

A89-40857
MD-11 ENTERS THE FRAY

JOHN BAILEY Flight International (ISSN 0015-3710), vol. 135, May 6, 1989, p. 34-39.

The design features and operational capabilities of the MD-11 follow-on aircraft to the DC-10 airliner are presented. The derivative approach employed by the manufacturer has saved millions of dollars in development costs; the same assembly line and workforce as the DC-10 will be used. A prominent feature of the cabin is the flexibility with which it can be reconfigured. The galleys and lavatories are secured to the main deck by the seat tracks, and can be adjusted in 1-inch increments along the length of the constant-section fuselage. Attention is given to the payload/range capability of the MD-11, the MD-11 'superstretch' version, and the currently operational DC-10-30. O.C.

A89-41029#
THE JOINED WING - THE BENEFITS AND DRAWBACKS. II [ZAMKNIETE SKRZYDLO - ZALETY I WADY. II]

STANISLAW DANILECKI (Warszawa, Politechnika, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, Oct. 1988, p. 8-10. In Polish.

Problems encountered in the design of aircraft featuring the joined wing are described. New design issues arising in the design processes are discussed. B.J.

A89-41063
SOVIET AEROSPACE INDUSTRY - MIKOYAN DESIGN GROUP UPGRADING MIG-29 WITH FLY-BY-WIRE CONTROLS, NEW COCKPIT

Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, June 5, 1989, p. 81.

The use of fly-by-wire controls by upgraded MiG-29 fighters will mark a turning point in the Mikoyan design bureau's design work, in the direction of aerodynamically unstable combat aircraft. The MiG-29 is also the first Mikoyan aircraft to make substantial use of composite materials, primarily in the form of carbon fiber-reinforced epoxy resins. R&D work has been undertaken by Mikoyan on combat aircraft thrust-vectoring concepts. The two-seat MiG-31 variant of the MiG-25 interceptor remains in production, with an improved avionics/fire-control system and different engines, as well as modified landing gear facilitating operation from soft airfields. O.C.

A89-41075
MODIFIED F-15B TO DEMONSTRATE STOL, MANEUVER CAPABILITY

STANLEY W. KANDEBO Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, May 29, 1989, p. 44, 45, 47.

The USAF STOL/Maneuver Technology Demonstrator F-15B testbed aircraft will incorporate canards, a four-channel FBW flight/propulsion-control system, rough-field landing gear, and

advanced cockpit controls and displays, as well as two-dimensional engine thrust-vectoring/thrust-reversing nozzles acting on the output of F100-PW-220 engines. Wing and empennage control surfaces will be coordinated with the canards and two-dimensional thrust vectoring nozzles in such a way as to greatly increase maneuvering and TO&L performance. A key goal of this flight test program is the achievement of landings on a 50 x 1500-ft airstrip, using the new nozzles' thrust-reversal capability. O.C.

A89-41092* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

IDENTIFICATION OF XV-15 AEROELASTIC MODES USING FREQUENCY-DOMAIN METHODS

C. W. ACREE, JR. (NASA, Ames Research Center, Moffett Field, CA) and MARK B. TISCHLER (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) *Vertica* (ISSN 0360-5450), vol. 13, no. 1, 1989, p. 51-62. Previously announced in STAR as N88-17646. refs

The XV-15 Tilt-Rotor wing has six major aeroelastic modes that are close in frequency. To precisely excite individual modes during flight test, dual flaperon exciters with automatic frequency-sweep controls were installed. The resulting structural data were analyzed in the frequency domain (Fourier transformed) with cross spectral and transfer function methods. Modal frequencies and damping were determined by performing curve fits to transfer function magnitude and phase data and to cross spectral magnitude data. Results are given for the XV-15 with its original metal rotor blades. Frequency and damping values are also compared with earlier predictions. Author

A89-41093* Texas A&M Univ., College Station.

GENERIC ICING EFFECTS ON FORWARD FLIGHT PERFORMANCE OF A MODEL HELICOPTER ROTOR

ANA F. TINETTI and KENNETH D. KORKAN (Texas A & M University, College Station) *Vertica* (ISSN 0360-5450), vol. 13, no. 1, 1989, p. 63-85. refs (Contract NAG3-626)

An experimental program using a commercially available model helicopter has been conducted in the TAMU 7 ft x 10 ft Subsonic Wind Tunnel to investigate main rotor performance degradation due to generic ice adhesion. Base and iced performance data were gathered as functions of fuselage incidence, blade collective pitch, main rotor rotational velocity, and freestream velocity. The experimental values have shown that, in general, the presence of generic ice introduces decrements in performance caused by leading edge separation regions and increased surface roughness. In addition to the expected changes in aerodynamic forces caused by variations in test Reynolds number, forward flight data seemed to be influenced by changes in freestream and rotational velocity. The dependence of the data upon such velocity variations was apparently enhanced by increases in blade chord. Author

A89-41109#

HALE - A HIGH-ALTITUDE, LONG-ENDURANCE MANNED AIRCRAFT

CHRIS BURMEISTER, SCOTT DANENHAUER, DAVID FANNING, DAVID HENN, and NIKOS MILLS (Kansas, University, Lawrence) *AIAA Student Journal* (ISSN 0001-1460), vol. 26, Winter 1988-1989, p. 14-22.

The design of a high-altitude, long-endurance aircraft called the Summit is presented. The mission specifications for the Summit include an endurance of 72 hrs of flight at or above 45,000 ft and a cruise speed of at least 150 kts. The configurations considered for the Summit craft are outlined and the final joined-wing centered engine configuration is described in detail. The aerodynamic calculations to determine the Summit specifications are given, including airfoil selection, lift and drag determination, time-to-climb and endurance requirements, take-off and landing lengths, engine performance characterization, and powerplant, propulsion system, and propeller selection. R.B.

A89-41562#

HYDRODYNAMIC CHARACTERISTICS OF SEAPLANES AS AFFECTED BY HULL SHAPE PARAMETERS

INGO DATHE (Dornier Luftfahrt GmbH, Federal Republic of Germany) and MANRICO DE LEO (Aeritalia S.p.A, Gruppo Velivoli Trasporto, Pomigliano d'Arco, Italy) IN: Intersociety Advanced Marine Vehicles Conference and Exhibit, Arlington, VA, June 5-7, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 275-284. refs (AIAA PAPER 89-1540)

The contour of a seaplane hull are more fundamentally determined by hydrodynamic requirements than aerodynamic ones; in order to fulfil these requirements for safe, stable take-off with low resistance and spray irrespective of sea-state, extensive reference will have to be made to published data regarding scale-model tests. The most significant trends associated with hull shape will be discussed with a view to their relevance to the minimization of resistance and spray, as well as the maximization of hull stability and the reduction of impact loads. O.C.

A89-41563#

THE CANADAIR CL-215 AMPHIBIOUS AIRCRAFT - DEVELOPMENT AND APPLICATIONS

W. B. REMINGTON (Bombardier, Inc.; Canadair, Inc., Aerospace Group, Montreal, Canada) IN: Intersociety Advanced Marine Vehicles Conference and Exhibit, Arlington, VA, June 5-7, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 285-293. (AIAA PAPER 89-1541)

An account is given of the development history of the CL-215 amphibious seaplane from 1963 to the present, with attention to the refinement of the aircraft's aerodynamics and hydrodynamics and the impending conversion of its powerplant from reciprocating to turboprop engines. For a given set of nondimensionalized hull hydrodynamic characteristics, the marked effect of significant aerodynamic low-speed lift on dimensionalized hydrodynamic characteristics is noted. The primary mission that has evolved for the CL-215 is that of 'water bombing', which involves the scooping up of water in over-water flight and its subsequent dumping over forest fires. O.C.

A89-41571#

SEARCH AND RESCUE AMPHIBIOUS AIRCRAFT IN JAPAN

YUSHI TANAKA (Shin Meiwa Industry Co., Ltd., Aircraft Div., Kobe, Japan) IN: Intersociety Advanced Marine Vehicles Conference and Exhibit, Arlington, VA, June 5-7, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 439-443. refs (AIAA PAPER 89-1500)

The Japan Maritime Self-Defense Force has operated the US-1A amphibious variant of the PS-1 flying boat for search-and-rescue missions since 1976. An account is presently given of representative rescue operations concerning disabled ships at sea or natural disaster victims on inaccessible islands, as well as the modifications to which the baseline seaplane was subjected in order to arrive at an effective amphibian. Also noted are the training measures taken to maximize rescue crew effectiveness. O.C.

A89-41589

EVOLUTION OF ROTOR BLADE ABRASION STRIPS AT BELL HELICOPTER TEXTRON

JOE B. DUNHAM (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: Competitive advances in metals and processes; Proceedings of the First International SAMPE Metals and Metals Processing Conference, Cherry Hill, NJ, Aug. 18-20, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 203-208.

Abrasion strips, which are incorporated by the structures of helicopter rotor blades for the sake of protection against erosion and impact damage must meet close tolerance requirements to satisfy aerodynamic configuration constraints, as well as to maintain the requisite degree of structural bonding. They must also be finished to weigh within very tight tolerance requirements, in order

to achieve the necessary balancing in a given rotor. A development history is presently given for a major helicopter manufacturer's variously plated stainless steel, titanium, and electroformed nickel abrasion strips. O.C.

A89-41652
ON THE OPTIMUM CRUISE SPEED OF A HYPERSONIC AIRCRAFT

DIETRICH E. KOELLE (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 4, May 1989, p. 13-16.

Some preliminary results that have been obtained in the frame of the Saenger system studies are presented. Saenger is a West German study project and technology reference system for a future advanced space transportation system. The first stage of this vehicle is a hypersonic aircraft from which a passenger version could be derived. The analyses indicate that a speed of Mach 4.4 will lead to maximum seat mileage per day as well as to minimum propellant consumption. The speed-related cruise altitude of 24,500 m or 80,000 ft is above the most sensitive ozone layer and high enough to produce only one-third of the noise ground pressure which is considered as the acceptable limit (1 lb/sq ft) over populated areas. The aircraft surface temperatures at these conditions can still be managed by a conventional titanium alloy structure with special provisions only at the leading edge and the engine inlets. The potential route structure and economics of such an aircraft are discussed. I.E.

A89-41913#
THE USE OF OPERATIONAL LOADS DATA TO ASSESS FATIGUE DAMAGE RATES IN A JET TRAINER AIRCRAFT

P. C. CONOR (National Aeronautical Establishment, Structures and Materials Laboratory, Ottawa, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 35, March 1989, p. 26-35. refs

Concern over the fatigue damage accumulation rate of a fleet of jet trainers led to an operational load survey of the aircraft using a single-channel microprocessor recorder measuring the strain levels in wing lower-spar booms of instrumented aircraft. The discovery of unanticipated fatigue cracks in the wings of several aircraft led to an assessment of in-flight strain levels, as well as to an evaluation of the fatigue damage derived from individual missions and mission types. The elevated rate of fatigue damage appears to be associated with maneuvers flown near the end of missions, when bending-relief effects due to wing tank fuel loads were negligible. O.C.

A89-41950
WESTERN EXPERTS IMPRESSED BY DESIGN OF MI-28 PROTOTYPE

DONALD E. FINK Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, June 26, 1989, p. 44-46, 51.

The Mi-28 helicopter gunship prototype was on display at the 1989 Paris Air Show, where Western helicopter specialists witnessing its demonstration flights conceded its incorporation of design features and possession of performance capabilities that would give its production versions impressive value on the battlefield. The Mi-28's payload includes a chin-mounted 30-mm cannon, a day/night sighting system, and a variety of radar-guided missiles and unguided rockets; the choice of this weapons suite is driven by the Soviet Army's antitank requirements. The downward orientation of the engines' IR suppressors indicates that the Mi-28 has been designed for nap-of-the-earth operations. O.C.

A89-42018*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, CA.
IDENTIFICATION OF XV-15 AEROELASTIC MODES USING FREQUENCY SWEEPS

C. W. ACREE, JR. (NASA, Ames Research Center, Moffett Field, CA) and MARK B. TISCHLER (U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 667-674. refs

The XV-15 tilt-rotor wing has six major aeroelastic modes that are close in frequency. To precisely excite individual modes during flight test, dual flap-eron exciters with automatic frequency-sweep controls were installed. The resulting structural data were analyzed in the frequency domain (Fourier-transformed). Modal frequencies and damping were determined by performing curve fits to frequency-response magnitude and phase data. Results are given for the XV-15 with its original metal rotor blades. Frequency and damping values are also compared with predictions by two different programs, CAMRAD and ASAP. Author

A89-42019*# Technische Univ., Brunswick (Germany, F.R.).
EXPERIMENTAL INVESTIGATION OF THE CRASHWORTHINESS OF SCALED COMPOSITE SAILPLANE FUSELAGES

KARL-PETER KAMPF (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany), EDWARD F. CRAWLEY, and R. JOHN HANSMAN, JR. (MIT, Cambridge, MA) Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 675-681. refs (Contract NAG1-690)

The crash dynamics and energy absorption of composite sailplane fuselage segments undergoing nose-down impact were investigated. More than 10 quarter-scale structurally similar test articles, typical of high-performance sailplane designs, were tested. Fuselage segments were fabricated of combinations of fiberglass, graphite, Kevlar, and Spectra fabric materials. Quasistatic and dynamic tests were conducted. The quasistatic tests were found to replicate the strain history and failure modes observed in the dynamic tests. Failure modes of the quarter-scale model were qualitatively compared with full-scale crash evidence and quantitatively compared with current design criteria. By combining material and structural improvements, substantial increases in crashworthiness were demonstrated. Author

A89-42025#
COMMENT ON 'GENERAL FORMULATION OF THE AEROELASTIC DIVERGENCE OF COMPOSITE SWEEP-FORWARD WING STRUCTURES'

WILLIAM P. RODDEN Journal of Aircraft (ISSN 0021-8669), vol. 26, July 1989, p. 694, 695; Author's Reply, p. 695, 696. refs

A89-42525
FITTER'S HANDBOOK FOR THE ASSEMBLY OF THE HYDRAULIC, GAS, AND FUEL SYSTEM LINES OF FLIGHT VEHICLES [SPRAVOCHNIK SLESARIA-MONTAZHNIKA TRUBOPROVODNYKH KOMMUNIKATSII GIDROGAZOVYKH I TOPLIVNYKH SISTEM LETATEL'NYKH APPARATOV]

VALENTIN M. SAPOZHNIKOV Moscow, Izdatel'stvo Mashinostroenie, 1988, 192 p. In Russian. refs

Basic data are presented on the design and technical features of the hydraulic, gas, and fuel system lines of flight vehicles. Particular attention is given to methods of ensuring the purity of hydraulic and fuel systems and testing for leaks and proper functioning. The book contains schematic diagrams, descriptions, and technical specifications of testing and monitoring equipment used in the assembly and maintenance of the hydraulic, gas, and fuel systems of flight vehicles. V.L.

A89-42535
METHODS OF FLYING MODEL STUDIES [METODY ISSLEDOVANIYA NA LETAIUSHCHIKH MODELIYAKH]

ARSENII D. MIRONOV, GENNADII P. VLADYCHIN, ANATOLII A. KONDRATOV, I. K. KHANOV, V. N. BYZOV et al. Moscow, Izdatel'stvo Mashinostroenie, 1988, 144 p. In Russian. refs

Methods of studying aerodynamic phenomena, high-velocity heat transfer, flight dynamics at large angles of attack, and aeroelastic stability using specially designed free-flying models are discussed. The role of flying model studies in the overall process of aircraft design is defined, and requirements for models, stabilization and control systems, and measurement equipment are formulated. The discussion also covers methods for the identification of the aerodynamic, dynamic, and aeroelastic

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characteristics of individual components and complete models.

V.L.

A89-42600

**THE MI-8 HELICOPTER: DESIGN AND MAINTENANCE
[VERTOLET MI-8: USTROISTVO I TEKHNIЧЕСKOE
OBSLUZHIVANIE]**

VIACHESLAV A. DANILOV Moscow, Izdatel'stvo Transport, 1988, 280 p. In Russian.

The book contains basic technical data on the Mi-8 helicopter. In particular, attention is given to the general design of the helicopter and its main components, including the fuselage, takeoff and landing gear, powerplant, transmission, main and auxiliary rotors, and the pneumatic and deicing systems. The discussion also covers helicopter control, the hydraulic system, heating and ventilation, maintenance procedures, and support services. V.L.

A89-42934

**DEVELOPMENT OF A MONOLITHIC FUSELAGE SHELL USING
CFRP [ENTWICKLUNG EINER MONOLITHISCHEN
RUMPFSCHALE AUS CFK]**

MARTIN VOGLSINGER and HELMUT JAKOB (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) IN: Research and development: Technical and scientific publications 1988. Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, p. 121-126. In German.

(MBB-FE-234/S/PUB/338)

The design and construction of a monolithic fuselage shell using CFRP are described. The loads on the fuselage and the design of the integral tank and outer skin are addressed, and the protection against lightning is briefly considered. The overall design is reviewed, and the materials used, the mode of production, and the tests performed on the final product are outlined. The automation of the entire process is discussed. C.D.

A89-42936

**FLIGHT TESTS WITH THE VFW 614 - ATTAS LAMINAR
GLOVE [FLUGVERSUCHE MIT DEM LAMINARHANDSCHUH
AM VFW 614 - ATTAS]**

UDO DRESSLER and JOACHIM SZODRUCH (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: Research and development: Technical and scientific publications 1988. Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, p. 133-140. In German.

(MBB-UT-0132-88-PUB)

The development of a low-resistance, transonic airfoil using natural laminarity is discussed. The laminar-turbulent transition is reviewed, and flight tests using the VFW 614 ATTAS laminar glove are described, including the test technology and the first results. The results have made it possible to design a laminar wing and to undertake optimization of its performance and characteristics.

C.D.

A89-42949#

**ENHANCED PERFORMANCE LOW FLYING AIRCRAFT
(EPLFA) - A FUTURE?**

J. M. L. REEVES (U.S. Navy, Naval Air Development Center, Warminster, PA) AIAA, ASME, Canadian Air Cushion Technology Society, et al., Intersociety Advanced Marine Vehicles Conference and Exhibit, Arlington, VA, June 5-7, 1989. 7 p. (AIAA PAPER 89-1499)

During the 1960s the author conducted free-flight and wind tunnel tests on a ram wing. Some of the wind tunnel results are presented and the L/Ds compared with theory. To account for the discrepancy between theory and the wind tunnel tests, it is postulated that while flying close to the ground, the aircraft boundary layer gradually transitions from turbulent to laminar, hence substantially increasing cruise L/Ds. The cruise L/Ds of an aircraft having both low and high altitude capability experiencing partial and full laminar flow conditions are presented and conclusions drawn. Author

A89-43058#

**EFFECT OF HEAD-UP DISPLAY DYNAMICS ON FIGHTER
FLYING QUALITIES**

RANDALL E. BAILEY (Calspan Corp., Buffalo, NY) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 743-754) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, July-Aug. 1989, p. 514-520. Previously cited in issue 23, p. 3399, Accession no. A86-47485. refs (Contract F33615-83-C-3603)

A89-43115#

**COCKPIT-CANOPY FRAGMENTATION SYSTEM FOR
IMMEDIATE PILOT RESCUE**

**[COCKPITHAUBEN-ANBRUCHSYSTEM ZUR
VERZOEGERUNGSFREIEN RETTUNG DES PILOTEN]**

HARTMUT GEHSE and RALPH KOCH Dornier Post (ISSN 0012-5563), no. 3, 1988, p. 28, 29. In German.

The design and test performance of prototype cockpit-canopy fragmentation systems for advanced fighter aircraft are described and illustrated with diagrams and photographs. The design requirements include rapid clearance of the pilot ejection path and avoidance of glass splinters; the design analysis accounts for the forces due to the ejecting seat, the aircraft aerodynamics, the cabin pressure, and the integrated string-type explosive charge of the fragmentation system itself. Initial tests with a cast acrylic-glass canopy were evaluated photographically to determine the stress distribution, and a new design using a stronger drawn acrylic glass was developed and validated in tests involving ejection of a dummy at zero velocity and altitude. T.K.

A89-43450* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

INTERDISCIPLINARY AND MULTILEVEL OPTIMUM DESIGN

JAROSLAW SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA) and RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) IN: Computer aided optimal design: Structural and mechanical systems. Berlin, Springer-Verlag (NATO ASI Series. Volume F27), 1987, p. 655-701. Previously announced in STAR as N87-15205. refs

Interactions among engineering disciplines and subsystems in engineering system design are surveyed and specific instances of such interactions are described. Examination of the interactions that a traditional design process in which the numerical values of major design variables are decided consecutively is likely to lead to a suboptimal design. Supporting numerical examples are a glider and a space antenna. Under an alternative approach introduced, the design and its sensitivity data from the subsystems and disciplines are generated concurrently and then made available to the system designer enabling him to modify the system design so as to improve its performance. Examples of a framework structure and an airliner wing illustrate that approach. Author

N89-23447*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FLUTTER OF A LOW-ASPECT-RATIO RECTANGULAR WING

STANLEY R. COLE Jun. 1989 19 p (NASA-TM-4116; L-16544; NAS 1.15:4116) Avail: NTIS HC A03/MF A01 CSCL 01/3

A flutter test of a low-aspect-ratio rectangular wing was conducted in the Langley Transonic Dynamics Tunnel (TDT). The model used in this flutter test consisted of a rigid wing mounted to the wind-tunnel wall by a flexible, rectangular beam. The flexible support shaft was connected to the wing root and was cantilevered mounted to the wind-tunnel wall. The wing had an aspect ratio of 1.5 based on the wing semispan and an NACA 64A010 airfoil shape. The flutter boundary of the model was determined for a Mach number range of 0.5 to 0.97. The shape of the transonic flutter boundary was determined. Actual flutter points were obtained on both the subsonic and supersonic sides of the flutter bucket. The model exhibited a deep transonic flutter bucket over a narrow range of Mach number. At some Mach numbers, the flutter conditions were extrapolated using a subcritical response

technique. In addition to the basic configuration, modifications were made to the model structure such that the first bending frequency was changed without significantly affecting the first torsion frequency. The experiment showed that increasing the bending stiffness of the model support shaft through these modifications lowered the flutter dynamic pressure. Flutter analysis was conducted for the basic model as a comparison with the experimental results. This flutter analysis was conducted with subsonic lifting-surface (kernel function) aerodynamics using the k method for the flutter solution. Author

N89-23449# Aeronautical Research Labs., Melbourne (Australia).

MODELLING AIRCRAFT DYNAMICS Aerodynamics Technical Memo.

C. A. MARTIN Sep. 1988 21 p
(AD-A204086; ARL-AERO-TM-400; DODA-AR-005-534) Avail: NTIS HC A03/MF A01 CSCL 01/3

A review has been made of the approaches currently under development for the modelling of aircraft flight dynamics at high angles-of-attack. The review is based on current research literature and on discussions held during an overseas visit carried out for the purpose of technical updating in the areas of flight dynamic modelling and parameter estimation. GRA

N89-23450 Kansas Univ., Lawrence.

A CORRELATION STUDY OF X-29A AIRCRAFT AND ASSOCIATED ANALYTICAL DEVELOPMENTS D.E. Thesis

ALI REZA AHMADI 1988 280 p
Avail: Univ. Microfilms Order No. DA8903074

Contractor results of the structural and aerodynamic analysis of the X-29A aircraft were verified. A brief history and potential advantages of the X-29A aircraft are discussed. The NASA developed computer package, STARS (Structures, Aerodynamics, and Related Systems), which is used in verifying contractor results is discussed. Enhancements of the STARS package are described, particularly the incorporation of the FASTEX computer program into STARS, and the development of a complete computer graphics system. A comparative study of free vibration and aerodynamic analysis of the X-29A aircraft is given. It was shown that the natural frequencies and modeshapes determined analytically by STARS and the contractor compare relatively well with experimentally determined data. Also included is the formulation and development of the higher-order plane-stress finite dynamic triangular element. Dissert. Abstr.

N89-23451# Aircraft Research and Development Unit, Edinburg (Australia).

FLIGHT TESTING OF THE SOUTHERN CROSS REPLICA AIRCRAFT

N. G. COULSON Sep. 1988 98 p
(AD-A205303; ARDU-TI-953; DODA-AR-003-256) Avail: NTIS HC A05/MF A01 CSCL 01/3

Aircraft Research and Development Unit was tasked to carry out the test flying of a replica of the 1926 Fokker Tri-Motor as flown by Australian aviation pioneer, Sir Charles Kingsford-Smith. The purpose of the test program was, firstly, to ensure safe operation of the aircraft throughout its proposed flight envelope and, secondly, to provide data to allow the issue of a Certificate of Airworthiness or Permit to Fly. The trial included a cockpit and systems assessment as well as an evaluation of the aircraft's flight and ground handling characteristics. Airborne assessments covered stability and control characteristics, stall characteristics, general aircraft performance, asymmetric power characteristics and an evaluation of the aircraft's take-off and landing performance and handling. The flight characteristics of the test aircraft were found to be similar to those expected from an original Fokker VIIb-3M. Consequently, the aircraft could not meet some modern certification requirements. Notwithstanding this the aircraft was found to be generally safe and airworthy provided it was operated by experienced pilots in daylight Visual Meteorological Conditions and that the main recommendations of this report are adopted. GRA

N89-23452# Polytechnic Univ., Farmingdale, NY. Dept. of Aerospace Engineering.

OPTIMUM AEROELASTIC CHARACTERISTICS FOR COMPOSITE SUPERMANEUVERABLE AIRCRAFT Final Technical Report, 1 Jun. 1987 - 31 Sep. 1988

GABRIEL A. OYIBO, JAMES BENTSON, and T. A. WEISSHAAR
27 Nov. 1988 136 p
(Contract F49620-87-C-0046)
(AD-A205503; POLY-AE-88-8; AFOSR-89-0127TR) Avail: NTIS HC A07/MF A01 CSCL 01/3

The investigation of an aeroelastically induced constrained warping phenomenon for a composite, supermaneuverable type aircraft wing has continued in this second year of the study. The first year investigation was concentrated mainly on the static phenomena and the search for closed form solutions for free vibration of aircraft wings having constrained warping in the presence of elastic coupling. The wing is analytically modelled as a straight flat laminated plate. Various forms of highly simplified aerodynamic loads are employed in the analysis. The free vibrations and stability aspects of this phenomenon are examined to obtain some physical insights and to determine its importance and/or design implications. Analytical tools employed include an affine transformation concept which was formulated previously (by the present principal investigator) as well as a non-dimensionalization scheme. GRA

N89-23454# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

PRELIMINARY DESIGN OF A MODULAR UNMANNED RESEARCH VEHICLE. VOLUME 2: SUBSYSTEM TECHNICAL DEVELOPMENT DESIGN STUDY M.S. Thesis

CHRISTOPHER D. HALL, RICHARD L. JOHNSON, PETER J. LAMATSCH, DOUGLAS A. MCCABE, and PAUL J. MUELLER, III
Dec. 1988 277 p
(AD-A205678; AFIT/GSE/AA/88D-2) Avail: NTIS HC A13/MF A01 CSCL 01/3

This thesis presents the analysis and development of a modular unmanned research vehicle (MURV) to support AFIT's aeronautical research. The MURV is proposed as a test vehicle to permit experimental efforts beyond the restrictions of pure analytical and wind tunnel research, yet less costly and more accessible than full-scale flight tests. A classical systems approach was applied, in concert with a conventional aircraft design process, which emphasized system level needs and objectives in the design of MURV subsystems. Primary design drivers were the need for adequate data acquisition for anticipated experiments, structural and functional modularity to permit simple reconfiguration, and focus on a set of unique experiments relating to fighter-like supermaneuverability. The supermaneuverability experiments dictated that the general arrangement of the MURV baseline design would resemble a typical modern fighter aircraft configuration, the recommended baseline being a turbojet-powered delta wing design with canards, single vertical tail, and control-configured ventral fins. Modularity implications resulted in the design of a flexible, digital flight control system with primary functions distributed between the vehicle and a remote pilot/control ground station and a fuselage design which allows for relocation and replacement of wings and tails or canards. The data acquisition system is fully integrated with the flight control system and the remote ground station. GRA

N89-23455# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

A METHODOLOGY FOR DETERMINING THE SURVIVABILITY OF FIXED-WING AIRCRAFT AGAINST SMALL ARMS M.S. Thesis

JOHN M. GROVER Mar. 1989 119 p
(AD-A205730; AFIT/GST/ENS/89M-05) Avail: NTIS HC A06/MF A01 CSCL 15/3

The purpose of this study was to develop an efficient and effective method of evaluating the survivability of a fixed-wing aircraft against small arms. A computer model was created to predict the probability an aircraft survives given an encounter with

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a small arms weapon, P(s/e), and the expected number of hits it receives, E(hits). The model was a one-on-one deterministic duel of a small arms weapon and an aircraft. The aircraft was represented on a straight and level flight approaching the weapon at a given velocity, angle, distance, and altitude. The small arms weapon was located at a fixed position, firing at fixed point in front of the aircraft. The weapon orientation varied by normal distributions around the fixed aim point. The bullet trajectories were represented using an interactive technique. Bullet and aircraft intersections were calculated using a sphere to represent the aircraft. All probability distributions were broken into discrete intervals providing the means to maintaining a deterministic model. The results of the model supplied a probability of survival and expected hits for a specific weapon and aircraft with a set velocity, distance away, altitude, and angle of approach. GRA

N89-23457# General Dynamics Corp., Fort Worth, TX.
USAF (US AIR FORCE) DURABILITY DESIGN HANDBOOK: GUIDELINES FOR THE ANALYSIS AND DESIGN OF DURABLE AIRCRAFT STRUCTURES Final Report, Oct. 1984 - Sep. 1987
S. D. MANNING and J. N. YANG 20 Feb. 1989 150 p Prepared in cooperation with United Analysis, Inc., Vienna, VA (Contract F33615-84-C-3208)
(AD-A206286; AFWAL-TR-88-3119) Avail: NTIS HC A07/MF A01 CSCL 11/6

Objectives of this handbook are to: (1) summarize and interpret the essential USAF durability design requirements for metallic airframes; (2) provide durability analysis criteria for economic life and durability-critical parts; (3) provide state-of-the-art durability analysis concepts and methods for determining the initial fatigue quality of fastener holes, the probability of distribution of service time to reach any specified crack size; (4) provide guidelines and design process and for making design tradeoffs. The method accounts for the initial fatigue quality variation, crack growth damage accumulation in a population of structural details (e.g., fastener holes, lugs, fillets, cutouts, etc.), load spectra and structural properties. During manufacturing and assembly, flaws of various types, are produced in structural details. The initial fatigue quality of such details is represented by an Equivalent Initial Flaw Size Distribution (EIFSD). An Equivalent Initial Flaw Size (EIFS) is an artificial crack size which results in an actual crack size at an actual point in time when the initial flaw is grown forward. EIFSs are determined by back-extrapolating fractographic results. GRA

N89-23460# Aerospatiale, Toulouse (France). Aircraft Div.
CENTER OF GRAVITY CONTROL ON AIRBUS AIRCRAFT: FUEL, RANGE AND LOADING
BERNARD HUBER 13 Jun. 1988 38 p Presented at the 47th Annual Conference of the Society of Allied Weight Engineers, Inc., Plymouth, MI, 23-25 May 1988
(REPT-882-111-101; ETN-89-94477) Avail: NTIS HC A03/MF A01

The advantage of an active center of gravity control are described, with reference to the control system by fuel transfer adopted in the A330 and A340 aircraft design. These aircraft can carry fuel in the tailplane in addition to the wing and fuselage tanks. The tail tank has a capacity of 5 tons. The installation results in fuel, range and loading benefits which are detailed in the examples. ESA

N89-23461# Aerospatiale, Toulouse (France).
A330/340 HYDRAULIC SYSTEM
L. SIGNORELLI 1988 37 p Presented at the Vickers 32nd International Aerospace Fluid Power Conference on the Hydraulic Architecture of the A330/A340 Aircraft, Jackson, MS, 11-13 Apr. 1988
(REPT-882-111-102; ETN-89-94478) Avail: NTIS HC A03/MF A01

The Airbus hydraulics design specifications are reviewed. The hydraulic system is basically the same as A300/A310 aircraft, with three fully independent circuits at 3000 psi and mostly the same components used on A310/A30. The description includes

details of system layout, flight controls, hydraulic aspects and segregation aspects. Hydraulic fittings, safety aspects and cockpit monitoring are discussed. ESA

N89-24308*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROSERVOELASTIC MODELING AND APPLICATIONS USING MINIMUM-STATE APPROXIMATIONS OF THE UNSTEADY AERODYNAMICS

SHERWOOD H. TIFFANY and MORDECHAY KARPEL (Technion - Israel Inst. of Tech., Haifa.) Apr. 1989 13 p Presented at the AIAA 30th Structures, Structural Dynamics and Materials Conference, Mobile, AL, 3-5 Apr. 1989 Previously announced in IAA as A89-30678
(NASA-TM-101574; NAS 1.15:101574) Avail: NTIS HC A03/MF A01 CSCL 01/3

Various control analysis, design, and simulation techniques for aeroelastic applications require the equations of motion to be cast in a linear time-invariant state-space form. Unsteady aerodynamics forces have to be approximated as rational functions of the Laplace variable in order to put them in this framework. For the minimum-state method, the number of denominator roots in the rational approximation. Results are shown of applying various approximation enhancements (including optimization, frequency dependent weighting of the tabular data, and constraint selection) with the minimum-state formulation to the active flexible wing wind-tunnel model. The results demonstrate that good models can be developed which have an order of magnitude fewer augmenting aerodynamic equations more than traditional approaches. This reduction facilitates the design of lower order control systems, analysis of control system performance, and near real-time simulation of aeroservoelastic phenomena. Author

N89-24309# Army Aviation Engineering Flight Activity, Edwards AFB, CA.

LOSS OF TAIL ROTOR EFFECTIVENESS EVALUATION OF THE OH-58C HELICOPTER WITH DIRECTIONAL SAS (STABILITY AUGMENTATION SYSTEM) Final Report, 23 Jun. - 25 Sep. 1987

FREDERICK W. STELLAR, JAMES D. BROWN, MICHAEL K. HERBST, CHRISTOPHER P. BUTLER, and TIMOTHY HATHORN Aug. 1988 297 p
(AD-A206181; USAAEFA-86-22) Avail: NTIS HC A13/MF A01 CSCL 01/3

The U.S. Army Aviation Engineering Flight Activity conducted a loss of tail rotor effectiveness (LTE) evaluation of the JOH-58C. The JOH-58C configuration includes a directional stability augmentation system (SAS) manufactured by the SFENA Corporation, the larger-diameter tail rotor, and the improved engine fuel control. Handling qualities were evaluated at Edwards AFB, California (elevation 2302 feet). Twenty-eight flights were conducted for a total of 26.7 productive flight test hours. Primary emphasis of the evaluation was to evaluate the handling qualities of the JOH-58C in comparison to the standard OH-58C. The limited authority SAS (7 percent of full control travel) will not significantly reduce the conditions conducive to LTE. The overall handling qualities of the JOH-58C were moderately improved compared to the standard OH-58C. The concept of a SAS which damps uncommanded yaw rates demonstrated potential for reducing conditions conducive to LTE. However, the limited authority SAS saturated at small yaw rates (deg/sec) and did not significantly reduce the characteristic high yaw rates and moderate yaw attitude excursions observed in the JOH-58C. The JOH-58C exhibited moderate pitch, roll, and yaw excursions at 15 to 25 KTAS in azimuths from 240 degrees clockwise to 280 degrees. This characteristic was a shortcoming, upgraded from a deficiency for the standard OH-58C. Five additional shortcomings, of which four were previously identified in the standard OH-58C, were noted.

GRA

N89-24311# Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Direction Scientifique de la Résistance des Structures.

GROUND VIBRATION TEST OF THE Foudre A04 TRANSALL AIRCRAFT [ESSAI DE VIBRATIONS AU SOL - PARTIEL - DE L'AVION TRANSALL Foudre A04. PROCES-VERBAL 20/7234-PY-382-R]

P. LUBRINA Sep. 1988 68 p In FRENCH
(Contract DRET-88-34-001)
(REPT-20/7234-PY-382-R; ETN-89-94528) Avail: NTIS HC A04/MF A01

Ground test are performed to verify the aircraft dynamic behavior after structural modifications done in a study concerning inflight measurements of lightning discharges. The results show that the main vibration modes are not affected by the additions. On the other hand, the proximity of resonant frequency between the new element and some of the structure modes can reduce the fatigue life on the aircraft. ESA

N89-24313*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROSERVOELASTIC WIND-TUNNEL INVESTIGATIONS USING THE ACTIVE FLEXIBLE WING MODEL: STATUS AND RECENT ACCOMPLISHMENTS

THOMAS E. NOLL, BOYD PERRY, III, SHERWOOD H. TIFFANY, STANLEY R. COLE, CAREY S. BUTTRILL, WILLIAM M. ADAMS, JR., JACOB A. HOUCK, S. SRINATHKUMAR, VIVEK MUKHOPADHYAY, ANTHONY S. POTOTZKY (Planning Research Corp., Hampton, VA.) et al. Apr. 1989 14 p Presented at the AIAA 30th Structures, Structural Dynamics and Materials Conference, Mobile, AL, 3-5 Apr. 1989
(NASA-TM-101570; NAS 1.15:101570) Avail: NTIS HC A03/MF A01 CSCL 01/3

The status of the joint NASA/Rockwell Active Flexible Wing Wind-Tunnel Test Program is described. The objectives are to develop and validate the analysis, design, and test methodologies required to apply multifunction active control technology for improving aircraft performance and stability. Major tasks include designing digital multi-input/multi-output flutter-suppression and rolling-maneuver-load alleviation concepts for a flexible full-span wind-tunnel model, obtaining an experimental data base for the basic model and each control concept and providing comparisons between experimental and analytical results to validate the methodologies. The opportunity is provided to improve real-time simulation techniques and to gain practical experience with digital control law implementation procedures. Author

N89-24314*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

RECENT ACTIVITIES WITHIN THE AEROSERVOELASTICITY BRANCH AT THE NASA LANGLEY RESEARCH CENTER

THOMAS E. NOLL, BOYD PERRY, III, and MICHAEL G. GILBERT May 1989 11 p Presented at the European Forum on Aeroelasticity and Structural Dynamics, Aachen, Fed. Republic of Germany, 17-19 Apr. 1989
(NASA-TM-101582; NAS 1.15:101582) Avail: NTIS HC A03/MF A01 CSCL 01/3

The objective of research in aeroservoelasticity at the NASA Langley Research Center is to enhance the modeling, analysis, and multidisciplinary design methodologies for obtaining multifunction digital control systems for application to flexible flight vehicles. Recent accomplishments are discussed, and a status report on current activities within the Aeroservoelasticity Branch is presented. In the area of modeling, improvements to the Minimum-State Method of approximating unsteady aerodynamics are shown to provide precise, low-order aeroservoelastic models for design and simulation activities. Analytical methods based on Matched Filter Theory and Random Process Theory to provide efficient and direct predictions of the critical gust profile and the time-correlated gust loads for linear structural design considerations are also discussed. Two research projects leading towards improved design methodology are summarized. The first program is developing an integrated structure/control design capability

based on hierarchical problem decomposition, multilevel optimization and analytical sensitivities. The second program provides procedures for obtaining low-order, robust digital control laws for aeroelastic applications. In terms of methodology validation and application the current activities associated with the Active Flexible Wing project are reviewed. Author

N89-24315*# Oklahoma Univ., Norman. School of Aerospace and Mechanical Engineering.

AN INTEGRATED AERODYNAMIC/PROPULSION STUDY FOR GENERIC AERO-SPACE PLANES BASED ON WAVERIDER CONCEPTS Summary Report, May - Sep. 1988

M. L. RASMUSSEN and GEORGE EMANUEL 1989 24 p
(Contract NAG1-886)
(NASA-CR-183389; NAS 1.26:183389) Avail: NTIS HC A03/MF A01 CSCL 01/3

The design of a unified aero-space plane based on waverider technology is analyzed. The overall aerodynamic design and performance of an aero-space plane are discussed in terms of the forebody, scramjet, and afterbody. Other subjects considered in the study are combustion/nozzle optimization, the idealized tip-to-tail waverider model, and the two-dimensional minimum length nozzle. Charts and graphs are provided to show the results of the preliminary investigations. Author

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AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A89-40254
RECONNAISSANCE SENSOR MANAGEMENT SYSTEM - VICON 2000**

R. G. HARRIS (W. Vinten, Ltd., Military Marketing Dept., Bury Saint Edmunds, England) IN: Airborne reconnaissance XII; Proceedings of the Meeting, San Diego, CA, Aug. 16, 17, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 16-19.

Vicon 2000 is a modular, digital, reconnaissance-management system capable of accommodating all types of airborne sensors as well as of interfacing with most extant aircraft data-bus and analog sensors. Vicon 2000 is composed of a systems-management unit, a camera-control unit, a navigational-interface unit, and a sensor-interface unit. The Vicon 2000 has been used in conjunction with the Vicon 18 series 401 reconnaissance pod fitted to Sea Harrier VTOL fighters. O.C.

**A89-40272
USER FRIENDLY REAL TIME DISPLAY**

DENISE M. MCCARTHY and BILL MCCRACKEN (Honeywell, Inc., Electro-Optics Div., Lexington, MA) IN: Airborne reconnaissance XII; Proceedings of the Meeting, San Diego, CA, Aug. 16, 17, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 183-194.

An account is given of the 'human-engineered' features of a real-time display system incorporated by an IR reconnaissance apparatus for use in oil tanker pollution monitoring. Using a convenient joystick controller, on-screen mode menus, and a movable cursor, the operator can examine scenes of interest at four different display magnifications using a four-step bidirectional zoom. In military reconnaissance missions, application of this system will allow the normal review of recorded videotape imagery at a ground station immediately after the aircraft's return to base. The real-time display is packaged as two LRUs, a scan converter, and a control unit. O.C.

A89-40719

DETERMINATION OF THE DEVIATION COEFFICIENTS OF A MAGNETIC COMPASS DURING A TURN [K OPREDELENIU KOEFFITSIENTOV DEVIATSI MAGNITNOGO KOMPASA NA VIRAZHE]

V. V. MELESHKO (Kievskii Politekhnikheskii Institut, Kiev, Ukrainian SSR) *PriBOROstroenie* (ISSN 0021-3454), vol. 32, April 1989, p. 38-41. In Russian.

The effect of the deflection of the measuring elements of an induction (magnetic) compass during a regular turn on the magnetic deviation coefficients of horizontal flight is investigated analytically. It is shown that the measurement of the deviation corresponding to horizontal flight can be carried out during a regular turn if the angle of bank is less than 10 deg. The measurement accuracy in this case will depend on the accuracy of turn error compensation.

V.L.

A89-42656

ADAPTIVE OPTIMUM ATTITUDE EXTRAPOLATION FOR PRECISE ANTENNA POINTING CONTROL

HENRY E. LEE (Westinghouse Electric Corp., Electronics Systems Group, Baltimore, MD) IN: 1989 IEEE National Radar Conference, 4th, Dallas, TX, Mar. 29, 30, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 24-28.

An adaptive attitude extrapolator is described for the precise control of an airborne radar antenna. The extrapolator is an optimum design that provides extrapolation output with minimal mean-square angular prediction error. The effects of INS (inertial navigation system) attitude measurement noise, aircraft maneuver, and environmental gust condition are automatically taken into account. Because the extrapolation filter coefficients are computed on the basis of a real-time estimate of the aircraft attitude motion autocorrelation lags, it is capable of adapting to the varying operating conditions. Analysis and simulation results show a significantly lower antenna pointing error with the use of the adaptive extrapolator than with the conventional deterministic attitude extrapolator. The adaptive extrapolator is applicable to airborne phased-array radar systems making monopulse angular measurements for which the precise pointing of the radar antenna is crucial.

I.E.

A89-42932

MODULAR AVIONICS ARCHITECTURE FOR MODERN FIGHTER AIRCRAFT [MODULARE AVIONIKARCHITEKTUREN FUER MODERNE KAMPFFLUGZEUGE]

PETER BECHER and ANTONIO ESTRELLA (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) IN: Research and development: Technical and scientific publications 1988. Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, p. 107-144. In German. refs (MBB-FE-301/S/PUB/339)

The increasing role of modularization of avionics in fighter aircraft is discussed. A generic functional diagram of such avionics is presented and discussed, showing how functions can be modularized. Modular avionics architecture is addressed, taking into consideration system control, data distribution networks, arrangement of data processors and signal processors, sensors and effectors, and integration. The results of experimental studies of modular avionics are summarized.

C.D.

A89-43059*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLIGHT EVALUATION OF PURSUIT DISPLAYS FOR PRECISION APPROACH OF POWERED-LIFT AIRCRAFT

CHARLES S. HYNES, JAMES A. FRANKLIN, GORDON H. HARDY, JAMES L. MARTIN, and ROBERT C. INNIS (NASA, Ames Research Center, Moffett Field, CA) *Journal of Guidance, Control, and Dynamics* (ISSN 0731-5090), vol. 12, July-Aug. 1989, p. 521-529. refs

Flight experiments with NASA Ames Research Center's quiet short-haul research aircraft evaluated the influence of pursuit displays on the ability of pilots to execute precision-instrument

flight operations in the terminal area, particularly approaches to and landings on a short runway. The aircraft is a powered-lift, short-takeoff and landing configuration equipped with a modern digital fly-by-wire flight control system, a head-up display, and a color head-down display that make it possible to investigate control and display concepts for full-envelope, powered-lift operations. Flight-path-oriented displays that provide status and command information in a format with minimal clutter were investigated. The pilots could fly the aircraft with the precision associated with flight-director guidance and with a high degree of situation awareness. The primary benefits of this display concept were realized when the pilot was required to execute a complex transition and approach under instrument conditions and in the presence of a wide range of wind and turbulence conditions.

Author

N89-23463# National Aerospace Lab., Tokyo (Japan).

CHARACTERISTICS OF A FIVE-HOLE SPHERICAL PITOT TUBE

TOSHIHO SAKAI and TOSHIHARU INAGAKI Apr. 1988 25 p In JAPANESE; ENGLISH summary

(NAL-TR-971; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

A five-hole spherical pitot tube produced for experimental purposes was tested for measuring such air data as velocity, angle of attack, sideslip angle and static pressure of aircraft. There are few cases in measuring the static pressure by five-hole spherical pitot tube, although the measurements of airspeed, angle of attack and sideslip-angle are well known. Since the five-hole spherical pitot tube is normally installed at a position far from the lifting surface, one can expect to measure the static pressure without position error. First, wind tunnel tests of the five-hole spherical pitot tube were conducted. The pressure on the surface of the sphere was different from that estimated by theory. Such a difference between theory and practice induced considerable adverse effects on the accuracy of the measured air data. So, by using new revised equations based on the results of the wind tunnel tests, the air data was estimated with much more accuracy. Next, some flight tests were made in order to ascertain position error in free static pressure measurements. The tests were performed under such conditions as level-flight, steady turn, landing and takeoff during the experiments. The static pressure measured by the five-hole spherical pitot tube agreed well with measurements taken with a swivel pitot and the resulting airspeed was shown to be almost the same as that obtained from the position error correction chart, which was made by the speed course method.

Author

N89-24305# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuehrung.

DISPLAY OF FLIGHT GUIDANCE INFORMATION IN THE AIRCRAFT COCKPIT

H.-D. SCHENK *In its Image Signal Processing for Flight Guidance* p 249-266 Sep. 1988 In GERMAN; ENGLISH summary Avail: NTIS HC A14/MF A01; DFVLR, VB-PL-DO, Postfach 40 60 58, 5000 Cologne, Fed. Republic of Germany, DM 108

The application of computer generated electronic flight displays is discussed. It became the standard in cockpits since the introduction of the Airbus 310. The technical problems of the use of cathode ray tubes in an aircraft environment are described, and solutions for the display of cockpit information to the pilot are described. Further developments of the display technology leads to cockpit concepts using panoramic displays and the virtual presentation of cockpit control elements and the outside world.

ESA

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.

A89-39842#

ENGINE ASPECTS IN THE DESIGN OF ADVANCED ROTORCRAFT

WOLFGANG MUGGLI (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) and H. RICK (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) Associazione Industrie Aerospaziali and Associazione Italiana di Aeronautica ed Astronautica, European Rotorcraft Forum, 14th, Milan, Italy, Sept. 20-23, 1988, Paper. 21 p. refs (MBB-UD-528-88-PUB)

The mutual influence of aircraft and engine design in the development of advanced transportation rotorcraft is examined. A baseline aircraft and engine are described and the total operating costs are estimated. The influence of engine mass, price, and performance on the overall aircraft design is summarized in a sensitivity matrix. Engine technology projections and design optimizations are also considered. Feasible limits on fuel consumption and operating costs are determined for a tiltrotor.

R.B.

A89-40596

HYDRAULIC RESISTANCE OF THE INLET CHANNELS OF A ROTOR COOLING SYSTEM [GIDRAVLICHESKOE SOPROTVIENIE VKHODNYKH KANALOV SISTEMY OKHLAZHDENIIA ROTORA]

E. P. DYBAN, B. D. BILEKA, and V. A. MEL'NIKOVA (AN USSR, Institut Tekhnicheskoi Teplofiziki, Kiev, Ukrainian SSR) Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 11, no. 2, 1989, p. 3-7. In Russian. refs

The paper is concerned with the problem of calculating the hydraulic resistance coefficient for short ($L/d=3-5$) cylindrical and plane channels under static conditions and in the case of rotation about an axis normal to the channel axis. Calculated values of the hydraulic resistance coefficients are presented for the inlet channels of the cooling system of a static and operating gas turbine. It is shown that the hydraulic resistance of the rotating cylindrical and plane channels is higher than that of the static channels by a factor of 1.5-2.3 and 5.6-7.5, respectively.

V.L.

A89-40624

A METHOD FOR ESTIMATING THE STOCHASTIC VIBRATIONAL STRESS LEVEL OF IMPELLER BLADINGS OF AIRCRAFT GAS TURBINE ENGINES IN OPERATING CONDITIONS ON THE BASIS OF DEVELOPMENTAL BENCH TEST DATA [METOD OTSENKI UROVNIYA STOKHASTICHESKOI VIBRONAPRIAZHENNOSTI VENTILIATORNYKH LOPATOCHNYKH VENTSOV AVIATSIONNYKH GTD V USLOVIAKH EKSPLOATATSII PO DANNYM STENDOVOI DOVODKI]

V. V. MALYGIN Problemy Prochnosti (ISSN 0556-171X), April 1989, p. 91-95. In Russian. refs

A computational/experimental method has been developed to estimate the level of maximum dynamic stresses in impellers of aircraft gas turbine engines in operating conditions on the basis of developmental bench test data. The algorithm and the probabilistic prediction procedure are described. The proposed method was applied to the investigation of the vibrational stress level of the impeller of a turbojet engine. Satisfactory convergence of the predicted and real values of the dynamic stresses is shown.

B.J.

A89-40964

MECHANICAL MODEL STUDY FOR SHRINK FIT ROTOR

SONGBO XIA, XINHUA WU, GUANGMIN WANG (Harbin Institute

of Technology, People's Republic of China), WEN ZHANG, and FADA CHEN (Fudan University, Shanghai, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 2, Feb. 1989, p. 49-55.

The shrink-fitted rotor shaft section of a single-spool gas turbine engine has been mechanically modeled in order to characterize the behavior of the shrink fit under deflection loads. The transfer matrix across the shrink-fit section is established, and experimental and computational efforts are undertaken to validate the model. The natural frequencies predicted by the model are noted to be in agreement with observed values.

O.C.

A89-41050

NEXT-GENERATION POWER FOR NEXT-GENERATION CIVIL ROTORCRAFT

RON L. ALTO and L. SCIPIONI (Light Helicopter Turbine Engine Co., Saint Louis, MO) Vertiflite (ISSN 0042-4455), vol. 35, May-June 1989, p. 54-59.

A parallel military qualification/civil certification process has been undertaken for the T800 1200-shp class helicopter turboshaft, with the intention of obtaining a quantum improvement in reliability, durability, and reduced life-cycle costs for next-generation civil helicopter operators. The full-authority digital electronic controls employed by the T800's CTS800 civil version will achieve an optimum integration of engine and airframe capabilities, thereby yielding maximum engine responsiveness, minimum rotor drag, and superior handling qualities. Lower life-cycle costs are also achieved over current powerplants of comparable output.

O.C.

A89-41058

SOVIET AEROSPACE INDUSTRY - PROPULSION RESEARCH CENTER FOCUSES ON DEVELOPING FUEL-EFFICIENT AIRCRAFT

Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, June 5, 1989, p. 40-43.

The USSR's research and design resources for aircraft propulsion development are concentrated in Moscow's Central Institute for Aviation Motors; design bureaus concerned with specific design tasks have limited research staffs, and are accordingly dependent on this institute for fundamental studies and test support. Full-scale test rigs are located at a facility outside Moscow; aircraft engines of all sizes can be run there at simulated flight speeds. The state-of-the-art turbofan engine that has been developed by this system is the Soloviev D-90, a 35,000-lb thrust class engine powering the Tu-204 and Il-96-300 transport aircraft currently undergoing testing; a specific fuel consumption level of 0.58 at Mach 0.8/36,000 ft altitude has been achieved.

O.C.

A89-41115#

THE MODEL OF COMBUSTION EFFICIENCY AND CALCULATION OF FLOW PROPERTIES FOR SCRAMJET COMBUSTOR

LING LIU, ZHEN ZHANG, HAIFA NIU, and JINGHUA LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), April 1989, p. 1-7, 70. In Chinese, with abstract in English. refs

A combustion efficiency model for scramjet combustors is presented and analyzed. The model takes into account factors affecting fuel injection, entrance conditions, and combustor configuration. One-dimensional flow properties are computed step by step through the combustor. A comparison of theoretical predictions with experimental results indicates that the theory is satisfactory.

C.D.

A89-41126#

INVESTIGATION ON THRUST MEASUREMENT OF TURBOJET ENGINE IN ALTITUDE SIMULATION FACILITY

QING ZHU and SHIFU TANG (31st Research Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), April 1989, p. 57-61, 76. In Chinese, with abstract in English.

At present, the thrust of turbojet engines in flight is measured using simulation tests in an altitude chamber. The technology

07 AIRCRAFT PROPULSION AND POWER

involved in the simulation and measurement, the facility, and the measurement results are discussed here in the context of an actual example. Corrections of thrust measurements and measurement accuracy are addressed. C.D.

A89-41223

DESIGN POINT OPTIMIZATION OF AN AXIAL-FLOW COMPRESSOR STAGE

JIN SHIK LIM and MYUNG KYOON CHUNG (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) *International Journal of Heat and Fluid Flow* (ISSN 0142-727X), vol. 10, March 1989, p. 48-58. Research supported by the Korea Science and Engineering Foundation. refs

The application of the gradient-projection method to a simulation program has yielded a design-optimization program for axial-flow compressor stages in which the total pressure losses required to calculate the total-to-total efficiency are estimated through the integration of the empirical loss coefficients of six loss mechanisms along the radial direction of a three-dimensional blade. Illustrative optimization problems for maximum efficiency, minimum weight, and balanced optimum between efficiency and weight are presented. In the maximum-efficiency design with a given stage pressure ratio, the meridional flow path tends to be deflected radially outward, while the axial velocity is decreased in both rotor and stator. C.O.

A89-41224

CHARACTERISTICS OF DUMP COMBUSTOR FLOWS

RONALD M. C. SO and SAAD A. AHMED (Arizona State University, Tempe) *International Journal of Heat and Fluid Flow* (ISSN 0142-727X), vol. 10, March 1989, p. 66-74. Research sponsored by DARPA. refs

(Contract N60530-85-C-0191)

Turbulent flows through dump combustors with different inlet geometries and flow conditions were investigated. The combustor was simulated by an axisymmetric tube with a sudden expansion geometry. Specifically two different inlet geometries were studied; one resembled an actual inlet, another a well-designed convergent nozzle. Furthermore, two different step heights were examined. Finally, the effects of rotation on the flow behavior were also studied. The results show that of all the geometric and flow parameters investigated, inlet turbulence and rotation have the greatest effect on the flow inside the combustor, in particular, the characteristics of the toroidal recirculating flow. Both parameters act to decrease the toroidal recirculation region and hence the reattachment length. The limited data available tend to show that the effects due to these two parameters are additive. On the other hand, inlet geometry only has an indirect effect on the combustor flow. It influences the flow characteristics because it creates different inlet turbulence at the sudden expansion.

Author

A89-41910#

SERVICE-INDUCED DAMAGE IN TURBINE DISCS AND ITS INFLUENCE ON DAMAGE TOLERANCE-BASED LIFE PREDICTION

M. R. PISHVA, N. C. BELLINGER (Carleton University, Ottawa, Canada), A. K. KOUL, and T. TERADA (National Aeronautical Establishment, Structures and Materials Laboratory, Ottawa, Canada) *Canadian Aeronautics and Space Journal* (ISSN 0008-2821), vol. 35, March 1989, p. 4-11. Research supported by DND. refs

The damage tolerance-based life prediction concepts proposed for gas turbine components are explained. The results of a demonstration program carried out to calculate the Safe Inspection Intervals (SII) for new and service-exposed turbine disks are presented. Effects of service exposure on the microstructure and fatigue crack growth rate of Inconel 718 disks are studied in detail. It is suggested that there may be considerable risk involved in assuming that crack-free components can be used repeatedly beyond 'safe life limit' for several SII, unless the SII value is continually updated, taking into account the deterioration of microstructure with increasing service. Author

A89-42422

DETERMINATION OF THE NATURAL FREQUENCY SPECTRA AND MODES OF THE FAN BLADE RINGS OF AVIATION GAS TURBINE ENGINES [K OPREDELENIU SPEKTROV SOBSTVENNYKH CHASTOT I FORM KOLEBANII VENTILIATORNYKH LOPATOCHNYKH VENTSOV AVIATSIONNYKH GTD]

V. V. MALYGIN *Problemy Prochnosti* (ISSN 0556-171X), May 1989, p. 92-95. In Russian. refs

An approach to the study of the natural frequency spectra of the fan rotors of bypass engines is proposed which is based on the use of both analytical and experimental data. The advantages of the approach, which allows the identification of all frequencies and modes of blade rings, are demonstrated. A method for the identification of the natural modes of rotors, which has been tested on various designs of bypass engines, is presented. V.L.

A89-42462

EXPERIMENTAL INVESTIGATION OF THE CHARACTERISTICS OF COMBINATION ENGINES [K VOPROSU EKSPERIMENTAL'NOGO ISSLEDOVANIIA KHARAKTERISTIK KOMBINIROVANNYKH DVIGATELEI]

V. I. BAKULEV, I. V. KRAVCHENKO, and V. A. UFIMKINA IN: *Pioneers of space and the present age*. Moscow, Izdatel'stvo Nauka, 1988, p. 67-71. In Russian.

A small-scale model engine has been developed for the experimental investigation of the performance characteristics of the steam-hydrogen combination rocket-turbine engine scheme. The general design, operation, and principal components of the small-scale model engine are described. The model combination engine makes it possible to study the throttle characteristics of the rocket-turbine engine under bench testing conditions for different control programs and also to study the operation of the engine in transient regimes. V.L.

A89-42463

TWO-TIME PROBABILISTIC MODEL OF THE EVOLUTION OF AIRCRAFT ENGINE RELIABILITY [DVUKHVREMENNAIA VEROIATNOSTNAIA MODEL' RAZVITIIA NADEZHNOСТИ AVIADVIGATELEI]

L. F. KOSHKINA, E. A. LOKSHANOV, S. A. MIRZOIAN, and E. V. NABOKIN IN: *Pioneers of space and the present age*. Moscow, Izdatel'stvo Nauka, 1988, p. 71-77. In Russian. refs

A two-factor exponential-logistic model for predicting the reliability of aircraft engines is developed which accounts for the increased engine reliability resulting from operation experience and general technological progress in aircraft engine building. The model is verified using the Fisher test. It is noted that models of this kind could also be applied to other quality characteristics of complex improvable systems. V.L.

A89-42466

A STUDY OF THE CHARACTERISTICS OF AIRCRAFT POWERPLANTS UNDER CONDITIONS OF OPTIMAL CONTROL OF THEIR PRINCIPAL COMPONENTS [ISSLEDOVANIE KHARAKTERISTIK AVIATSIONNYKH SILOVYKH USTANOVOK PRI OPTIMAL'NOM UPRAVLENII IKH OSNOVNYMI ELEMENTAMI]

IU. N. NECHAEV, V. N. KOBEL'KOV, and E. V. TOFANOVSKII IN: *Pioneers of space and the present age*. Moscow, Izdatel'stvo Nauka, 1988, p. 98-103. In Russian. refs

The problem of the optimization of the throttle characteristics of augmented bypass engines with flow mixing behind the turbine is analyzed to investigate the possibility of improving powerplant performance characteristics through optimal control of their principal components. It is shown that optimization of the control of engine components makes it possible to significantly improve engine efficiency under various flight conditions and engine operation regimes. In the case of the engine studied, a 20-25-percent increase in efficiency is achieved through optimal control of the air intake. V.L.

A89-42467

OPTIMIZATION OF THE PARAMETERS AND CHARACTERISTICS OF BYPASS ENGINES [OPTIMIZATSIIA PARAMETROV I KHARAKTERISTIKI TRDD]A. L. PARKHOMOV IN: *Pioneers of space and the present age.* Moscow, Izdatel'stvo Nauka, 1988, p. 103-109. In Russian.

The paper is concerned with the optimization of the process parameters and characteristics of bypass engine with respect to fuel efficiency. In particular, it is shown that all the dimensionless process parameters of bypass engines, from the fan inlet to the nozzle exit section, are a function of the gas generator regime only and do not depend on flight conditions. In the case of subcritical flow from the nozzle, all the engine process parameters depend not only on the gas generator regime but also on the flight Mach number. V.L.

A89-42468

AN ANALYTICAL STUDY OF THE CHARACTERISTICS OF BYPASS ENGINE MIXING CHAMBERS IN THE CASE OF INCOMPLETE MIXING OF GAS FLOWS [RASCHETNOE ISSLEDOVANIIE KHARAKTERISTIK KAMER SMESHENIIA TRDD PRI NEPOLNOM PEREMESHIVANII GAZOVYKH POTOKOV]IU. N. NECHAEV, V. A. NEMYKIN, and V. M. TREMBACH IN: *Pioneers of space and the present age.* Moscow, Izdatel'stvo Nauka, 1988, p. 109-120. In Russian. refs

An approximate engineering method for calculating the characteristics of the mixing chambers of bypass engines is proposed which allows for incomplete mixing of the gas flows. It is assumed that (1) the mechanism of mixing layer evolution is the same as in the case of a free turbulent jet; (2) the transverse gradient of static pressure equals zero; and (3) velocity and temperature profiles in the mixing layer are finite. It is shown that flow parameters at the exit of the mixing chamber and mixing efficiency depend to a large degree on the inlet conditions and geometrical shape of the mixing chamber, which provides a way to optimize the mixing chamber parameters and calculate engine characteristics. V.L.

A89-42509

AUTOMATIC CONTROL OF JET ENGINES (3RD REVISED AND ENLARGED EDITION) [AVTOMATIKA I REGULIROVANIIE VOZDUSHNO-REAKTIVNYKH DVIGATELEI /3RD REVISED AND ENLARGED EDITION/]

BORIS A. CHERKASOV Moscow, Izdatel'stvo Mashinostroenie, 1988, 360 p. In Russian. refs

The fundamentals of the automatic control theory for ramjet and gas turbine engines are presented. Topics discussed include the main characteristics of the cycle of jet engines and possible control programs; the main components of jet engine control systems, their general design, and operation; and control of the rotor speed, gas temperature, engine thrust, and intake parameters. Attention is also given to methods for the analysis of the dynamic characteristics of linear and nonlinear automatic control systems; hydrodynamic control systems; digital control systems; and mathematical modeling of gas turbine engines. V.L.

A89-43213#

PNS CODE ASSESSMENT STUDIES FOR SCRAMJET COMBUSTOR AND NOZZLE FLOWFIELDS

R. A. LEE, N. SINHA, and S. M. DASH (Science Applications International Corp., Propulsion Gas Dynamics Div., Princeton, NJ) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989, 14 p. refs (AIAA PAPER 89-1697)

Two-dimensional computer codes (SCORCH, SCHNOZ, SCRINT) developed for the analysis of scramjet propulsive flowfields are reviewed and recent upgrades to these codes are reported. Comparative studies of these two-dimensional codes are described for representative unit processes. The two-dimensional studies indicate that the use of implicit upwind (Roe/TVD) numerics, as incorporated in the SCRINT code, provides the most reliable, robust, and accurate methodology for scramjet combustor/nozzle

flow problems. Progress towards the development of three-dimensional PNS models is described which incorporates time-iterative extensions to the Roe/TVD numerics for added robustness and accuracy. All codes described contain generalized finite-rate chemistry capabilities and two-equation turbulence models. Author

N89-23464# National Aerospace Lab., Tokyo (Japan).

EXPERIMENT ON A CYLINDRICAL SCRAMJET COMBUSTOR.**2: SIMULATED FLIGHT MACH NUMBER 6.7**

TOMOYUKI KOMURO, ATSUO MURAKAMI, KENJI KUDOU, GORO MASUYA, and NOBUO CHINZEI Mar. 1988 20 p In JAPANESE; ENGLISH summary

(NAL-TR-969; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

An experimental study was made on a cylindrical scramjet combustor with a rear-facing step in a vitiated air flow. The stagnation temperature and pressure of the vitiated air were 2000 K and 1.0 MPa, respectively. The simulated flight speed was Mach 6.7 at a particular altitude of 40 km. Three different types of fuel injector were used, consisting of two perpendicular schemes and a parallel scheme of fuel injection into the mainstream. Auto-ignition of hydrogen fuel occurred when the air stagnation temperature reached about 1500 K. In all test cases, the flame was anchored on the step. For high air stagnation temperature and low fuel flow rate, however, the flame holding position shifted downstream from the step. At a fuel equivalence ratio of 0.55, mixing efficiency of the parallel injector was higher than that of the perpendicular injectors, but the axial variations in combustion efficiency were almost in the same form for all injectors, except immediately downstream of the injector. In a supersonic combustion mode, significant influence of flight Mach number on mixing was not observed. For a constant inlet Mach number, fuel flow rates at which transition from supersonic to subsonic combustion took place increased nearly in proportion to the stagnation temperature of air. A one-dimensional analysis using the measured pressure distribution served to determine other chemical and fluid mechanical properties. The calculated combustion efficiencies were slightly higher as compared to the experimental data, while the Mach number distributions were in reasonable agreement. Author

N89-23465*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ADVANCES IN COMPUTATIONAL DESIGN AND ANALYSIS OF AIRBREATHING PROPULSION SYSTEMS

JOHN M. KLINEBERG 1989 19 p Proposed for presentation at the 9th International Symposium on Airbreathing Engines, Athens, Greece, 4-9 Sep. 1989; sponsored by International Society for Air Breathing Engines (NASA-TM-101987; E-4689; NAS 1.15:101987) Avail: NTIS HC A03/MF A01 CSCL 21/5

The development of commercial and military aircraft depends, to a large extent, on engine manufacturers being able to achieve significant increases in propulsion capability through improved component aerodynamics, materials, and structures. The recent history of propulsion has been marked by efforts to develop computational techniques that can speed up the propulsion design process and produce superior designs. The availability of powerful supercomputers, such as the NASA Numerical Aerodynamic Simulator, and the potential for even higher performance offered by parallel computer architectures, have opened the door to the use of multi-dimensional simulations to study complex physical phenomena in propulsion systems that have previously defied analysis or experimental observation. An overview of several NASA Lewis research efforts is provided that are contributing toward the long-range goal of a numerical test-cell for the integrated, multidisciplinary design, analysis, and optimization of propulsion systems. Specific examples in Internal Computational Fluid Mechanics, Computational Structural Mechanics, Computational Materials Science, and High Performance Computing are cited and described in terms of current capabilities, technical challenges, and future research directions. Author

07 AIRCRAFT PROPULSION AND POWER

A89-23466*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

METHOD AND SYSTEM FOR MONITORING AND DISPLAYING ENGINE PERFORMANCE PARAMETERS Patent Application

TERENCE S. ABBOTT, inventor (to NASA) and LEE H. PERSON, JR., inventor (to NASA) 14 Nov. 1988 34 p Sponsored by NASA. Langley Research Center (NASA-CASE-LAR-14049-1; NAS 1.71:LAR-14049-1; US-PATENT-APPL-SN-270189) Avail: NTIS HC A03/MF A01 CSCL 21/5

The invention is believed a major improvement that will have a broad application in governmental and commercial aviation. It provides a dynamic method and system for monitoring and simultaneously displaying in easily scanned form the available, predicted, and actual thrust of a jet aircraft engine under actual operating conditions. The available and predicted thrusts are based on the performance of a functional model of the aircraft engine under the same operating conditions. Other critical performance parameters of the aircraft engine and functional model are generated and compared, the differences in value being simultaneously displayed in conjunction with the displayed thrust values. Thus, the displayed information permits the pilot to make power adjustments directly while keeping him aware of total performance at a glance of a single display panel. NASA

A89-24319*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A MODEL FOR PREDICTION OF STOVL EJECTOR DYNAMICS

COLIN K. DRUMMOND 1989 15 p Presented at the 20th Annual Conference on Modeling and Simulation, Pittsburgh, PA, 4-5 May 1989; cosponsored by the Univ. of Pittsburgh, IEEE and ISA

(NASA-TM-102098; E-4861; NAS 1.15:102098) Avail: NTIS HC A03/MF A01 CSCL 21/5

A semi-empirical control-volume approach to ejector modeling for transient performance prediction is presented. This new approach is motivated by the need for a predictive real-time ejector sub-system simulation for Short Take-Off Vertical Landing (STOVL) integrated flight and propulsion controls design applications. Emphasis is placed on discussion of the approximate characterization of the mixing process central to thrust augmenting ejector operation. The proposed ejector model suggests transient flow predictions are possible with a model based on steady-flow data. A practical test case is presented to illustrate model calibration. Author

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AIRCRAFT STABILITY AND CONTROL

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

A89-39847#

OPST 1 - A DIGITAL OPTICAL TAIL ROTOR CONTROL SYSTEM

K. BENDER, G. MANSFELD (DFVLR, Brunswick, Federal Republic of Germany), BERNARD FORMICA, and HERBERT KOENIG (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Associazione Industrie Aerospaziali and Associazione Italiana di Aeronautica ed Astronautica, European Rotorcraft Forum, 14th, Milan, Italy, Sept. 20-23, 1988, Paper. 17 p. refs (MBB-UD-533-88-PUB)

OPST 1 (which is a German acronym for Optical Control System, Phase 1) is a technology program for future helicopter controls. OPST 1 has the control loop consisting of pilot's input transducers, control and display unit, flight control computer (FCC), actuator, and yaw rate gyros. The hardware is of triplex design for the FCC, the position pick-offs and rate gyros, and duplex design for hydraulics, with duo-duplex electronics for loop closure and

monitoring; the data transfer is made by means of fiber optics. Within the program, and experimental fault-tolerant four-axis fly-by-wire/fly-by-light control system DISCUS is being developed, the key element of which is a fault-tolerant flight control computer system. Diagrams and flow diagrams describing the OPST 1 and DISCUS designs and architecture are included. I.S.

A89-40961

THE RESEARCH OF THE AIRCRAFT NEUTRAL STABILITY

YIDONG YUANG, SHUMEI ZHANG, and SUOFENG GUO (Nanjing Aeronautical Institute, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 2, Feb. 1989, p. 23-31.

A novel fuselage-aiming mode may be achieved in neutrally stable aircraft through the symmetric deflection of flaps and dynamic decoupling for minor angle-of-attack disturbances. This control mode transforms an aircraft's dynamics model from one of short-period oscillation into a nonoscillatory one, which then effectively accelerates the dynamic process of attitude-tracking, decreases dynamic error, increases gust-rejection capabilities, and yields a flight path that remains unchanged during the process of attitude control. Aircraft designs of neutrally stable and quasi-neutrally stable type are presently treated. O.C.

A89-40963

ACTIVE FLUTTER SUPPRESSION ON A DELTA WING

KUNYI CHENG (Chengdu Aircraft Corp., Development Dept., People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 2, Feb. 1989, p. 39-48.

Control laws for the active flutter suppression system were designed for a delta wing by means of the fictitious structural modification method and the Nyquist criterion concept. Based on an accurate determination of the model structure parameters, the transfer behavior of the electrohydraulic actuator system, and suitable positions of the sensors, the lowest critical flutter speed was increased by 25 percent with different and simple control laws. Good agreement was achieved between calculated and measured results. Author

A89-42939

SYSTEM TESTING EXEMPLIFIED BY THE A320-LANDING FLAPS FLIGHT MANEUVERING SYSTEM

[SYSTEMERPROBUNG AM BEISPIEL DES A320-LANDEKLAPPEN-FLUGSTEUERUNGSSYSTEMS]

GUENTHER MASCHKE (Messerschmitt-Boelkow-Blohm GmbH, Lemwerder, Federal Republic of Germany) IN: Research and development: Technical and scientific publications 1988. Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, p. 163-172. In German. (MBB-UT-0131-88-PUB)

The testing of the A320 flight maneuvering system using landing flaps is described. The realization of the testbed for the system is reviewed, and the general criteria for the test are described along with the simulation method utilized. An overview of the test program is presented. C.D.

A89-43051*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FLYING QUALITIES FROM EARLY AIRPLANES TO THE SPACE SHUTTLE

WILLIAM H. PHILLIPS (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, July-Aug. 1989, p. 449-459. Previously cited in issue 07, p. 953, Accession no. A88-22568. refs

A89-43057*# Kansas Univ., Lawrence.

ANALYSIS OF A CANDIDATE CONTROL ALGORITHM FOR A RIDE-QUALITY AUGMENTATION SYSTEM

REINER SUIKAT, KENT DONALDSON, and DAVID R. DOWNING (Kansas, University, Lawrence) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, July-Aug. 1989, p. 505-513. Previously cited in issue 03, p. 288, Accession no. A88-14277. refs (Contract NAG1-345)

A89-43071#

THREE-DIMENSIONAL ENERGY-STATE EXTREMALS IN FEEDBACK FORM

M. D. ARDEMA (Santa Clara University, CA), N. RAJAN, and L. YANG (Sterling Software, Palo Alto, CA) *Journal of Guidance, Control, and Dynamics* (ISSN 0731-5090), vol. 12, July-Aug. 1989, p. 601-605. refs

The present analysis of energy-state extremals generates trajectories displaying features which agree with aircraft pursuit-evasion and target-interception experience; the trajectories primarily involve segments of hard turning on the corner-velocity locus and high-speed dash on the maximum-speed boundary, with occasional, short intervals of optimal energy accumulation. The fact that these trajectories exhibit frequent and large jumps between these various branches of the three-dimensional energy-state solution means that the transitions between these branches, the boundary-layer motions, will be important. O.C.

A89-43104

THE VAAC/VSTOL FLIGHT CONTROL RESEARCH PROJECT

O. P. NICHOLAS and C. M. STEPHENS (Royal Aerospace Establishment, Bedford, England) *Aerospace (UK)* (ISSN 0305-0831), vol. 16, July 1989, p. 8-11.

VAAC (vectored thrust aircraft advanced flight control), a research program investigating advanced VSTOL flight control, strives to develop concepts and design and assessment techniques. In the discussion of the flight control of advanced VSTOL aircraft, consideration is given to the background, broad control strategy, inceptor sense, displays, the VAAC program, the VAAC aircraft and system, and simulation results. The experimental flight control system fitted to the rear cockpit of the research aircraft was designed to permit a wide range of experimental laws to be flown safely. K.K.

N89-23467# National Aerospace Lab., Tokyo (Japan).

THE FUNCTIONAL MOCK-UP TEST OF THE FLIGHT CONTROL SYSTEM OF THE NAL QSTOL RESEARCH AIRCRAFT ASKA

TADAO UCHIDA, AKIRA TADA, NORIYUKI OKADA, HIROYUKI YAMATO, and TOSHIO OGAWA Apr. 1988 64 p In JAPANESE; ENGLISH summary (NAL-TR-972; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

The functional mockup test of the flight control system of ASKA with the stability and control augmentation systems is described. The tests made included software verification, simulated failure effects testing, closed loop test, and piloted simulation test. The results show that the functions and performance of the control system are satisfactory for flight safety of ASKA. Author

N89-23468*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A CLOSED-FORM TRIM SOLUTION YIELDING MINIMUM TRIM DRAG FOR AIRPLANES WITH MULTIPLE LONGITUDINAL-CONTROL EFFECTORS

KENNETH H. GOODRICH, STEVEN M. SLIWA, and FREDERICK J. LALLMAN Washington May 1989 30 p (NASA-TP-2907; L-16484; NAS 1.60:2907) Avail: NTIS HC A03/MF A01 CSCL 01/3

Airplane designs are currently being proposed with a multitude of lifting and control devices. Because of the redundancy in ways to generate moments and forces, there are a variety of strategies for trimming each airplane. A linear optimum trim solution (LOTS) is derived using a Lagrange formulation. LOTS enables the rapid calculation of the longitudinal load distribution resulting in the minimum trim drag in level, steady-state flight for airplanes with a mixture of three or more aerodynamic surfaces and propulsive control effectors. Comparisons of the trim drags obtained using LOTS, a direct constrained optimization method, and several ad hoc methods are presented for vortex-lattice representations of a three-surface airplane and two-surface airplane with thrust vectoring. These comparisons show that LOTS accurately predicts the results obtained from the nonlinear optimization and that the

optimum methods result in trim drag reductions of up to 80 percent compared to the ad hoc methods. Author

N89-23469*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SIMULATOR EVALUATION OF A DISPLAY FOR A TAKEOFF PERFORMANCE MONITORING SYSTEM

DAVID B. MIDDLETON, RAGHAVACHARI SRIVATSAN, and LEE H. PERSON, JR. Washington May 1989 29 p (NASA-TP-2908; L-16510; NAS 1.60:2908) Avail: NTIS HC A03/MF A01 CSCL 01/3

A Takeoff Performance Monitoring System (TOPMS) has been developed to provide the pilot with graphic and numeric information pertinent to his decision to continue or abort a takeoff. The TOPMS information display consists primarily of a runway graphic overlaid with symbolic status, situation, and advisory information including: (1) current position and airspeed; (2) predicted locations for reaching decision speed (V sub 1) and rotation speed (V sub R); (3) groundroll limit for reaching (V sub R); (4) predicted stop point for an aborted takeoff from current conditions; (5) engine-status flags; and (6) an overall situation advisory flag that recommends continuation or rejection of the takeoff. In this study, 32 experienced multi-engine pilots evaluated the TOPMS on the Langley B-737 real-time research simulator. They rated the system satisfactory - good and judged it to be suitable for implementation on an aircraft. The TOPMS, the TOPMS simulation, and the results of the simulator evaluation are described here. Appendices contain the pilot's prebriefing package (written explanation of the TOPMS--sent to the pilots prior to their visit), evaluation instructions, debriefing questions, and rating criteria (organized into a flow diagram similar to the Cooper-Harper diagram for evaluation of aircraft handling qualities). Author

N89-23470*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.

DETAILED DESIGN OF A RIDE QUALITY AUGMENTATION SYSTEM FOR COMMUTER AIRCRAFT Final Report

REINER SUIKAT, KENT E. DONALDSON, and DAVID R. DOWNING Washington NASA May 1989 127 p (Contract NAG1-345) (NASA-CR-4230; NAS 1.26:4230; KU-FRL-6132-7) Avail: NTIS HC A07/MF A01 CSCL 01/3

The design of a Ride Quality Augmentation System (RQAS) for commuter aircraft is documented. The RQAS is designed for a Cessna 402B, an 8 passenger prop twin representative to this class of aircraft. The purpose of the RQAS is the reduction of vertical and lateral accelerations of the aircraft due to atmospheric turbulence by the application of active control. The detailed design of the hardware (the aircraft modifications, the Ride Quality Instrumentation System (RQIS), and the required computer software) is examined. The aircraft modifications, consisting of the dedicated control surfaces and the hydraulic actuation system, were designed at Cessna Aircraft by Kansas University-Flight Research Laboratory. The instrumentation system, which consist of the sensor package, the flight computer, a Data Acquisition System, and the pilot and test engineer control panels, was designed by NASA-Langley. The overall system design and the design of the software, both for flight control algorithms and ground system checkout are detailed. The system performance is predicted from linear simulation results and from power spectral densities of the aircraft response to a Dryden gust. The results indicate that both accelerations are possible. Author

N89-23471*# Boeing Commercial Airplane Co., Seattle, WA.

THE 4D-TECS INTEGRATION FOR NASA TSRV AIRPLANE Final Report

I. KAMINER and P. R. OSHAUGHNESSY Washington NASA Jun. 1989 168 p (Contract NAS1-18027) (NASA-CR-4231; NAS 1.26:4231) Avail: NTIS HC A08/MF A01 CSCL 01/3

The integration of the Total Energy Control System (TECS) concept with 4D navigation is described. This integration was made

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to increase the operational capacity of modern aircraft and encourage incorporation of this increased capability with the evolving National Airspace System (NAS). Described herein is: 4D smoothing, the basic concepts of TECS, the spoiler integration concept, an algorithm for nulling out time error, speed and altitude profile modes, manual spoiler implementation, 4D logic, and the results of linear and nonlinear analysis. Author

N89-23473# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

FLIGHT CONTROL SYSTEM FOR THE CRCA (CONTROL RECONFIGURABLE COMBAT AIRCRAFT) USING A COMMAND GENERATOR TRACKER WITH PI (PROPORTIONAL-PLUS-INTEGRAL) FEEDBACK AND KALMAN FILTER, VOLUME 1 M.S. Thesis

STEVEN S. PAYSON Mar. 1989 154 p
(AD-A205723; AD-E501079; AFIT/GE/ENG/89M-6-VOL-1)
Avail: NTIS HC A08/MF A01 CSCL 01/4

This research develops an integrated software design package useful in the synthesis of CGT/PI/KF control systems, and uses this software package to design and evaluate a longitudinal flight control system for the Control Reconfigurable Combat Aircraft (CRCA). The software package, called CGTPIKE and built with MATRIXx commands, allows for the synthesis and evaluation of a Command Generator Tracker (CGT) which provides inputs to the system and acts as a pre-compensator, and a regulator with proportional plus integral (PI) feedback which forces the system outputs to mimic the model output. The software also allows the incorporation of a Kalman filter for estimation of the system states. Certainty equivalence can be invoked by adopting the LQG assumptions, thereby allowing the Kalman filter to be designed independently of the CGT/PI controller. The total CGT/PI/KF controller can then be evaluated and the design refined. CGTPIKF is an interactive, menu-driven CAD package which can be used in the development of any CGT/PI/KF control system, regardless of application. A flight control system was designed for the CRCA air combat mode (ACM) entry using CGTPIKF. This control system was designed to force the aircraft to emulate a first order response in pitch rate. GRA

N89-23474# Department of the Navy, Washington, DC.
ACTUATOR RATE SATURATION COMPENSATOR Patent Application

SHAWN T. DONLEY, inventor (to Navy), GARRY L. GROSS, inventor (to Navy), and JUDITH L. KOPER, inventor (to Navy) 5 May 1988 13 p Filed 5 May 1988
(AD-D013962; US-PATENT-APPL-SN-204152) Avail: NTIS HC A03/MF A01 CSCL 20/3

A device for compensating for actuator rate saturation is disclosed by this patent application. The device is an improvement to a servomechanism of the type wherein a command signal and a position feedback signal from a member being positioned are summed to produce an error signal for driving an actuator to position the member in accordance therewith. The improvement is a means for inverting the error signal when the ratio of the slope of the position feedback signal to the slope of the command signal is less than one and the polarity of the error signal is opposite to the polarity of the slope of the command signal, and the absolute value of the error signal is not increasing. Application of the invention to the flight controls of an aircraft is disclosed. GRA

N89-23475# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

CONTROL DESIGN OF AN UNSTABLE NON-MINIMUM PHASE AIRCRAFT SUBJECT TO CONTROL SURFACE SATURATION M.S. Thesis

OLIVER J. MERWIN Mar. 1989 164 p
(AD-A206024; AFIT/GE/ENG/89M-5) Avail: NTIS HC A08/MF A01 CSCL 01/4

This thesis seeks to validate a design technique for the control of unstable aircraft which are subject to limited control authority. It applies the technique to a realistic aircraft model, instead of the

simplified models used in the theoretical development, to produce a pitch rate controller for widely spaced regions of the flight envelope. First the aircraft is stabilized by feeding back pitch rate. Then an adjustable command limiter is placed in the input path for the stable effective plant. The saturation level of the limiter, adjusted by a second feedback loop, provides the proper command tracking response when the command limiter is not saturated. The final element is a minor feedback loop around the command limiter to provide a second degree of freedom to ensure the limiter comes out of saturation as quickly as possible. Simulations for step commands ranging from 1 to 5 deg/sec pitch rate show the design is quite successful. The stabilator does not saturate in a manner which causes instability even when responding to extreme commands. Simulations of a pulse command show that the command limiter unsaturates rapidly and the aircraft responds appropriately to a reduced pitch command even when the stabilator is near the limit. The technique applies relatively simple linear design tools to the nonlinear problem of control surface saturation. GRA

N89-23476# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

MULTIVARIABLE FLIGHT CONTROL DESIGN WITH PARAMETER UNCERTAINTY FOR THE AFTI/F-16 M.S. Thesis
BRIAN J. PAWLOWSKI Mar. 1989 141 p
(AD-A206068; AFIT/GE/ENG/89M-1) Avail: NTIS HC A07/MF A01 CSCL 01/4

Quantitative Feedback Theory (QFT) techniques are used in the design of a multivariable flight control law for the AFTI/F-16. The techniques were developed by Professor Isaac Horowitz, University of California, Davis, California. The flight control problem involves a multiple input-multiple output (MIMO) plant requiring regulation and control in the presence of parameter uncertainty and disturbances. Based on frequency response fundamentals, the technique uses feedback to achieve closed-loop system response within performance tolerances despite plant uncertainty. The range of uncertainty and the output performance specifications are quantitative parameters in the design process. The MIMO control problem is restructured into a set of two input - single output (multiple input - single output (MISO)) problems where one input is a command input to the system and the other is a disturbance input to be attenuated. The control laws for the MISO problems taken together form the solution of the MIMO problem. To obtain a point of comparison between various design techniques, the identical aircraft model previously developed by Mr. A. Finley Barfield is used in this study. The state space form of the model is converted to the transfer function relationships between the plant input and output variables. GRA

N89-24321# National Aerospace Lab., Tokyo (Japan).
WIND TUNNEL TESTS ON FLUTTER CONTROL OF A HIGH-ASPECT-RATIO CANTILEVERED WING Report No. 1
Jun. 1988 101 p In JAPANESE; ENGLISH summary
(NAL-TR-978; ISSN-0389-4010) Avail: NTIS HC A06/MF A01

Wind tunnel test results obtained on flutter control are presented. The test was conducted in the NAL 5.5 x 6.5 m low-speed wind tunnel. The wing model used in the tests assumes a future type of energy efficient transport. It has two control surfaces, one at the leading edge and the other at the trailing edge. Various control laws based on the Linear Quadratic Gaussian theory were implemented and tested with either control surface after reducing the order of the laws. The results showed a prominent effect of the leading edge control surface on flutter suppression. The maximum increase in flutter speed was 9.7 percent of the violent bending-torsion flutter. For the test, a special device was installed in the wind tunnel to prevent this highly mechanical model from being destroyed, which enabled us to execute very efficient tests. Author

N89-24322# National Aerospace Lab., Tokyo (Japan). Aircraft Aerodynamics Division.

COMPUTATIONAL AND EXPERIMENTAL RESEARCH ON BUFFET PHENOMENA OF TRANSONIC AIRFOILS

NAOKI HIROSE and HITOSHI MIWA Sep. 1988 22 p Presented at the IUTAM Symposium TRANSSONICUM 3, Goettingen, Fed. Republic of Germany, 24-27 May 1988
(NAL-TR-996T; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

Buffet phenomena on supercritical airfoils were investigated both experimentally and numerically. The experiment was done for NACA0012 and KORN 75-06-12 airfoils using a high-speed Schlieren video tape recorder and pressure transducers. The analysis shows significant effects of the geometries and the Reynolds number. A 2-D N-S code was used to predict these phenomena. The result shows the macro-scale effects of airfoil geometry, Reynolds number and transition. A fine structure of the motion such as the periodic trailing edge pressure history was captured. The basic frequency of the buffet motion agrees well with the experiment. Author

N89-24323*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

RESULTS OF AN A109 SIMULATION VALIDATION AND HANDLING QUALITIES STUDY

MICHELLE M. ESHOW, DIEGO ORLANDI, GIOVANNI BONAITA, and SERGIO BARBIERI (Italian Air Force Pratica di Mare, Rome.) May 1989 31 p Presented at the 14th European Rotocraft Forum, Milan, Italy, 20-23 Sep. 1988
(NASA-TM-101062; A-88271; NAS 1.15:101062; USAAVSCOM-TR-88-A-002) Avail: NTIS HC A03/MF A01 CSCL 01/3

The results for the validation of a mathematical model of the Agusta A109 helicopter, and subsequent use of the model as the baseline for a handling qualities study of cockpit centerstick requirements, are described. The technical approach included flight test, non-realtime analysis, and realtime piloted simulation. Results of the validation illustrate a time- and frequency-domain approach to the model and simulator issues. The final A109 model correlates well with the actual aircraft with the Stability Augmentation System (SAS) engaged, but is unacceptable without the SAS because of instability and response coupling at low speeds. Results of the centerstick study support the current U.S. Army handling qualities requirements for centerstick characteristics. Author

N89-24324*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

RESULTS OF A PARAMETRIC AEROELASTIC STABILITY ANALYSIS OF A GENERIC X-WING AIRCRAFT

JESSICA A. WOODS, MICHAEL G. GILBERT, and TERRENCE A. WEISSHAAR Apr. 1989 10 p Presented at the AIAA 30th Structures, Structural Dynamics and Materials Conference, Mobile, AL, 3-5 Apr. 1989 Previously announced in IAA as A89-30858
(NASA-TM-101572; NAS 1.15:101572) Avail: NTIS HC A02/MF A01 CSCL 01/3

This paper discusses the trends in longitudinal dynamic aeroelastic stability of a generic x-wing aircraft model with design parameter variations. X-wing rotor blade sweep angle, ratio of blade mass to total vehicle mass, blade structural stiffness cross-coupling and vehicle center-of-gravity location were parameters considered. The typical instability encountered is body-freedom flutter involving a low frequency interaction of the first elastic mode and the aircraft short period mode. Parametric cases with the lowest static margin consistently demonstrated the highest flutter dynamic pressures. As mass ratio was increased, the flutter boundary decreased. The decrease was emphasized as center-of-gravity location was moved forward. As sweep angle varied, it was observed that the resulting increase in forward-swept blade bending amplitude relative to aft blade bending amplitude in the first elastic mode had a stabilizing effect on the flutter boundary. Finally, small amounts of stiffness cross-coupling in the aft blades increased flutter dynamic pressure. Author

N89-24325# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

FLIGHT CONTROL SYSTEM FOR THE CRCA (CONTROL RECONFIGURABLE COMBAT AIRCRAFT) USING A COMMAND GENERATOR TRACKER WITH PI (PLUS INTEGRAL) FEEDBACK AND KALMAN FILTER, VOLUME 2

M.S. Thesis
STEVEN S. PAYSON Mar. 1989 315 p
(AD-A206202; AFIT/GE/ENG/89M-6-VOL-2) Avail: NTIS HC A14/MF A01 CSCL 01/4

This research develops an integrated software design package useful in the synthesis of CGT/PI/KF control systems, and uses this software package to design and evaluate a longitudinal flight control system for the Control Reconfigurable Combat Aircraft (CRCA). The software package, called CGTPIKF and built with MATRIX commands, allows for the synthesis and evaluation of a Command Generator Tracker (CGT) which provides inputs to the system and acts as a pre-compensator, and a regulator with proportional plus integral (PI) feedback which forces the system outputs to mimic the model output. The software also allows the incorporation of a Kalman filter for estimation of the system states. Certainty equivalence can be invoked by adopting the LQC assumptions, thereby allowing the Kalman filter to be designed independently of the CGT/PI controller. The total CGT/PI/KF controller can then be evaluated and the design refined. CGTPIKF is an interactive, menu driven CAD package which can be used in the development of any CGT/PI/KF control system, regardless of application. GRA

N89-24326 Virginia Polytechnic Inst. and State Univ., Blacksburg.

NUMERICAL SIMULATION OF FEEDBACK CONTROL OF AERODYNAMIC CONFIGURATIONS IN STEADY AND UNSTEADY GROUND EFFECTS Ph.D. Thesis

ABDULLAH OTHMAN NUHAIT 1988 188 p
Avail: Univ. Microfilms Order No. DA8904960

A general numerical simulation of closely coupled lifting surfaces in steady and unsteady ground effects was developed. This model was coupled with the equations of motion to simulate aerodynamic-dynamic interaction. The resulting model was then coupled with a feedback-control law to form a general nonlinear unsteady numerical simulation of control of an aircraft in and out of ground effect. The aerodynamic model is based on the general unsteady vortex-lattice method and the method of images. It is not restricted by plan-form, angle of attack, sink rate, dihedral angle, twist, camber, etc., as long as stall or vortex bursting does not occur. In addition, it has the versatility to model steady and unsteady aerodynamic interference. The present model can be used to simulate any prescribed flare and to model the effects of cross and/or head winds near the ground. The present results show the influences of various parameters on the aerodynamic coefficients for both steady and unsteady flows. Generally, the ground increases the aerodynamic coefficients; the greater the sink rates, the stronger the effects. Increasing the aspect ratio increases both the steady and unsteady ground effects. An exception is a large aspect-ratio wing with large camber. The present results are generally in close agreement with limited exact solutions and experimental data. In the aerodynamic-dynamic simulation, the equations of motion were solved by Hamming's predictor-corrector method. The aircraft, air stream, and control surfaces were treated as a single dynamic system. The present results demonstrate the feasibility of using the current simulation to model more complicated motions and the importance of including the unsteady ground effects when analyzing the performance of an airplane during a landing maneuver. Dissert. Abstr.

N89-24327*# National Aeronautics and Space Administration. Flight Research Center, Edwards, CA.

DEVELOPMENT AND FLIGHT TEST EXPERIENCES WITH A FLIGHT-CRUCIAL DIGITAL CONTROL SYSTEM

DALE A. MACKALL Washington Nov. 1988 116 p
(NASA-TP-2857; H-1344; NAS 1.60:2857) Avail: NTIS HC A06/MF A01 CSCL 01/3

Engineers and scientists in the advanced fighter technology integration (AFTI) F-16 program investigated the integration of emerging technologies into an advanced fighter aircraft. AFTI's three major technologies included: flight-crucial digital control, decoupled aircraft flight control, and integration of avionics, flight control, and pilot displays. In addition to investigating improvements in fighter performance, researchers studied the generic problems confronting the designers of highly integrated flight-crucial digital control. An overview is provided of both the advantages and problems of integration digital control systems. Also, an examination of the specification, design, qualification, and flight test life-cycle phase is provided. An overview is given of the fault-tolerant design, multimoded decoupled flight control laws, and integrated avionics design. The approach to qualifying the software and system designs is discussed, and the effects of design choices on system qualification are highlighted. Author

N89-24328*# TAU Corp., Los Gatos, CA.
**OPTIMAL GUIDANCE WITH OBSTACLE AVOIDANCE FOR
 NAP-OF-THE-EARTH FLIGHT**

NICHOLAS J. PEKELSMAN Dec. 1988 72 p
 (Contract NAS2-12402)
 (NASA-CR-177515; NAS 1.26:177515) Avail: NTIS HC A04/MF
 A01 CSDL 01/3

The development of automatic guidance is discussed for helicopter Nap-of-the-Earth (NOE) and near-NOE flight. It deals with algorithm refinements relating to automated real-time flight path planning and to mission planning. With regard to path planning, it relates rotorcraft trajectory characteristics to the NOE computation scheme and addresses real-time computing issues and both ride quality issues and pilot-vehicle interfaces. The automated mission planning algorithm refinements include route optimization, automatic waypoint generation, interactive applications, and provisions for integrating the results into the real-time path planning software. A microcomputer based mission planning workstation was developed and is described. Further, the application of Defense Mapping Agency (DMA) digital terrain to both the mission planning workstation and to automatic guidance is both discussed and illustrated. Author

N89-24329*# National Aeronautics and Space Administration.
 Ames Research Center, Moffett Field, CA.

**SURVEY OF ARMY/NASA ROTORCRAFT AEROELASTIC
 STABILITY RESEARCH**

ROBERT A. ORMISTON, WILLIAM G. WARMBRODT, DEWEY H. HODGES, and DAVID A. PETERS (Georgia Inst. of Tech., Atlanta.) Oct. 1988 183 p Prepared in cooperation with Army Aviation Systems Command, Moffett Field, CA
 (NASA-TM-101026; A-88266; NAS 1.15:101026;
 USAAVSCOM-TR-88-A-005) Avail: NTIS HC A09/MF A01
 CSDL 01/3

Theoretical and experimental developments in the aeroelastic and aeromechanical stability of helicopters and tilt-rotor aircraft are addressed. Included are the underlying nonlinear structural mechanics of slender rotating beams, necessary for accurate modeling of elastic cantilever rotor blades, and the development of dynamic inflow, an unsteady aerodynamic theory for low frequency aeroelastic stability applications. Analytical treatment of isolated rotor stability in hover and forward flight, coupled rotor-fuselage stability are considered. Results of parametric investigations of system behavior are presented, and correlations between theoretical results and experimental data from small- and large-scale wind tunnel and flight testing are discussed. Author

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A89-39843#
**DEVELOPMENT OF AN ADVANCED EXPERIMENTAL ROTARY
 TEST RIG AND FIRST TEST RESULTS WITH A 60 KN-MAIN
 ROTOR**

RAINER VORWERG (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Associazione Industrie Aerospaziali and Associazione Italiana di Aeronautica ed Astronautica, European Rotorcraft Forum, 14th, Milan, Italy, Sept. 20-23, 1988, Paper. 23 p.
 (MBB-UD-525-88-PUB)

A rotary test rig with an advanced prime mover, swashplate control, and a thrust measuring device was developed to test rotors up to 70 kN thrust. A vertically installed direct current drive unit is used to determine the power required over a widely variable rotor rpm range. The swashplate control is used for stationary or periodical monocyclic, multicyclic, and collective inputs. A strain-gaged sensor ring is integrated into the shaft bearing system for performing thrust measurements. The test rig is described in detail and preliminary results are presented from tests of a 60-kn bearingless rotor. R.B.

A89-39846#
A NEW WIND TUNNEL TEST RIG FOR HELICOPTER TESTING
 MICHAEL STEPHAN, VALENTIN KLOEPEL (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany), and H.-J. LANGER (DFVLR, Brunswick, Federal Republic of Germany) Associazione Industrie Aerospaziali and Associazione Italiana di Aeronautica ed Astronautica, European Rotorcraft Forum, 14th, Milan, Italy, Sept. 20-23, 1988, Paper. 22 p. refs
 (MBB-UD-532-88-PUB)

The construction of a modular wind tunnel model for rotorcraft testing is discussed. The model is scaled for rotors with a diameter of 4 meters and may be used to test interference effects and performance, flight mechanical problems, rotor control and rotor noise. The model design requirements are outlined and the process of choosing subsystems to meet these requirements is examined. The fixed system, model core, measurement signal transmissions, rotor control, and sensors are described. The procedures for calibrating rotor balance, actuators, and pitch angles are presented. Also, results are given from tests to determine the accuracy of measurements made with the modular wind tunnel model. R.B.

A89-41060
**SOVIET AEROSPACE INDUSTRY - AERODYNAMIC INSTITUTE
 AIDS EFFORT TO DEVELOP FUEL-EFFICIENT TRANSPORTS**

Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, June 5, 1989, p. 52, 56.

Two new turbofan-powered transports currently undergoing flight testing, the Il-96-300 and the Tu-204, are believed to substantially owe their excellent fuel efficiencies to the research work conducted by the Central Aero-Hydrodynamic Institute in Moscow. This institute is responsible for the bulk of the USSR's aerodynamic, stability and control, aeroelasticity, and airframe structural characteristics research. As a measure of the quality of aerodynamic design achievable on the basis of these research efforts, it has been claimed that the Il-96-300 has a L/D value of 19 at Mach 0.92. The primary shortcoming of the institute is its poor hardware resources for CFD; these are compensated by the intensive development of sophisticated computer programs. O.C.

A89-42499

HIGH-EFFICIENCY THERMAL INSULATION IN THE BASE OF AIRFIELDS AND HIGHWAYS [VYSOKOEFFEKTIVNAIA TEPLOIZOLIATSIA V OSNOVANIYAKH AERODROMOV I DOROG]

VADIM N. IVANOV Moscow, Izdatel'stvo Transport, 1988, 136 p. In Russian. refs

The use of high-efficiency thermal insulation materials in the construction of airfields and highways is discussed. The discussion covers thermophysical characteristics of soils, strength and thermophysical characteristics of high-efficiency thermal insulation, the deformation properties of the multilayer bases of airfield and highway pavements, and methods used in the design and construction of airfield and highway structures with a thermal insulation layer. The cost effectiveness of high-efficiency thermal insulation is estimated. V.L.

A89-42937

ACCURACY PROBLEMS IN WIND TUNNELS DURING TRANSPORT AIRCRAFT DEVELOPMENT

GUENTER KRENZ (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) (NATO, AGARD Panel Meeting, 61st, Naples, Italy, Sept. 28-Oct. 2, 1987) IN: Research and development: Technical and scientific publications 1988. Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, p. 141-150. (MBB-UT-134-88-PUB)

Wind tunnel test data accuracy requirements for transport aircraft are derived. Airline performance guarantees, model and tunnel test techniques available and the quality of prediction methods used form the concept for wind tunnel test programs and set accuracy requirements for test data. The paper describes procedures followed in high-speed cruise and low-speed takeoff and landing. The accuracy of wind tunnel tests is limited by several parameters, the most important being flow quality, model and model suspension quality, and balance accuracy. Problems which occurred during the tests with small models in the transonic regime led to new test concepts, the use of large models on a specific suspension with a range-limited balance and the improvement of small-model test techniques in connection with the requirements for measurements in cryogenic facilities. Low-speed tests are ambitious and extensive due to the many configurations at takeoff and landing. Furthermore, the work is complicated by many details like closing plates and shutters, which can have a strong effects on the performance data. Author

N89-23477# National Aeronautical Lab., Bangalore (India). Propulsion Div.

A RESEARCH FACILITY FOR FILM COOLING INVESTIGATIONS WITH EMPHASIS ON THE INSTRUMENTATION SYSTEM

M. D. MANICKAM May 1987 46 p
(NAL-TM-PR-8704) Avail: NTIS HC A03/MF A01

The layout and the instrumentation of a facility for film cooling investigation is described. The injectant air is heated and the mainflow air remains at ambient temperature while the temperature ratio between the injectant and the main flow is simulated. The lift-off/attachment characteristics, the nature of streamwise penetration, and the lateral spreading of the injectant film for a discrete hole injection configuration in an accelerating turbine blade passage was studied. Though detailed studies of injectant films in the case of flat plates have been carried out by many researchers, little work has been done on the above topic for the case of actual blades. Many regions remain unexplored in this discrete hole cooling process which is considered promising for turbine blades. The instrumentation system has been geared to obtain details of flow and mixing in the vicinity of the injection holes, including the upstream and the downstream regions. Author

N89-23479# Swedish Inst. for Materials Testing, Boras.
INVESTIGATIONS ON THE CRACKING BEHAVIOR OF JOINTS IN AIRFIELDS AND ROADS: FIELD INVESTIGATIONS AND LABORATORY SIMULATIONS

S. LINDE 1988 27 p

(PB89-141279; SP-RAPP-1988:23; ISBN-91-7848-108-2) Avail: NTIS HC A03/MF A01 CSCL 13/2

Cracks in airfield runways and loose debris resulting from the cracks cause severe damage to airplanes and airplane engines. The problem of cracks in airfield runways is examined in a series of field investigations and laboratory simulations. Fundamental parameters studied include: influence of water on adhesion of joint sealants/concrete/bituminous concrete; dessication velocity in concrete; the magnitude and speed of the thermal movement on a number of airfields in different climate zones (for a period of three years); the rheological behavior of the bituminous concrete at different temperatures and mechanical loads, especially with regard to tensile speed; and the behavior of the crack repair compound at different tensile speeds and temperatures. These fundamental parameters were computerized into a dynamic program, a so-called function test. Author

N89-23480# Federal Aviation Administration, Atlantic City, NJ.
HELIPORT NIGHT PARKING AREA CRITERIA TEST PLAN

Technical Note, Jan. - Apr. 1989

MARVIN S. PLOTKA and ROSANNE M. WEISS Mar. 1989
14 p

(Contract FAA-TO701-R)

(DOT/FAA/CT-TN88/45) Avail: NTIS HC A03/MF A01

This flight test plan describes the methodology to examine the issue of heliport night parking surface separation criteria. Operational measures will be collected at the Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, New Jersey, using an instrumented UH-1H helicopter. Flight maneuvers will be conducted at the Technical Center to identify night parking area separation criteria under various wind conditions. Wind velocity and direction data will be collected during night parking operations to determine effects at different locations around the parking area. This data will be used to create a baseline for characterizing heliport night parking area separation criteria. The test development, test equipment, data collection, data reduction, and analysis of flight data are discussed. A schedule for the completion of the associated tasks is presented. Author

N89-23482# Naval Postgraduate School, Monterey, CA.

AEROTHERMODYNAMIC ANALYSIS OF A COANDA/REFRACTION JET ENGINE TEST FACILITY M.S. Thesis

ANDRE MARAOUI Dec. 1988 140 p

(AD-A205937) Avail: NTIS HC A07/MF A01 CSCL 14/2

A computer model of the Coanda/Refraction Jet Engine Test Cell facility was developed using the PHOENICS computer code. The PHOENICS code was utilized to determine the steady aerothermal characteristics of the test cell during the testing of an F404 gas turbine engine with afterburner in operation. Computer generated aerothermodynamic field variables of pressure, velocity and temperature parameters were compared to operational field test data. Observations regarding compared results as well as system behavior are presented. Additionally, recommendations of the applications of PHOENICS to future modeling projects are made. GRA

N89-24330# Federal Aviation Administration, Atlantic City, NJ.

IMPROVED MARKING OF TAXIWAY INTERSECTIONS FOR INSTRUMENT FLIGHT RULES (IFR) OPERATIONS Interim Report

ERIC S. KATZ Feb. 1989 14 p

(DOT/FAA/CT-TN89/23) Avail: NTIS HC A03/MF A01 CSCL 01/5

A visual aid to advise pilots that a taxiway intersection is being approached was developed at the Federal Aviation Administration (FAA) Technical Center. Subject pilots were asked to comment on the effectiveness of the taxiway intersection markings. Results of the evaluation indicate that the markings provide adequate advance warning of the approaching taxiway intersection and an indication of where to stop to ensure clearance from aircraft using the intersecting taxiway. Author

ASTRONAUTICS

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

A89-42022#

ACCELERATION FORCES ABOARD NASA KC-135 AIRCRAFT DURING MICROGRAVITY MANEUVERS

DENNIS E. BAHR and ROBERT D. SCHULZ (Bahr Technologies, Inc., Madison, WI) *Journal of Aircraft* (ISSN 0021-8669), vol. 26, July 1989, p. 687, 688.

A89-42456

PROBLEMS OF THE UNIFICATION OF THE ON-BOARD SYSTEMS OF FLIGHT VEHICLES [VOPROSY UNIFIKATSII BORTOVYKH SISTEM LETATEL'NOGO APPARATA]

G. V. MALYSHEV, V. I. ZERNOV, and V. A. LAMZIN IN: *Pioneers of space and the present age*. Moscow, Izdatel'stvo Nauka, 1988, p. 31-38. In Russian.

The unification of on-board systems and modular design are examined as way of increasing the efficiency of the systems and reliability of the flight vehicle as a whole. Unified design of modular on-board systems involves the development of mathematical models describing the performance, weight, reliability, and cost effectiveness characteristics of the systems, as well as the development of algorithms and programs for determining the optimal number of unification areas and design parameters of the unified systems. A model unification problem is considered as an example. V.L.

A89-42459

A MODEL OF THE REACHABILITY ZONE AND ITS USE IN THE BALLISTIC DESIGN OF FLIGHT VEHICLES [MODEL' ZONY DOSTIZHIMOSTI I EE ISPOL'ZOVANIE V BALLISTICHESKOM PROEKTIROVANII LETATEL'NYKH APPARATOV]

G. A. VINOGRADOVA, S. A. VOEVODIN, and E. F. KAMENKOV IN: *Pioneers of space and the present age*. Moscow, Izdatel'stvo Nauka, 1988, p. 49-56. In Russian.

The concept of the reachability zone can be used for evaluating the maneuvering capacity of a flight vehicle in certain problems of the ballistic design of flight vehicles. Here, a simple, computationally efficient model of the reachability zone is proposed which requires only two trajectory calculations and provides a good approximation of the real reachability zone with minimum computer requirements. The model is particularly suitable at the early stage of ballistic design for estimating the maneuvering capabilities of flight vehicles, determining the guidance region, and developing sufficiently accurate multistep flight range control algorithms. V.L.

A89-43193*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

COMPUTATIONAL REQUIREMENTS FOR HYPERSONIC FLIGHT PERFORMANCE ESTIMATES

UNMEEL B. MEHTA (NASA, Ames Research Center, Moffett Field, CA) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 15 p. refs (AIAA PAPER 89-1670)

The computational requirements for hypersonic flight performance estimates are discussed and a procedure for fulfilling these requirements is presented. In order to effectively use computational fluid dynamics in design, especially for estimating performance quantities, consideration should be given to the credibility of CFD, design sensitivities, test uncertainties, risk assessment, and consistency in determination. It is found that a

design-specific computational technology developed with programmatic research can be used in the design of hypervelocity vehicles. K.K.

A89-43620

NASP KEEPS MOVING

DONALD F. ROBERTSON *Interavia Space Markets* (ISSN 0258-4212), vol. 4, May-June 1989, p. 82-89.

A development status evaluation is undertaken for the envisioned component technologies, technology-integration schemes, and mission scenarios envisioned for the National Aerospace Plane (NASP) and its proof-of-concept experimental prototype, the X-30. NASP-derived operational vehicles are expected to demonstrate an order-of-magnitude reduction of current cost-to-orbit levels. Intensive efforts in CFD are envisioned to refine the hypersonic-to-hypervelocity aerothermodynamics of these vehicles. They will also be the first operational vehicles to which the use of hydrogen fuel will be essential, not merely for scramjet thrust generation but for active cooling, fuel-cell electricity generation, and orbital maneuvering reaction control. O.C.

CHEMISTRY AND MATERIALS

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

A89-40085

A FOIL ADHESIVE FOR CONSTRUCTION - THE LETOXIT SYSTEM [KONSTRUKCNI FOLIOVE LEPIDLO - SYSTEM LETOXIT]

MARCELA VANKOVA and JURI SOUCEK *Zpravodaj VZLU* (ISSN 0044-5355), no. 1, 1989, p. 31-37. In Czech. refs

A survey of adhesive technologies in the Czechoslovak aircraft industry is presented. The development of the Letoxit system, intended to replace imported adhesives, is described. Test results on the basis of which the system has been approved for application in aeronautics are reviewed. B.J.

A89-40619

PROBABILISTIC-PARAMETRIC MODELS OF THE LONG-TERM STRENGTH OF METALLIC MATERIALS OF AIRCRAFT GAS TURBINE ENGINES [VEROIATNOSTNO-PARAMETRICHESKIE MODEL' DLITEL'NOI PROCHNOSTI METALLICHESKIKH MATERIALOV AGTD]

A. N. VETROV, A. G. KUCHER, and N. A. KOVESHNIKOV (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR) *Problemy Prochnosti* (ISSN 0556-171X), April 1989, p. 14-17. In Russian. refs

The long-term strength curves of materials are described by exponentially semirandom functions with three types of constant random components. The temperature-time parameters of these functions and the dispersion of random components are determined by the maximum likelihood method with allowance for changes in the temperature dependences of the parameters induced by the phase transformations in the materials. Numerical characteristics of the proposed model are obtained for the following heat-resistant materials: ZhS6U, ZhS6K, EP99VD, EI437B, and Kh18N10T. B.J.

A89-41585

ADVANCED CONCEPTS AND MATERIALS FOR HIGH-SPEED FLIGHT

J. E. FISCHLER (Douglas Aircraft Co., Long Beach, CA) IN: *Competitive advances in metals and processes; Proceedings of the First International SAMPE Metals and Metals Processing Conference*, Cherry Hill, NJ, Aug. 18-20, 1987. Covina, CA, Society

for the Advancement of Material and Process Engineering, 1987, p. 144-165. refs

Significant weight savings result from the joining of MMCs to SPF/DB Ti alloy sandwich panels, yielding a structural system whose service temperature is sufficiently high to offer designers structural mass ratios in supersonic Mach-number environments comparable to those which are typical of current subsonic aircraft structural masses. The initial costs of this structural concept are presently evaluated in terms of airframe weight-reduction value; significant direct operating cost reductions are obtained. Even greater advantages accrued to the use of rapid solidification rate Ti alloys in the SPF/DB sandwich. O.C.

A89-41591

WHITHER TITANIUM POWDER METALLURGY?

GERALD FRIEDMAN (PCC Airfoils, Inc., Cleveland, OH) IN: Competitive advances in metals and processes; Proceedings of the First International SAMPE Metals and Metals Processing Conference, Cherry Hill, NJ, Aug. 18-20, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 222-227.

The Ti alloy-forming elemental or prealloyed powders and P/M consolidation methods thus far developed for such aerospace structural components as engine mounts and turbine disks are evaluated with a view to their curious lack of adoption, and an evaluation is made of the prospects for future applications of P/M Ti-alloy technologies. It is noted that the production cost reductions initially projected have been insufficient to overcome industry inertia. The most attractive novel applications involve such light weight/high strength materials as gamma aluminide-containing TiAl alloys, whose ductility is too low for effective forging, dispersion-strengthened Ti, extremely complex configurations, bimetallic components, and hollow turbine structure components. O.C.

A89-41601

THE ENVIRONMENTAL CRACKING BEHAVIOUR OF ALUMINIUM-LITHIUM BASED ALLOYS

A. GRAY, N. J. H. HOLROYD, and W. S. MILLER (Alcan International, Ltd., Banbury, England) IN: Competitive advances in metals and processes; Proceedings of the First International SAMPE Metals and Metals Processing Conference, Cherry Hill, NJ, Aug. 18-20, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 339-351. refs

The objective of this paper is to highlight the current understanding of the environmental cracking behavior of Al-Li base alloys. Particular emphasis is placed on the Al-Li-Cu-Mg-Zr alloy system (alloys 8090 and 8091). The effect of alloy chemistry, alloy temper and test environment on both crack initiation and propagation is discussed; these parameters significantly influence crack initiation behavior, but have a reduced effect on crack-growth rate. The initiation behavior of the alloys can be explained largely by invoking an anodic dissolution mechanism, whereas propagation behavior appears dependent upon a mechanical effect as well as on crack tip chemistry and anodic dissolution. The stress corrosion behavior of the alloys is compared with that of conventional alloys used in airframe construction. Author

A89-41888

RAPIDLY SOLIDIFIED AL-TI ALLOYS VIA ADVANCED MELT SPINNING

S. C. JHA, T. A. MOZHI, and R. RAY (Marko Materials, Inc., North Billerica, MA) JOM (ISSN 0148-6608), vol. 41, May 1989, p. 27-30. refs

Rapidly solidified Al-Ti based binary and ternary alloys containing 3 to 12 wt pct titanium and additions of cerium or vanadium have been produced by melt spinning continuous ribbons, pulverization into powders, and consolidation by hot-extrusion into round bars. The mechanical property data show that significantly improved elevated-temperature strengths can be obtained by suitable alloy design and processing. The rapidly solidified Al-Ti base alloys have improved general corrosion and pitting corrosion resistance in

comparison to ingot metallurgy Al 7075-T73 alloys, and higher resistance to pitting corrosion than rapidly solidified Al-8Fe-2Mo. Author

A89-43211#

MEASUREMENTS OF PARTICLES REBOUND CHARACTERISTICS ON MATERIALS USED IN GAS TURBINES

W. TABAKOFF (Cincinnati, University, OH) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 11 p. Research sponsored by DOE. refs (AIAA PAPER 89-1693)

This paper describes an experimental method used to find the rebound characteristics of small solid particles impacting different materials. Such data are used for particle trajectories and erosion calculations in turbomachinery. The materials which are investigated are: 410 Stainless Steel, 2024 Aluminum, 6Al-4V Titanium, INCO 718, RENE 41, AM355, L605 Cobalt and Alumina (Al₂O₃). Particle materials are fly ash of 15 microns. Author

A89-43216*# Eloret Corp., Sunnyvale, CA.

CALCULATION OF NONEQUILIBRIUM HYDROGEN-AIR REACTIONS WITH IMPLICIT FLUX VECTOR SPLITTING METHOD

SEUNG-HO LEE (Eloret Institute, Sunnyvale, CA) and GEORGE S. DEIWERT (NASA, Ames Research Center, Moffett Field, CA) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 13 p. refs (AIAA PAPER 89-1700)

Two methods, fully- and loosely-coupled, are developed to incorporate nonequilibrium hydrogen-air chemistry into the fluid dynamic implicit flux vector splitting code (F3D). The new code (F3D/Chem) is validated against other existing codes for two cases: nozzle expansion, and shock-induced combustion around a blunt body. The shock-induced combustion case is compared also with an experimental data. The reaction rate constants are varied in an effort to reproduce the experimental data. The fully- and loosely-coupled methods are found to yield comparable results, but the computation time is shorter using the loosely-coupled method. The present method is found to reproduce results obtained using different existing codes. The experimental data was not reproduced with any selected rate coefficients set. Author

N89-23656# National Aerospace Lab., Amsterdam (Netherlands). Dept. of Materials.

QUENCH SENSITIVITY OF AIRFRAME ALUMINIUM ALLOYS

H. J. KOLKMAN, W. G. J. THART, and L. SCHRA 29 Jan. 1988 11 p Presented at the 8th International Conference on the Strength of Metals and Alloys, Tampere, Finland, 22-26 Aug. 1988 (PB89-146039; NLR-MP-88003-U) Avail: NTIS HC A03/MF A01 CSCL 11/6

The quench sensitivity of six precipitation hardened aluminum alloys for aerospace applications was investigated and explained by means of TEM (Transmission Electron Microscopy). The quench sensitivity was mainly caused by the solute depletion associated with heterogeneous precipitation at dispersoids for low quench rates. Author

N89-23712# North Dakota Univ., Grand Forks. Energy and Minerals Research Center.

PRODUCTION OF JET FUELS FROM COAL-DERIVED LIQUIDS. VOLUME 8: HETEROATOM REMOVAL BY CATALYTIC PROCESSING Interim Report, 1 Jan. - 30 Aug. 1988

J. R. RINDT, M. D. HETLAND, C. L. KNUDSON, and W. G. WILLSON Jan. 1989 99 p (Contract MIPR-FY1455-86-N-0657; AF PROJ. 2480) (AD-A205470; AFWAL-TR-87-2042-VOL-8) Avail: NTIS HC A05/MF A01 CSCL 21/4

In September 1986, the Fuels Branch of the Aero Propulsion Laboratory at Wright-Patterson Air Force Base, Ohio, commenced an investigation of the potential of the production of jet fuel from the liquid by-products streams produced by the gasification of lignite

11 CHEMISTRY AND MATERIALS

at the Great Plains Gasification Plant in Beulah, North Dakota. Funding was provided to the Department of Energy (DOE), Pittsburgh Energy Technology Center (PETC), to administer the experimental portion of this effort. This report details the program with the University of North Dakota Energy and Mineral Research Center (UNDEMRC) to study the removal of heteroatoms and the saturation of aromatics found in the Great Plains tar oil stream. UNDEMRC tested a processing approach consisting of multiple-stage hydrogenations. GRA

N89-24459*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMPOSITE BLADE STRUCTURAL ANALYZER (COBSTRAN) DEMONSTRATION MANUAL

ROBERT A. AIELLO Apr. 1989 69 p
(NASA-TM-101957; E-4735; NAS 1.15:101957) Avail: NTIS HC A04/MF A01 CSCL 11/4

The input deck setup is described for a computer code, composite blade structural analyzer (COBSTRAN) which was developed for the design and analysis of composite turbofan and turboprop blades and also for composite wind turbine blades. This manual is intended for use in conjunction with the COBSTRAN user's manual. Seven demonstration problems are described with pre- and postprocessing input decks. Modeling of blades which are solid thru-the-thickness and also aircraft wing airfoils with internal spars is shown. Corresponding NASTRAN and databank input decks are also shown. Detail descriptions of each line of the pre- and post-processing decks is provided with reference to the Card Groups defined in the user's manual. A dictionary of all program variables and terms used in this manual may be found in Section 6 of the user's manual. 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.

A89-39841#

COMPARISON OF THE CRUSHING BEHAVIOUR OF METALLIC SUBFLOOR STRUCTURES

JOHANNES FRESE and DIETER NITSCHKE (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Associazione Industrie Aerospaziali and Associazione Italiana di Aeronautica ed Astronautica, European Rotorcraft Forum, 14th, Milan, Italy, Sept. 20-23, 1988, Paper. 24 p. refs (MBB-UD-535-88-PUB)

A program to analytically and experimentally study the crushing behavior of helicopter subfloor structures is discussed. Metal stiffened panels and honeycomb sandwich panels were examined under quasistatic and dynamic conditions. The behavior of sandwich panels is described in detail and compared to the behavior of stiffened panels. The results are used to design subfloor structures with high efficiency for crash impact. R.B.

A89-40084

DETERMINATION OF THE INTERACTION PARAMETER OF A TWIN-ROTOR GAS GENERATOR [STANOVENI PARAMETRU OTAKOVE INTERAKCE DVOUROTOROVEHO GENERATORU PLYNU]

BOHUSLAV RIHA Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1989, p. 25-30. In Czech. refs

A sufficiently accurate approach for the rapid determination of the interaction parameter for a twin-rotor gas generator is described. Attention is given to an approximate method of interaction

determination, which is especially suitable for application to the development of turbine engines and their automatic control systems. B.J.

A89-40255

GENERIC IMAGERY PROCESSING AND EXPLOITATION

KAREN PIGOTT (Loral Corp., Loral Defense Systems Div., Litchfield Park, AZ) IN: Airborne reconnaissance XII; Proceedings of the Meeting, San Diego, CA, Aug. 16, 17, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 20-24.

The Modular Image Exploitation System (MIMS), a state-of-the-art generic imagery-processing/exploitation system, is under development to meet the requirements of all levels of imagery-based intelligence. The generic system has been conceived as highly modular with respect to both hardware and software, allowing rapid reconfiguration to match specific applications. A windows/icon/mouse/pointer-type interface is being used by the MIMS command control system; simple, icon-selectable commands will perform such tasks as image annotation, report formatting, image roaming and zooming, rotation, etc. An RPV mission-planning screen is also under development as part of the MIMS effort. O.C.

A89-40262

USE OF MAGNETIC SUSPENSION FOR SENSOR VIBRATION ISOLATION

KEITH O. STUART (Aura Systems, Inc., Innovative Information Systems Div., Los Angeles, CA) IN: Airborne reconnaissance XII; Proceedings of the Meeting, San Diego, CA, Aug. 16, 17, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 84-92.

Magnetically suspended isolation systems which have been developed for airborne reconnaissance instruments are presently illustrated by the results of a proprietary magnetic gimbal fabrication-and-test project and those of the miniaturization of magnetic and electronic components used in magnetic-suspension isolation. In the former case, a line-of-sight accuracy of 3-8 microrad has been achieved in conjunction with an angular disturbance of 48 rad/sq sec; vibration rejection is therefore of the order of up to 79 dB. In the latter effort, a vast reduction in the size of magnetic bearings and their associated electronics has been achieved since the program's inception in 1986. O.C.

A89-40266

THE CONFORMED PANORAMIC - A NEW CONCEPT IN ELECTRO-OPTICAL SENSORS

RALPH WIGHT (Fairchild Weston Systems, Inc., Syosset, NY) IN: Airborne reconnaissance XII; Proceedings of the Meeting, San Diego, CA, Aug. 16, 17, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 138-152.

The 'conformed' electrooptic panoramic camera concept for aerial reconnaissance and mapping that yields high scan efficiency, maintains a constant GSD in both directions throughout the field-of-regard, and is free of redundancies. The best characteristics of a panoramic camera (wide field-of-regard/narrow field-of-view), a strip camera (high duty cycle), and a vertical frame camera (uniformity of GSD), are all combined in the conformed concept. O.C.

A89-40907#

PREDICTION OF TRANSITION DUE TO ISOLATED ROUGHNESS

TUNCER CEBECI (California State University, Long Beach) and DAVID A. EGAN AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 870-875. Previously cited in issue 07, p. 1002, Accession no. A88-22100. refs (Contract NSF MEA-80-56237)

A89-40914#

TRANSVERSE VIBRATIONS OF A TRAPEZOIDAL CANTILEVER PLATE OF VARIABLE THICKNESS

P. A. A. LAURA, R. H. GUTIERREZ (Instituto de Mecanica Aplicada,

Puerto Belgrano Naval Base, Argentina), and R. B. BHAT (Concordia University, Montreal, Canada) AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 921, 922.

Natural frequencies of a trapezoidal cantilever plate of variable thickness, which model an aircraft wing structure approximately, are determined using energy techniques. Characteristic orthogonal polynomials in two variables are constructed to describe the structural deflections, which are used in the Rayleigh-Ritz method to obtain the natural frequencies. The fundamental natural frequencies for different parameter values are also obtained using a deflection function containing an optimized exponent. The first technique can be used to obtain the natural frequencies and corresponding mode shapes for the preliminary design of aircraft wing structures. Author

A89-40921#

TRAJECTORY INTEGRATION IN VORTICAL FLOWS

EARLL M. MURMAN and KENNETH G. POWELL (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 982-984. refs
(Contract N00014-86-K-0288)

Trajectory integrations employed in the use of streamlines or particle traces in studies of the complex patterns encountered in vortical flows can be subject to numerical errors. Results are presented showing the step size and order-of-accuracy effects of the integration method on the computation of vortical streamlines; conical vortex figures demonstrate the correct behavior expected when the more accurate method is used, in contrast to erroneous results reported by Murman et al. (1987). O.C.

A89-41044

A SOLUTION METHOD FOR THE THREE-DIMENSIONAL COMPRESSIBLE TURBULENT BOUNDARY-LAYER EQUATIONS

L. J. JOHNSTON (Von Karman Institute for Fluid Dynamics, Rhode-Saint-Genese, Belgium) Aeronautical Journal (ISSN 0001-9240), vol. 93, April 1989, p. 115-131. Research supported by the Ministry of Defence of England. refs

The development of a new calculation method for compressible 3D boundary layers is described. The method involves a finite-difference discretisation of the governing mean-flow equations. In particular, the differencing scheme used to discretise spanwise derivatives adapts automatically to the sign of the local crossflow within the boundary layer. A plane-by-plane solution procedure in the spanwise direction enables second-order accuracy to be maintained throughout the whole flowfield. A normal coordinate scaling with the local total momentum thickness removes most of the boundary layer growth in computational space. The Cebeci-Smith algebraic turbulence model is used for the initial validation of the calculation method. A simple modification to this model is tested, involving an explicit dependence of the outer eddy viscosity on the crossflow within the boundary layer. There results a significantly improved prediction of the NLR infinite swept wing flow experiment. Author

A89-41083

A REVIEW OF METHODS OF ESTIMATING PERFORMANCE CHARACTERISTICS OF CENTRIFUGAL COMPRESSORS

SHIMPEI MIZUKI International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 5, no. 1-4, 1988, p. 171-188. refs

The current status of techniques for evaluating the performance of centrifugal compressors is surveyed, and typical data are presented in extensive tables and graphs. The parameters to be measured are listed and defined, and particular attention is given to the determination of specific speed, efficiency, and total pressure ratio; Reynolds number and Mach number; slip factor; choking, surging, and rotating stall; and the ratio of relative velocity at the inducer inlet to that at the impeller exit. T.K.

A89-41547

AN INTEGRATED APPROACH TO REMANUFACTURING TURBINE BLADES

G. MALONE (Battelle Memorial Institute, Columbus, OH) Welding Journal (ISSN 0043-2296), vol. 68, June 1989, p. 20-26.
(Contract F33615-80-C-5153)

The design and implementation of an automated welding machine developed using an integrated welding and grinding (IWAG) system for the repair of turbine blades are discussed. Particular attention is given to the IWAG system's workload requirements, the process requirements, and special technical requirements. The process of selecting the best available welding technology for the repair process to be performed, developing a system design that integrates the repair processes into a computer-based system, and designing the equipment for the repair process are described. I.S.

A89-41564#

SEAPLANES AND THE TOWING TANK

ROBERT L. VAN DYCK (Stevens Institute of Technology, Hoboken, NJ) IN: Intersociety Advanced Marine Vehicles Conference and Exhibit, Arlington, VA, June 5-7, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 294-304. refs
(AIAA PAPER 89-1533)

A development history is presented for the use of the towing tank as a test apparatus for seaplane development from the 1930s to the present. Attention is given to the Stevens Institute of Technology 'collapsed data test', which is a generalized form for the presentation of existing model-derived data that is useful as a guide for the selection of new seaplanes' design parameters. Towing tank tests bear on seaplane buoyancy and static stability, planing resistance, and takeoff hydrodynamics, as well as on directional stability and control, water-spray pattern, and landing-impact loads. O.C.

A89-41568#

RFB RESEARCH AND DEVELOPMENT IN WIG VEHICLES

HANNO FISCHER (Rhein-Flugzeugbau GmbH, Moenchengladbach, Federal Republic of Germany) IN: Intersociety Advanced Marine Vehicles Conference and Exhibit, Arlington, VA, June 5-7, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 360-366.
(AIAA PAPER 89-1495)

An account is given of the development history of wing-in-ground (WIG) effect aircraft at a major West German aircraft manufacturer since 1964; these efforts have encompassed the development of the X113 and X114 'airfoilboat' WIG seaplanes. Attention is given to the aerodynamic efficiency and operational economy trends that result from up-scaling of WIG craft configurations to takeoff gross weights of the order of 300 tons. Also noted is the illustration of comparative efficiency among types of transportation, including WIG vehicles, given by the von Karman-Gabrielli diagram. O.C.

A89-41569#

A REVIEW OF CURRENT TECHNICAL KNOWLEDGE NECESSARY TO DEVELOP LARGE SCALE WING-IN-SURFACE EFFECT CRAFT

STEPHAN F. HOOKER (Aerocon, Inc., Arlington, VA) IN: Intersociety Advanced Marine Vehicles Conference and Exhibit, Arlington, VA, June 5-7, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 367-429. refs
(AIAA PAPER 89-1497)

A comprehensive review is made of the conceptual development to date of large 'wing-in-ground' (WIG) aircraft suitable for large-payload/long range oceanic transport irrespective of the sea-states thus encountered. These WIG 'wingship' craft would be of a scale comparable to current cruise ships, while being capable of speeds fully one-half as great as those of existing airliners. Attention is given to the consequences of incorporating power-augmented ram propulsion schemes into these low aspect-ratio wingship configurations, as well as to extant methods for the prediction of the flight dynamics and efficiencies of such aircraft. O.C.

A89-41584

AGE CREEP FORMING ALUMINUM AIRCRAFT SKINS

DENISE M. HAMBRICK (Avco Aerostructures Textron, Nashville, TN) IN: Competitive advances in metals and processes; Proceedings of the First International SAMPE Metals and Metals Processing Conference, Cherry Hill, NJ, Aug. 18-20, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 135-143. refs

Avco Aerostructures Textron has advanced the technology of age creep forming by developing the ability to form aircraft structures which, previously, were difficult or impossible to form. The Autoclave Forming Aluminum process, developed by Avco, has formed smooth airfoil contours in 15 m (50 ft.) long integrally stiffened wing skins of alloys 2124 and 2419. The process produces smooth contours even across abrupt changes in thickness. The age creep forming process has also proven its ability to form compound curvatures. A data base has been developed by forming single curvature parts of seven aluminum alloys. This paper reviews development of a data base, forming compound curvature parts of alloy 7075, and applications of age creep forming aluminum.

Author

A89-41586

ELECTRON BEAM WELDING AND REPAIR OF CRITICAL STRUCTURES

R. H. WITT and A. C. LOFSTEN (Grumman Corp., Aircraft Systems Div., Bethpage, NY) IN: Competitive advances in metals and processes; Proceedings of the First International SAMPE Metals and Metals Processing Conference, Cherry Hill, NJ, Aug. 18-20, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 166-182.

Electron-beam welding (EBW) methods for the joining of heavy, large cross-section structural components in a single, full-penetration pass yield near-virgin mechanical properties for most alloys to which they have thus far been applied. Characteristic structures in which EBW has been employed have been F-14A wing box center sections, Peace Keeper missile shrouds, and the CF6 BOC2 large bypass turbofan engine's fan stage stator frame. In addition to its primary use in aerospace structure fabrication, EBW can be employed in conjunction with other welding processes to repair discrepant detail parts, especially in the case of Ti alloy machinings.

O.C.

A89-41590

SUPERPLASTIC FORMING - A NEW PRODUCTION TECHNOLOGY

P. N. COMLEY (Murdock, Inc., Compton, CA) IN: Competitive advances in metals and processes; Proceedings of the First International SAMPE Metals and Metals Processing Conference, Cherry Hill, NJ, Aug. 18-20, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 209-221.

A development history and current status evaluation is presented for superplastic forming (SPF) techniques used to manufacture high strength/weight ratio aerospace structures. The most successful applications to date for SPF fall into two broad categories: (1) deep shapes with compound curvatures, which can be produced in this way without wrinkling, and (2) either flat or curved pan shapes with complex details, which are producible by SPF in a way obviating assemblies of many separate structural elements; longerons, hat-sections, gussets and plates are integrally generated. Illustrative examples of each application are presented.

O.C.

A89-41598

QUALIFICATION OF HIGH TEMPERATURE VACUUM CARBURIZING FOR AN AIRCRAFT GEAR STEEL

ROY J. CUNNINGHAM (Boeing Vertol Co., Philadelphia, PA) IN: Competitive advances in metals and processes; Proceedings of the First International SAMPE Metals and Metals Processing Conference, Cherry Hill, NJ, Aug. 18-20, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 301-307.

The case-hardening of helicopter transmission gearing by carburizing in vacuum reduces heat-treatment time by half, requires less energy than alternative methods, results in lower parts distortion, and obviates preheating. An account is presently given of the development and qualification of the high-temperature vacuum carburizing process for 9310 gear steel, as well as of the implementation of this method for quantity production. The microstructures typically obtained by means of vacuum carburization are noted to contain no metallurgical anomalies.

O.C.

A89-41691*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

LASER ALTIMETRY MEASUREMENTS FROM AIRCRAFT AND SPACECRAFT

JACK L. BUFTON (NASA, Goddard Space Flight Center, Greenbelt, MD) IEEE, Proceedings (ISSN 0018-9219), vol. 77, March 1989, p. 463-477. refs

The techniques involved in the design and application of laser altimeter instruments are reviewed, including a description of the instrument subsystems required for the range and waveform measurements. Laser pulse transmitters based on the relatively novel technology of diode-pumped solid-state lasers are considered. Various factors affecting laser altimeter instrument performance are discussed. These include the receiver signal-to-noise ratio, atmospheric propagation, and altimeter platform effects. Some examples of laser altimeter data are presented to illustrate the variety of possible instrument applications.

I.E.

A89-41843#

VORTEX FILAMENT CALCULATIONS BY ANALYTICAL/NUMERICAL MATCHING WITH COMPARISON TO OTHER METHODS

DONALD B. BLISS and WAYNE O. MILLER (Duke University, Durham, NC) AIAA, Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989. 11 p. refs (Contract DAAL03-88-K-0062) (AIAA PAPER 89-1962)

The calculation of fluid velocity from the Biot-Savart law integrated over vortex filaments has traditionally been computationally expensive. Discretizing the filaments into N vortex elements results in order N-squared elemental velocity evaluations per time step. Further, the elemental resolution has been governed by the need to resolve the large velocity gradients in the near field of the filaments, resulting in unnecessarily high element densities in the far field, where the velocities are slowly varying. The method of Analytical/Numerical Matching (ANM) improves the efficiency of the filament velocity calculation without loss of near-field accuracy. This is done by using a far field comprised of computationally inexpensive vortex particles with a large core size for smoothing. The near field is done by an analytical correction which uses a thin physically correct core size to predict the large rapidly varying near-field velocities, and a second correction with the large core size to cancel the local vortex particle error and match to the far-field solution.

Author

A89-41889* National Center for Atmospheric Research, Boulder, CO.

EVALUATION OF LIQUID WATER MEASURING INSTRUMENTS IN COLD CLOUDS SAMPLED DURING FIRE

ANDREW J. HEYMSFIELD and LARRY M. MILOSHEVICH (National Center for Atmospheric Research, Boulder, CO) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 6, June 1989, p. 378-388. refs (Contract NASA ORDER L-98100-B; NSF ATM-85-13975)

Airborne liquid water content (LWC) measurements were conducted with an icing detector and a forward-scattering spectrometer probe during 10 flights into cold clouds, as part of the First ISCCP Research Experiment (FIRE). The LWC measurements thus obtained compare favorably with those from the hot-wire probes in the range where LWC is above the detection limits of the latter; the hot-wire probes have detection thresholds

about one order of magnitude higher than is possible with the icing detector and spectrometer probe. FIRE experiment data indicate that LWC should be taken into consideration in cloud studies at temperatures down to at least 35 C. O.C.

A89-42027*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

DEVELOPMENT OF AN EFFICIENT MULTIGRID CODE FOR 3-D NAVIER-STOKES EQUATIONS

VEER N. VATSA (NASA, Langley Research Center, Hampton, VA) and BRUCE W. WEDAN (Vigyan Research Associates, Inc., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 20th, Buffalo, NY, June 12-14, 1989. 14 p. refs

(AIAA PAPER 89-1791)

A multigrid acceleration technique has been developed to solve the three-dimensional Navier-Stokes equations efficiently. An explicit multistage Runge-Kutta type of time-stepping scheme is used as the basic algorithm in conjunction with the multigrid scheme. Solutions for flow over a finite wing have been obtained on extremely fine meshes in order to achieve grid convergence of the solutions. Present solutions indicate that the number of multigrid cycles required to achieve a given level of convergence does not increase with the number of mesh points employed, making it a very attractive scheme for fine meshes. Author

A89-42161

EFFECT OF ELECTROMAGNETIC INTERFERENCE BY NEONATAL TRANSPORT EQUIPMENT ON AIRCRAFT OPERATION

WILLIAM A. NISH, WILLIAM F. WALSH, PATRICIA LAND, and MARK SWEDENBURG (USAF, Medical Center, Keesler AFB, MS; USAF, School of Aerospace Medicine, Brooks AFB, TX) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 60, June 1989, p. 599, 600.

With the increase of the number of civilian air ambulance services operating in the United States, the potential to interference with any of the aircraft's electrical systems by the electromagnetic interference (EMI) produced by medical equipment is steadily increasing. About 70 percent of neonatal incubators, monitors, and ventilators tested over the past 15 years produced excessive EMI, by military standards. It is recommended that standards for acceptable EMI levels should be developed by the FAA and that hospitals should not purchase transport equipment from manufacturers who refuse to meet EMI standards. It is also suggested that aircraft operators must be aware of possible interference with their aircraft, and insist on equipment which meets EMI standards. I.S.

A89-42421

OPTIMIZATION OF THE COLD ROLL-FORGING OF AXIAL-FLOW COMPRESSOR BLADES WITH ALLOWANCE FOR FATIGUE CHARACTERISTICS [OPTIMIZATSIYA TEKHNologii KHOLODNOI VAL'TSOVKI S UCHETOM KHARAKTERISTIK USTALOSTI LOPATOK OSEVYKH KOMPRESSOROV]

V. P. EGOROV, I. F. KORNET, V. M. KAPRALOV, and V. A. MATVIICHUK Problemy Prochnosti (ISSN 0556-171X), May 1989, p. 89-92. In Russian. refs

The paper is concerned with the problem of increasing the efficiency of the cold-forging of axial-flow compressor blades while maintaining good fatigue strength characteristics. The problem is solved by applying current concepts of the stress-strain state and through the optimal use of the ductility resource during the roll-forging process. The parameters of the key stages of the process are optimized, and the fatigue properties of blades of EP718 nickel alloy and EP866 stainless steel are determined from mass test results. V.L.

A89-42500

INVERSE PROBLEM IN NOZZLE THEORY [OBRATNAIA ZADACHA TEORII SOPLA]

UL'IAN G. PIRUMOV Moscow, Izdatel'stvo Mashinostroenie, 1988, 240 p. In Russian. refs

The inverse problem in nozzle theory is analyzed for the general case of three-dimensional flow, and numerical methods for solving the problem are presented. Particular attention is given to the practical applications of the inverse problem. Results of studies of nozzle flows, flows in ducts of complex shapes, and flows in ducts with mass and energy input are reported. Solutions results are also presented for the inverse problem of duct profiling. V.L.

A89-42524

PRECISION AND EFFICIENCY OF THE RADIO ELECTRONIC SYSTEMS OF AIRCRAFT [TOCHNOST' I RABOTOSPOSOBNOST' RADIOELEKTRONNYKH SISTEM LETATEL'NYKH APPARATOV]

SERGEI K. SAVIN Moscow, Izdatel'stvo Mashinostroenie, 1988, 192 p. In Russian. refs

The theoretical and practical aspects of the estimation of the precision of the radio electronic systems of aircraft are discussed. In particular, mathematical models for monitoring the performance of radio electronic systems are described, as are methods for evaluating the accuracy of such systems. A method is proposed for evaluating the overall efficiency of radio electronic systems from their performance and precision characteristics. V.L.

A89-42557

FORMATION OF SINGULARITIES IN A THREE-DIMENSIONAL BOUNDARY LAYER [FORMIROVANIE OSOBNOSTEI V PROSTRANSTVENNOM POGRANICHNOM SLOE]

V. B. ZAMETAEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Mar.-Apr. 1989, p. 58-64. In Russian. refs

The formation of singularities in a three-dimensional laminar boundary layer near the spread line of an ellipsoid is investigated analytically with allowance for the three-dimensional nature of the flow in the vicinity of the zero friction point. It is demonstrated, on the basis of full equations of the boundary layer, that an isolated point of zero longitudinal friction is in fact formed for a certain critical angle of attack of the ellipsoid. For angles of attack larger than the critical angle, a line on the body surface is defined beyond which the solution cannot be continued. V.L.

A89-42853

ACOUSTIC EMISSION DETECTION OF CRACK PRESENCE AND CRACK ADVANCE DURING FLIGHT

S. L. MCBRIDE, M. D. POLLARD, J. D. MACPHAIL, P. S. BOWMAN, and D. T. PETERS (Royal Military College of Canada, Kingston) Journal of Acoustic Emission (ISSN 0730-0050), vol. 8, Jan.-June 1989, p. S4-S7.

A dual-channel digital data acquisition system designed to record and interpret acoustic emission data during flight is described. The importance of the difference in arrival time of an event at different locations, signal risetime, and the magnitude and variation of the applied stress at the time of occurrence of the event is emphasized. A schematic diagram is presented of the inertially-loaded 7075-T651 aluminum fatigue specimen clamped in the inertial loading frame support. K.K.

A89-43076#

INNOVATIVE PRODUCTION TECHNOLOGY IN AIRCRAFT CONSTRUCTION: CIAM FORMING 'MADE BY MBB' - A HIGHLY PRODUCTIVE EXAMPLE

New-Tech News, no. 1, 1989, p. 21-23.

A novel production technology in aircraft construction was developed for manufacturing parts of shapes and dimensions that involve only small quantities for one machine. The process, called computerized integrated and automated manufacturing (CIAM), makes it possible to make ready-to-install sheet-metal parts for all types of aircraft. All of the system's job sequences, which include milling the flat sheet-metal parts in stacks, deburring, heat treatment, and forming under the high-pressure rubber-pad press, are automated. The CIAM production center, called SIAM Forming, fulfills the prerequisites for the cost-effective production of

sheet-metal parts made of aluminum alloys, titanium, or steel. The SIAM procedure results in negligible material loss through computerizing both component-contour nesting of the sheet-metal parts and contour milling. I.S.

A89-43177*# Engineering Analysis, Inc., Ames, IA.
A THREE-DIMENSIONAL UPWIND PARABOLIZED NAVIER-STOKES CODE FOR REAL GAS FLOWS

JOHN C. TANNEHILL, PHILIP E. BUELOW, JOHN O. IEVALTS (Engineering Analysis, Inc., Ames, IA), and SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Thermophysics Conference, 24th Buffalo, NY, June 12-14, 1989. 15 p. refs
 (Contract NAS2-12861)
 (AIAA PAPER 89-1651)

A real gas, upwind, parabolized Navier-Stokes (PNS) code has been developed to compute the three-dimensional hypersonic flow of equilibrium air around various body shapes. The new code is an extension of the upwind (perfect gas) PNS code of Lawrence et al. (1986). The upwind algorithm is based on Roe's (1981) flux-difference splitting scheme which has been modified to account for real gas effects using the nearly exact approach of Vinokur and Liu (1988). Simplified curve fits are employed to obtain the thermodynamic and transport properties of equilibrium air. The new code has been validated by computing the $M = 25$ laminar flow of air over cones at various angles of attack. The results of these computations are compared with the results from a conventional centrally-differenced, real gas PNS code and the previous axisymmetric, upwind, real gas code. The agreement is excellent in all cases. Author

A89-43268*# Tennessee Univ., Tullahoma.
MEASUREMENTS OF DIFFUSION LIMITED SOLIDIFICATION AT VARYING GRAVITY

T. D. MCCAY, M. H. MCCAY, S. A. LOWRY, L. M. SMITH, and A. H. HENDERSON (Tennessee, University, Tullahoma) AIAA, Thermophysics Conference, 24th, Buffalo, NY, June 12-14, 1989. 28 p. Research sponsored by NASA. refs
 (AIAA PAPER 89-1755)

The environment of the NASA KC-135 low gravity aircraft was employed to examine the effects of g-jitter on the growth of a solidification diffusion layer for 28 wt pct $\text{NH}_4\text{Cl-H}_2\text{O}$, a metal alloy model material. The hypothesis that jitter (vibrational) effects account for previously observed low gravity growth anomalies was investigated by comparing optical data (central dark ground method) for 10-squared g(e) (earth's gravity) KC-135 growth conditions and 1 g(e) laboratory conditions. Accelerometer data obtained during the flight program showed the KC-135 low gravity environment to have extreme levels of jitters. Author

A89-43535
BRAZE REPAIR OF AERO ENGINE COMPONENTS

K. B. GOVE Metals and Materials (ISSN 0266-7185), vol. 5, June 1989, p. 341-345.

The role of brazing in the repair of aircraft-engine components is discussed with special attention given to brazing techniques used in cost-effective repair of the hottest running components of so-called 'second generation' of fuel-efficient engines. The repair schemes used in cold-braze repairs of the fan and the compressor sections of gas turbine engines and in the hot-braze repair of gas-path-section components are examined. Consideration is also given to the procedures used in hot section braze repairs, the procedure of fluoride cleaning (to remove oxidized materials), and to wide-gap braze repairs. The questions of quality control and aircraft safety are given special consideration. Compositions of typical brazes used in the cold-section and hot section repairs are given. I.S.

N89-23740# Army Cold Regions Research and Engineering Lab., Hanover, NH.

RESPONSE OF PAVEMENT TO FREEZE-THAW CYCLES: LEBANON, NEW HAMPSHIRE, REGIONAL AIRPORT

WENDY L. ALLEN, WILLIAM F. QUINN, DONALD KELLER, and

ROBERT A. EATON Jan. 1989 35 p
 (Contract DOT-FA79WA1-059; DA PROJ. 4A7-62730-AT-42)
 (AD-A205559; CRREL-SR-89-2; DOT/FAA/PS-89/1) Avail: NTIS HC A03/MF A01 CSCL 13/2

In 1978 reconstruction was begun on the runway of the Lebanon Regional Airport, Lebanon, New Hampshire. The runway had experienced severe differential frost heaving and cracking during the previous three winters, which had resulted in closure of the facility during periods of extreme roughness. Temperature sensors were placed within the newly constructed pavement sections, and during the winters of 1979, 1980, and 1982 temperature data were recorded, and level surveys and repeated plate bearing tests were performed in order to provide data for the investigation. The three pavement sections were constructed to investigate the effect of section thickness on the level of frost protection provided. The sections consisted of 4 in. of asphalt concrete, 6 in. of crushed gravel and 22,30 dn 38 in. of well-graded sand subbase material. The 48-in section provided the highest level of frost protection to the subgrade. However, all three pavement sections maintained resilient stiffness values during the spring thaw period on the order of two to three times that of the pavement before reconstruction. Also, frost heave in all sections was reduced to levels that would not cause difficulty for aircraft using the facility. GRA

N89-23758# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.

ASR-9 WEATHER CHANNEL TEST REPORT, EXECUTIVE SUMMARY

SETH W. TROXEL 3 May 1989 29 p Original contains color illustrations
 (Contract DTFA01-80-Y-10546; F19628-85-C-0002)
 (DOT/FAA/PS-89/6-EXEC-SUMM; ATC-168-EXEC-SUMM)
 Avail: NTIS HC A03/MF A01

The next generation airport surveillance radar, (ASR-9), will be deployed by the FAA at over 100 locations throughout the United States. The system includes a weather channel designed to provide air traffic controller personnel with timely and accurate weather reflectivity information as a supplement to normal aircraft information. Comparisons between data from an ASR-9 in Huntsville, Alabama, recorded during design qualification and testing, and data from two other reference radars, were used as the basis for assessment of ASR-9 weather channel performance. Results suggest that, with the exception of an apparent 3 dB discrepancy between the weather products of the ASR-9 and the reference radars, the ASR-9 weather channel seems to perform according to FAA specifications. Author

N89-23774# Aeronautical Systems Div., Wright-Patterson AFB, OH. Human Factors Branch.

AN EVALUATION OF THE F/FB/EF-111 CREW/VOICE MESSAGE SYSTEM Final Report, Dec. 1987 - Jun. 1988

JOHN A. HASSOUN, J. M. BARNABA, and E. M. MATHESON Jan. 1989 68 p
 (AD-A205998; ASD-TR-88-5037) Avail: NTIS HC A04/MF A01 CSCL 25/4

In support of the F/FB/EF-111 Digital Flight Control System Program Office, subjective and performance data were collected in order to provide the government and contractor engineers with information needed in the design of a Voice Message Unit (VMU) interface for the F/FB/EF-111 aircraft. The VMU, one of the new safety of flight systems, is being included as part of the Digital Flight Control Computer. The VMU will be used as a means for alerting crew members to flight critical conditions. The evaluation was comprised of two phases. During the first phase, questionnaire data were collected from a sample of 119 operational F/FB/EF-111 crew members. The second phase of the evaluation involved the mechanization of the VMU interface in an FB-111 simulator, located at the Crew Station Design Facility, for pilots' on-hand experience with the content of the voice messages and the mechanization aspects of the interface. GRA

N89-23809*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ADVANCED COMPUTATIONAL TECHNIQUES FOR HYPERSONIC PROPULSION

LOUIS A. POVINELLI 1989 24 p Proposed for presentation at the 9th International Symposium on Air Breathing Engines, Athens, Greece, 4-9 Sep. 1989; sponsored by AIAA and International Society for Air Breathing Engines (NASA-TM-102005; E-4711; NAS 1.15:102005) Avail: NTIS HC A03/MF A01 CSCL 20/4

Computational Fluid Dynamics (CFD) has played a major role in the resurgence of hypersonic flight, on the premise that numerical methods will allow performance of simulations at conditions for which no ground test capability exists. Validation of CFD methods is being established using the experimental data base available, which is below Mach 8. It is important, however, to realize the limitations involved in the extrapolation process as well as the deficiencies that exist in numerical methods at the present time. Current features of CFD codes are examined for application to propulsion system components. The shortcomings in simulation and modeling are identified and discussed. Author

N89-23822 Colorado Univ., Boulder.
COMPUTATION OF DYNAMICS AND CONTROL OF UNSTEADY VORTICAL FLOWS PH.D. Thesis

KALPANA CHAWLA 1988 147 p
Avail: Univ. Microfilms Order No. DA8902887

In the first part of this work, unsteady, two-dimensional, vortical flows past stationary and oscillating normal plates and airfoil configurations with stationary and oscillating spoilers are studied using the Discrete-Vortex method. Vortical structures as well as unsteady lift and drag were computed for various flow conditions and body configurations. The comparison of force results for the airfoil configurations involving oscillating spoilers with the corresponding stationary cases indicates that there is no appreciable difference between the average values of lift and drag. In the second part, computational models are presented for multi-vortex systems in the presence of acoustic waves. Computational models are developed to study the stability of single infinite row of vortices and Karman's infinite, unsymmetric, double row of vortices. Results suggest that acoustic waves of specific wavelengths can be used to destabilize the Karman street manifested in nature, so as to scatter its vortices in an effort to weaken its impact. It is also shown that for vortex systems made up of small number of vortices, redistribution or recombination of vortices by conserving strength of the system and maintaining constant center of vorticity can result in vortex systems with different properties compared to the original systems.

Dissert. Abstr.

N89-23831# Nielsen Engineering and Research, Inc., Mountain View, CA.

EXPLOITATION OF MULTIPLE SOLUTIONS OF THE NAVIER-STOKES EQUATIONS TO ACHIEVE RADICALLY IMPROVED FLIGHT Final Report, 1 Aug. 1988 - 31 Jan. 1989

DAVID NIXON, S. C. CARUSO, and M. FARSHCHI 27 Feb. 1989 50 p
(Contract F49620-88-C-0097; AF PROJ. 3005)
(AD-A205939; NEAR-TR-398; AFOSR-89-0364TR) Avail: NTIS HC A03/MF A01 CSCL 20/4

It is known that the nonlinear Navier Stokes equations will model most fluid flow of aeronautical interest. The existence and uniqueness of the solutions to the Navier-Stokes equations have not been proven although it is known that in certain cases only the most stable solution is obtained. This present work is concerned with identifying multiple solutions of the Navier-Stokes equations for transonic flow. The objective is to exploit the existence of these solutions rather than avoid them as has been the custom in the past. The present work has shown that the cause of multiple solutions in potential flow is a bifurcation of solutions at a specific Mach number distribution; airfoils can be designed to give such a distribution. It is also found that the presence of entropy and

vorticity do not affect the occurrence of phantom solutions. A physical example of a phantom solution is explained by a study of the potential phantom solutions. GRA

N89-23920*# Boeing Helicopter Co., Philadelphia, PA.
GROUND SHAKE TEST OF THE BOEING MODEL 360 HELICOPTER AIRFRAME Final Report

D. A. REED and R. GABEL Mar. 1989 298 p
(Contract NAS1-17497)
(NASA-CR-181766; NAS 1.26:181766; D210-12328-3) Avail: NTIS HC A13/MF A01 CSCL 20/11

Boeing Helicopters, together with other U.S. Helicopter manufacturers, is engaged in a finite element applications program designed to emplace in the U.S. a superior capability to utilize finite element analysis models in support of helicopter airframe structural design. This program was given the acronym DAMVIBS (Design Analysis Methods for VIBrationS). The test plan is reviewed and results are presented for a shake test of the Boeing Model 360 helicopter. Results of the test will serve as the basis for validation of a finite element vibration model of the helicopter. Author

N89-24304# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuehrung.

TRANSFORMATION OF REAL AND VIRTUAL OBJECTS INTO A VIRTUAL, VISUAL ENVIRONMENT

R. BEYER *In its* Image Signal Processing for Flight Guidance p 217-247 Sep. 1988 In GERMAN; ENGLISH summary
Avail: NTIS HC A14/MF A01; DFVLR, VB-PL-DO, Postfach 40 60 58, 5000 Cologne, Fed. Republic of Germany, DM 108

The synthesis of dynamic images for control and surveillance purposes is discussed, with emphasis on the transformation of real and virtual objects into a user-adapted representation space. The acceptance and utilization problems of complex dynamic systems can be alleviated if a pictorial presentation of the system state and the user-accessible system parameters is employed. Methods to mathematically model the objects to be displayed, to transform their pictorial representation from object space to display space, and to visualize the objects therein real time are discussed. Applications are in the field of guidance and control of aerospace vehicles, air traffic systems, teleoperations, and other dynamic processes which require an interaction with man. ESA

N89-24563*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

AERODYNAMIC INTERACTION BETWEEN VORTICAL WAKES AND LIFTING TWO-DIMENSIONAL BODIES

PAUL M. STREMEEL Mar. 1989 34 p Previously announced in IAA as A88-22785
(NASA-TM-101074; A-89047; NAS 1.15:101074) Avail: NTIS HC A03/MF A01 CSCL 20/4

Unsteady rotor wake interactions with the empennage, tail boom, and other aerodynamic surfaces of a helicopter have a significant influence on its aerodynamic performance, the ride quality, and vibration. A numerical method for computing the aerodynamic interaction between an interacting vortex wake and the viscous flow about arbitrary two-dimensional bodies was developed to address this helicopter problem. The method solves for the flow field velocities on a body-fitted computational mesh using finite-difference techniques. The interacting vortex wake is represented by an array of discrete vortices which, in turn, are represented by a finite-core model. The evolution of the interacting vortex wake is calculated by Lagrangian techniques. The viscous flow field of the two-dimensional body is calculated on an Eulerian grid. The flow around circular and elliptic cylinders in the absence of an interacting vortex wake was calculated. These results compare very well with other numerical results and with results obtained from experiment and thereby demonstrate the accuracy of the viscous solution. The interaction of a rotor wake with the flow about a 4 to 1 elliptic cylinder at 45 degree incidence was calculated for a Reynolds number of 3000. The results demonstrate

the significant variations in the lift and drag on the elliptic cylinder in the presence of the interacting rotor wake. Author

N89-24607*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH.

COMPARISON OF PREDICTED AND MEASURED TEMPERATURES OF UH-60A HELICOPTER TRANSMISSION

HAROLD H. COE Washington Apr. 1989 15 p (NASA-TP-2911; NAS 1.60:2911; E-4588; AVSCOM-TR-89-C-010) Avail: NTIS HC A03/MF A01 CSCL 13/9

The 2109-kW (2828-hp) UH-60A Black Hawk helicopter transmission was one of the transmissions used to obtain an experimental data base. Component improvements or new transmission concepts can thus be evaluated by comparison with the established data. Results of efficiency and vibration tests of the UH-60A have been reported previously. In this investigation the transmission was instrumented internally and tested over a range of operating conditions. The speed was varied from 50 to 100 percent of the full rated value, and the torque was varied from 10 to 100 percent of the full rated value. Temperatures of internal bearings and gears were measured. The computer program Planetsys was used to simulate the thermal performance of this transmission. The calculated temperatures were then compared with the corresponding measured values. The highest measured temperature was 405 K (270 F) on the outer race of the high-speed input shaft roller bearing, at the 100-percent power condition. In general, the predicted temperatures compared very well with the measured values, most of them being within 5 kelvin (9 F). Specifically, the temperatures predicted for the single-row spherical roller planetary bearing averaged only about 4 kelvin (8 F) lower than the highest measured value. Author

N89-24624*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

CSM TESTBED DEVELOPMENT AND LARGE-SCALE STRUCTURAL APPLICATIONS

NORMAN F. KNIGHT, JR., R. E. GILLIAN, SUSAN L. MCCLEARY, C. G. LOTT, E. L. POOLE, A. L. OVERMAN, and S. C. MACY (Planning Research Corp., Washington, DC.) Washington Apr. 1989 25 p Original contains color illustrations (NASA-TM-4072; L-16499; NAS 1.15:4072) Avail: NTIS HC A03/MF A01 CSCL 20/11

A research activity called Computational Structural Mechanics (CSM) conducted at the NASA Langley Research Center is described. This activity is developing advanced structural analysis and computational methods that exploit high-performance computers. Methods are developed in the framework of the CSM Testbed software system and applied to representative complex structural analysis problems from the aerospace industry. An overview of the CSM Testbed methods development environment is presented and some new numerical methods developed on a CRAY-2 are described. Selected application studies performed on the NAS CRAY-2 are also summarized. Author

N89-24639*# Hibbitt, Karlsson and Sorensen, Providence, RI. **SOME ISSUES IN NUMERICAL SIMULATION OF NONLINEAR STRUCTURAL RESPONSE**

H. D. HIBBITT In NASA, Langley Research Center, Computational Methods for Structural Mechanics and Dynamics, Part 1 p 7-23 May 1989

Avail: NTIS HC A15/MF A01 CSCL 20/11

The development of commercial finite element software is addressed. This software provides practical tools that are used in an astonishingly wide range of engineering applications that include critical aspects of the safety evaluation of nuclear power plants or of heavily loaded offshore structures in the hostile environments of the North Sea or the Arctic, major design activities associated with the development of airframes for high strength and minimum weight, thermal analysis of electronic components, and the design of sports equipment. In the more advanced application areas, the effectiveness of the product depends critically on the quality of the mechanics and mechanics related algorithms that are implemented. Algorithmic robustness is of primary concern. Those

methods that should be chosen will maximize reliability with minimal understanding on the part of the user. Computational efficiency is also important because there are always limited resources, and hence problems that are too time consuming or costly. Finally, some areas where research work will provide new methods and improvements is discussed. Author

N89-24640*# Boeing Military Airplane Development, Seattle, WA.

COMPUTERIZED STRUCTURAL MECHANICS FOR 1990'S: ADVANCED AIRCRAFT NEEDS

A. V. VISWANATHAN and B. F. BACKMAN In NASA, Langley Research Center, Computational Methods for Structural Mechanics and Dynamics, Part 1 p 25-49 May 1989

Avail: NTIS HC A15/MF A01 CSCL 20/11

The needs for computerized structural mechanics (CSM) as seen from the standpoint of the aircraft industry are discussed. These needs are projected into the 1990's with special focus on the new advanced materials. Preliminary design/analysis, research, and detail design/analysis are identified as major areas. The role of local/global analyses in these different areas is discussed. The lessons learned in the past are used as a basis for the design of a CSM framework that could modify and consolidate existing technology and include future developments in a rational and useful way. A philosophy is stated, and a set of analyses needs driven by the emerging advanced composites is enumerated. The roles of NASA, the universities, and the industry are identified. Finally, a set of rational research targets is recommended based on both the new types of computers and the increased complexity the industry faces. Computerized structural mechanics should be more than new methods in structural mechanics and numerical analyses. It should be a set of engineering applications software products that combines innovations in structural mechanics, numerical analysis, data processing, search and display features, and recent hardware advances and is organized in a framework that directly supports the design process. Author

N89-24642*# Lockheed Missiles and Space Co., Palo Alto, CA. **COMPUTATIONAL PROCEDURES FOR POSTBUCKLING OF COMPOSITE SHELLS**

G. M. STANLEY and CARLOS A. FELIPPA In NASA, Langley Research Center, Computational Methods for Structural Mechanics and Dynamics, Part 1 p 67-87 May 1989

Avail: NTIS HC A15/MF A01 CSCL 20/11

A recently developed finite-element capability for general nonlinear shell analysis, featuring the use of three-dimensional constitutive equations within an efficient resultant-oriented framework, is employed to simulate the postbuckling response of an axially compressed composite cylindrical panel with a circular cutout. The problem is a generic example of modern composite aircraft components for which postbuckling strength (i.e., fail-safety) is desired in the presence of local discontinuities such as holes and cracked stiffeners. While the computational software does a reasonable job of predicting both the buckling load and the qualitative aspects of postbuckling (compared both with experiment and another code) there are some discrepancies due to: (1) uncertainties in the nominal layer material properties, (2) structural sensitivity to initial imperfections, and (3) the neglect of dynamic and local material delamination effects in the numerical model. Corresponding refinements are suggested for the realistic continuation of this type of analysis. Author

N89-24654*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

COMPUTATIONAL METHODS FOR STRUCTURAL MECHANICS AND DYNAMICS

W. JEFFERSON STROUD, ed., JERROLD M. HOUSNER, ed., JOHN A. TANNER, ed., and ROBERT J. HAYDUK, ed. Washington May 1989 256 p Workshop held in Hampton, VA, 19-21 Jun. 1985

(NASA-CP-3034-PT-2; L-16560-PT-2; NAS 1.55:3034-PT-2)

Avail: NTIS HC A12/MF A01 CSCL 20/11

Topics addressed include: transient dynamics; transient finite

element method; transient analysis in impact and crash dynamic studies; multibody computer codes; dynamic analysis of space structures; multibody mechanics and manipulators; spatial and coplanar linkage systems; flexible body simulation; multibody dynamics; dynamical systems; and nonlinear characteristics of joints.

N89-24655*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

IMPROVING TRANSIENT ANALYSIS TECHNOLOGY FOR AIRCRAFT STRUCTURES

R. J. MELOSH (Duke Univ., Durham, NC.) and MLADEN CHARGIN /in NASA, Langley Research Center, Computational Methods for Structural Mechanics and Dynamics p 343-353 May 1989

Avail: NTIS HC A12/MF A01 CSCL 20/11

Aircraft dynamic analyses are demanding of computer simulation capabilities. The modeling complexities of semi-monocoque construction, irregular geometry, high-performance materials, and high-accuracy analysis are present. At issue are the safety of the passengers and the integrity of the structure for a wide variety of flight-operating and emergency conditions. The technology which supports engineering of aircraft structures using computer simulation is examined. Available computer support is briefly described and improvement of accuracy and efficiency are recommended. Improved accuracy of simulation will lead to a more economical structure. Improved efficiency will result in lowering development time and expense. Author

N89-24658*# Grumman Aerospace Corp., Bethpage, NY. **TRANSIENT ANALYSIS TECHNIQUES IN PERFORMING IMPACT AND CRASH DYNAMIC STUDIES**

A. B. PIFKO and R. WINTER /in NASA, Langley Research Center, Computational Methods for Structural Mechanics and Dynamics p 383-406 May 1989

Avail: NTIS HC A12/MF A01 CSCL 20/11

Because of the emphasis being placed on crashworthiness as a design requirement, increasing demands are being made by various organizations to analyze a wide range of complex structures that must perform safely when subjected to severe impact loads, such as those generated in a crash event. The ultimate goal of crashworthiness design and analysis is to produce vehicles with the ability to reduce the dynamic forces experienced by the occupants to specified levels, while maintaining a survivable envelope around them during a specified crash event. DYCAST is a nonlinear structural dynamic finite element computer code that started from the plans systems of a finite element program for static nonlinear structural analysis. The essential features of DYCAST are outlined. B.G.

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GEOSCIENCES

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

N89-24777# Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Direction de la Physique Generale. **LIGHTNING INFLIGHT STUDY ONBOARD A TRANSALL AIRCRAFT. DEFINITION OF THE ONBOARD INSTRUMENTS Final Report [ETUDE DE FOUDROIEMENT EN VOL SUR AVION TRANSALL PREPARATION DE LA CAMPAGNE D'ESSAIS EN VOL. DEFINITION DE L'INSTRUMENTATION EMBARQUEE]**

P. Y. GONZALES, F. ISSAC, J. Y. JOUAN, J. P. MOREAU, J. P. APARICIO, P. GONDOT, and A. DELANNOY Jul. 1988 103 p In FRENCH

(Contract DRET-87-001)

(ONERA-RF-19/7234-PY; ONERA-RF-19/7154-PY; ETN-89-94527) Avail: NTIS HC A06/MF A01

The description includes the developed sensors, the computer programs for data acquisition and data processing, the experimental design of the ground tests, and the optimization studies of an ionic conductivity metering cell. The 32 k on 10 bits input of the data acquisition is processed in a 386 Compaq microcomputer with a 6 MHz memory extension. Processed data are then transferred to a Cray computer via specific programs. 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.

A89-40425

MILCOMP '88 - MILITARY COMPUTERS, GRAPHICS AND SOFTWARE; PROCEEDINGS OF THE CONFERENCE AND EXHIBITION, LONDON, ENGLAND, SEPT. 27-29, 1988

Conference and Exhibition organized by the Microwave Exhibitions and Publishers, Ltd. Tunbridge Wells, England, Microwave Exhibitions and Publishers, Ltd., 1988, 464 p. No individual items are abstracted in this volume.

Recent advances in computer software and hardware for military applications are discussed in reviews and reports, with an emphasis on developments in the UK. Topics addressed include system requirements, computer architectures, standards and interoperability, communications, systems architecture, security and integrity, civilian applications, software engineering and IPSEs, human-factors analysis, international policy, and education and training for information technology. Consideration is given to AI tools and applications, life-cycle costing, embedded computer applications, project management, and data-base technology. T.K.

A89-40447

AIRCRAFT RECOGNITION USING A PARTS ANALYSIS TECHNIQUE

G. A. ROBERTS (Ford Aerospace Corp., Newport Beach, CA) IN: Applications of digital image processing XI; Proceedings of the Meeting, San Diego, CA, Aug. 15-17, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 338-345. refs

A knowledge-based system for aircraft recognition is described. This system uses a parts-matching technique to identify aircraft. The target aspect is used and is determined using motion and skeletal feature analysis. Silhouette models for the particular aspect of the aircraft are generated using the aspect information. A parts analysis that compares the models' parts to the segmented aircraft is used to identify the aircraft. The techniques used for parts analysis, model generation, and aspect determination are described. Also a study is presented which compares the performance of two statistical classifiers to the knowledge based classifier. Author

A89-41081

THE APPLICATION OF ARTIFICIAL INTELLIGENCE TECHNIQUES FOR TURBOMACHINERY DIAGNOSTICS

CYRUS B. MEHER-HOMJI (Boyce Engineering International, Inc., Houston, TX) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 5, no. 1-4, 1988, p. 95-105. refs

This paper presents a study into the application of artificial intelligence techniques (specifically expert systems) to the problem of turbomachine diagnostics. The diagnostic process is described, and a model for computer implementation provided. Some

15 MATHEMATICAL AND COMPUTER SCIENCES

diagnostic examples are provided to explain the methodology. Expert-system development is underway for incorporation to on-line monitoring and diagnostic systems. Author

A89-41698* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

A RAPID PROTOTYPING FACILITY FOR FLIGHT RESEARCH IN ADVANCED SYSTEMS CONCEPTS

EUGENE L. DUKE (NASA, Flight Research Center, Edwards, CA), RANDAL W. BRUMBAUGH, and JAMES D. DISBROW (PRC Systems Services, McLean, VA) Computer (ISSN 0018-9162), vol. 22, May 1989, p. 61-66. Previously announced in STAR as N87-12273. refs

The Dryden Flight Research Facility of the NASA Ames Research Facility of the NASA Ames Research Center is developing a rapid prototyping facility for flight research in flight systems concepts that are based on artificial intelligence (AI). The facility will include real-time high-fidelity aircraft simulators, conventional and symbolic processors, and a high-performance research aircraft specially modified to accept commands from the ground-based AI computers. This facility is being developed as part of the NASA-DARPA automated wingman program. This document discusses the need for flight research and for a national flight research facility for the rapid prototyping of AI-based avionics systems and the NASA response to those needs. Author

A89-41796#

A HIGH-RESOLUTION EULER SOLVER

WIM A. MULDER (California, University, Los Angeles) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 212-220. refs (AIAA PAPER 89-1949)

In an earlier paper, an O(N) method for the computation of stationary solutions to the Euler equations of inviscid compressible gas dynamics has been described. The method is a variant of the multigrid technique and is able to provide good convergence rates for first-order upwind discretizations even in the case of alignment, the flow being aligned with the grid. The application of this scheme to higher-order discretizations is discussed. Two-level analysis for the linear constant-coefficient case has shown that it is difficult or impossible to obtain uniformly good convergence rates for a higher-order scheme, due to waves perpendicular to stream lines. The defect correction technique suffers from the same problem. However, convergence to a point where the residual of the total error (the sum of the iteration error and the discretization error) is of the order of the truncation error can be obtained in about 7 defect correction cycles, according to estimates for the linear constant-coefficient equations. Here this result is explored for the nonlinear case by some illustrative numerical experiments. Author

A89-43068#

IMPROVED TIME-DOMAIN STABILITY ROBUSTNESS MEASURES FOR LINEAR REGULATORS

DJORDJICA B. PETKOVSKI (Novi Sad, Univerzitet, Yugoslavia) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, July-Aug. 1989, p. 595-598. Research supported by the U.S.-Yugoslav Joint Fund for Scientific and Technological Cooperation and DOE. refs

A novel time-domain stability criterion for linear state-space models is presented in conjunction with a computationally effective algorithm whose perturbation bounds are superior to those based on the frequency-domain approach and the time-domain approach. Unlike many other criteria, this algorithm allows a designer to easily incorporate the directional information on structural perturbations in stability robustness analysis. An aircraft-control illustrative example is given. O.C.

A89-43127

SOFTWARE DEVELOPMENT REUSABILITY FOR AIRCRAFT SIMULATION SYSTEMS

B. A. SATHRE (Martin Marietta Corp., Orlando, FL) IN: 1988

Annual Summer Computer Simulation Conference, 20th, Seattle, WA, July 25-28, 1988, Proceedings. San Diego, CA, Society for Computer Simulation International, 1988, p. 57-63. refs

The rationale for having one set of reusable simulation components serve as the foundation for differing simulations where each simulation leads to a unique product is presented. A classification of simulation software modules is proposed. Their reusability is discussed for the following phases of software development: requirements analysis, design, code, implementation, testing, and documentation. K.K.

N89-24051# Federal Aviation Administration, Atlantic City, NJ. **HOST COMPUTER SYSTEM CAPACITY MANAGEMENT**

PROCEDURES Technical Note, 1987

NORMAN W. WATTS, PAUL CONNOLLY, ROBERT GOETTGE, GARY MORFITT, ROBERT WISEMAN, GARY WRIGHT, and FRANK YAZEK Feb. 1988 48 p

(Contract FAA-T0503-M)

(AD-A193416; DOT/FAA/CT-TN87/43) Avail: NTIS HC A03/MF A01 CSCL 09/2

The Federal Aviation Administration's Advanced Automation Program Office recognized the need for monitoring and assessing the National Airspace System's operational performance and for long term planning during the life-cycle of the Host Computer System. The assessment of the operational performance involved the acquisition and analysis of field measurement data, while the long-term capacity planning entails execution of a Host Computer System analytical model using current and project traffic and other system loads. The procedures document defines the activities to be executed in: measuring and monitoring operational performance; measuring projecting system workloads; predicting system performance using an analytical performance model; and analyzing and reporting current and predicted future performance of the Host Computer System. Author

N89-24079*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

APPLICATION OF A PC BASED, REAL-TIME, DATA-AQUISITION SYSTEM IN ROTORCRAFT WIND-TUNNEL TESTING

MATTHEW L. WILBUR Washington Jul. 1989 26 p Prepared in cooperation with Army Aviation Systems Command, Hampton, VA

(NASA-TM-41119; L-16565; NAS 1.15:4119; AVSCOM-TM-89-B-003) Avail: NTIS HC A03/MF A01 CSCL 09/2

Data has been acquired for a rotorcraft test in the NASA Langley Transonic Dynamics Tunnel using a desktop data acquisition system. The system, which consists of an IBM Personal Computer AT (PC-AT) and an Omega Engineering OM-900 Stand-Alone Interface System, is well suited for acquiring high speed data on a limited number of channels. The data acquisition system and the interrupt driven software which provides the capability for near real-time cyclic data acquisition as well as data storage and display are described. Author

N89-24127# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

A DEMONSTRATION OF THE METHOD OF STOCHASTIC FINITE ELEMENT ANALYSIS M.S. Thesis

PAUL R. BRYANT Mar. 1989 98 p

(AD-A206135; AFIT/GA/AA/89M-01) Avail: NTIS HC A05/MF A01 CSCL 12/4

Finite element analysis has been used as a design tool for many years, with structural reliability being ensured through use of a liberal factor of safety. Unfortunately, the safety factor is a blanket insurance against all hazards, and a designer has no way to optimize a structure against any particular hazard. This is particularly troublesome in the fields of aero/astro design, where every bit of mass must serve to maximum utility. The method of Stochastic Finite Element Analysis allows a designer to model any loading or hazard condition as closely to reality as desired by using an appropriate probability distribution function. Through a

Monte Carlo simulation, the finite element model is subject to the probability functions. The cumulative output is analyzed for trends in failure probability and the design is altered to enhance its reliability, repeating the process until the desired level of reliability is achieved. The resulting design is optimal for the imposed conditions, and compared to a structure designed with a traditional factor of safety approach, is either lighter or more reliable. This demonstration revealed that for similar reliabilities, a stochastically designed wing was 20 percent lighter than a wing strengthened by the factor of safety. The major drawback in applying the method of stochastic finite element analysis is that very large, complex models can require extraordinary amounts of computer resources.

GRA

N89-24876# Xerox Palo Alto Research Center, CA.
VISIBILITY WITH A MOVING POINT OF VIEW
 M. W. BERN, D. P. DOBKIN, and R. GROSSMAN (Illinois Univ., Chicago.) 7 Dec. 1988 11 p
 Avail: NTIS HC A03/MF A01

The 3-D visibility problems in which the viewing position moves along a straight flightpath was investigated. Two problems were focused on: determining the points along the flightpath at which the topology of the viewed scene changes, and answering ray-shooting queries for rays with origin on the flightpath. Three progressively more specialized problems are considered: general scenes, terrains, and terrains with vertical flightpaths. Author

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PHYSICS

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

A89-40175*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH.
UNSTEADY BLADE PRESSURE MEASUREMENTS ON A MODEL COUNTERROTATION PROPELLER
 LAURENCE J. HEIDELBERG and RICHARD P. WOODWARD (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 21 p. Previously announced in STAR as N89-20779. (AIAA PAPER 89-1144)

In an exploratory effort an advanced counterrotation propeller instrumented with blade-mounted pressure transducers was tested in the NASA Lewis 9- by 15-Foot Anechoic Wind Tunnel at a simulated takeoff and landing speed of Mach 0.20. The propeller's aft diameter was reduced to investigate possible noise reductions resulting from reduced blade row interaction with the tip vortex. The propeller was tested at three blade row spacings at fixed blade setting angles, at the maximum blade row spacing at higher blade setting angles and at propeller axis angles attack to the flow up to + or - 16 deg. A limited number of unsteady blade surface pressure measurements were made on both rotors of the model counterrotation propeller. Emphasis was placed on determining the effects of rotor-rotor interactions on the blade surface pressures. A unique method of processing the pressure signals was developed that enables even weak interaction waveforms and spectra to be separated from the total signal. The interaction on the aft rotor was many times stronger than that on the forward rotor. The fundamental rotor interaction tone exhibited complicated behavior but generally increased with rotational speed and blade setting angle and decreased with rotor spacing. With the propeller axis at an angle to the flow, the phase response of the aft rotor appeared to be significantly affected by the presence of the forward rotor. Author

A89-40470*# Duke Univ., Durham, NC.
REDUCTION OF SOUND TRANSMISSION THROUGH FUSELAGE WALLS BY ALTERNATE RESONANCE TUNING (A.R.T.)

DONALD B. BLISS and JAMES A. GOTTWALD (Duke University, Durham, NC) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 11 p. refs
 (Contract NAG1-722)
 (AIAA PAPER 89-1046)

The ability of alternate resonance tuning (ART) to block sound transmission through light-weight flexible paneled walls by controlling the dynamics of the wall panels is considered. Analytical results for sound transmission through an idealized panel wall illustrate the effect of varying system parameters and show that one or more harmonics of the incident sound field can be cancelled by the present method. Experimental results demonstrate that very large transmission losses with reasonable bandwidths can be achieved by a simple ART panel barrier in a duct. R.R.

A89-40472*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH.
COMPARISON OF PROPELLER CRUISE NOISE DATA TAKEN IN THE NASA LEWIS 8- BY 6-FOOT WIND TUNNEL WITH OTHER TUNNEL AND FLIGHT DATA

JAMES DITTMAR (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 22 p. Previously announced in STAR as N89-21628. refs
 (AIAA PAPER 89-1059)

The noise of advanced high speed propeller models measured in the NASA 8- by 6-foot wind tunnel has been compared with model propeller noise measured in another tunnel and with full-scale propeller noise measured in flight. Good agreement was obtained for the noise of a model counterrotation propeller tested in the 8- by 6-foot wind tunnel and in the acoustically treated test section of the Boeing Transonic Wind Tunnel. This good agreement indicates the relative validity of taking cruise noise data on a plate in the 8- by 6-foot wind tunnel compared with the free-field method in the Boeing tunnel. Good agreement was also obtained for both single rotation and counter-rotation model noise comparisons with full-scale propeller noise in flight. The good scale model to full-scale comparisons indicate both the validity of the 8- by 6-foot wind tunnel data and the ability to scale to full size. Boundary layer refraction on the plate provides a limitation to the measurement of forward arc noise in the 8- by 6-foot wind tunnel at the higher harmonics of the blade passing tone. The use of a validated boundary layer refraction model to adjust the data could remove this limitation. Author

A89-40473*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH.
PREDICTION OF UNSTEADY BLADE SURFACE PRESSURES ON AN ADVANCED PROPELLER AT AN ANGLE OF ATTACK
 M. NALLASAMY (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 20 p. refs
 (Contract NAS3-25266)
 (AIAA PAPER 89-1060)

The paper considers the numerical solution of the unsteady, three-dimensional, Euler equations to obtain the blade surface pressures of an advanced propeller at an angle of attack. The specific configuration considered is the SR7L propeller at cruise conditions with a 4.6 deg inflow angle corresponding to the +2 deg nacelle tilt of the Propeller Test Assessment (PTA) flight test condition. The results indicate nearly sinusoidal response of the blade loading, with angle of attack. For the first time, detailed variations of the chordwise loading as a function of azimuthal angle are presented. It is observed that the blade is lightly loaded for part of the revolution and shocks appear from hub to about 80 percent radial station for the highly loaded portion of the revolution. Author

A89-40474#

PREDICTION OF LOADING NOISE OF A PROPELLER WITH BLADES UNDER TRANSONIC OPERATING CONDITIONS

M. A. TAKALLU and P. L. SPENCE (PRC Systems Services, Hampton, VA) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 9 p. refs (AIAA PAPER 89-1080)

A hybrids method of solution has been applied to predict the aerodynamic loads of a generic propeller. This method combines the efficiency of linear strip theory, with the shock capturing capability of the conservation form of Euler equations, formulated in a finite difference algorithm. Free field noise predictions are made using time domain formulation. It is shown that for higher propeller advance ratios, the loading noise obtained from linear aerodynamics underestimates the predictions when compared with the present method. Author

A89-40475#

WHITHAM'S F-FUNCTION FOR A SUPERSONICALLY ROTATING PROPELLER

C. J. CHAPMAN (Cambridge, University, England) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 21 p. Research supported by the Royal Aircraft Establishment. refs (AIAA PAPER 89-1107)

On linear acoustic theory, propellers emit rays from supersonic leading and trailing edges, so that in certain regions of space the pressure field has a part equal to Whitham's F-function multiplied by ray tube area. A general method, which applies to propeller edges of arbitrary shape and motion, is presented for determining this product. In the particular case of a blade with straight edges pointing along radii, full details of the calculation are given, leading to explicit formulas for the F-function and ray tube area. The method brings out a well-known limitation of linear acoustics, namely its prediction of singularities in pressure as a result of focusing of weak shocks, and highlights the fact that a more complete theory would be necessary if peak pressures had to be calculated. Author

A89-40476#

SUPERSONIC RECTANGULAR JET IMPINGEMENT NOISE EXPERIMENTS

THOMAS D. NORUM (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 13 p. refs (AIAA PAPER 89-1138)

The discrete frequency sound produced by jets issuing from a convergent, rectangular nozzle of aspect ratio 4.24 was investigated. Experiments were performed both with the free jet and with the jet impinging on a hard ground surface. The impingement tones that dominate the impinging jet spectra show a definite staging behavior which appears to be biased toward the free jet screech frequency once the separation distance exceeds the region of substantial shock cell development. The frequency variation of the impingement tone stages fit the details of a feedback cycle if the disturbance convection velocity is chosen to be 20 percent higher than that necessary to satisfy the screech feedback loop. Phase locked optical records show a flapping mode of jet oscillation with tones at or near the screech frequency, with superimposed symmetric oscillations when a second dominant tone of unrelated frequency appears in the spectrum. Author

A89-40477*# University of Southern California, Los Angeles.

DYNAMIC LOADING ON IMPACT SURFACES OF A HIGH SUBSONIC ELLIPTIC JET

J. K. WAT and C. M. HO (Southern California, University, Los Angeles) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 9 p. (Contract NAG1-819) (AIAA PAPER 89-1139)

The feedback resonance in a high subsonic velocity range was investigated for the case where a small aspect ratio (2:1) elliptic jet impinged perpendicularly on a flat plate. This resonance

was observed for Mach numbers greater than 0.7 for plate locations between 4 and 9 major radii downstream of the exhaust plane. At the predominant resonant conditions, the loading region and sound source terms were found to be concentrated along the major axis direction on the impact surface. Author

A89-40478*# Texas A&M Univ., College Station.

AN ACOUSTIC EXPERIMENTAL AND THEORETICAL INVESTIGATION OF SINGLE DISC PROPELLERS

ELIZABETH A. BUMANN and KENNETH D. KORKAN (Texas A & M University, College Station) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 17 p. refs (Contract NAG3-354) (AIAA PAPER 89-1146)

An experimental study of the acoustic field associated with two, three, and four blade propeller configurations with a blade root angle of 50 deg was performed in the Texas A&M University 5 ft. x 6 ft. acoustically-insulated subsonic wind tunnel. A waveform analysis package was utilized to obtain experimental acoustic time histories, frequency spectra, and overall sound pressure level (OASPL) and served as a basis for comparison to the theoretical acoustic compact source theory of Succi (1979). Valid for subsonic tip speeds, the acoustic analysis replaced each blade by an array of spiraling point sources which exhibited a unique force vector and volume. The computer analysis of Succi was modified to include a propeller performance strip analysis which used a NACA 4-digit series airfoil data bank to calculate lift and drag for each blade segment given the geometry and motion of the propeller. Theoretical OASPL predictions were found to moderately overpredict experimental values for all operating conditions and propeller configurations studied. Author

A89-40904*#

Virginia Polytechnic Inst. and State Univ., Blacksburg.

ACTIVE CONTROL OF SOUND FIELDS IN ELASTIC CYLINDERS BY MULTICONTROL FORCES

J. D. JONES and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 27, July 1989, p. 845-852. Previously cited in issue 04, p. 570, Accession no. A88-16559. refs (Contract NAG1-390)

A89-41042#

EFFECT OF SLOTTING ON THE MIXING AND NOISE OF AN AXISYMMETRIC SUPERSONIC JET

ANJANEYULU KROTHAPALLI (Florida State University, Tallahassee), JAMES MCDANIEL (Virginia, University, Charlottesville), and DONALD BAGANOFF (Stanford University, CA) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 15 p. refs (AIAA PAPER 89-1052)

An experimental investigation has been carried out on an underexpanded jet of air issuing from a converging axisymmetric plain and slotted nozzles. Shadowgraph pictures as well as pitot tube and hot-wire measurements of the jet flow field were obtained at different pressure ratios. It is shown that the slotting of the nozzle exit helps to reduce the overall sound pressure level by as much as 10dB at a pressure ratio of about 4.4. The shock cell structure near the nozzle exit is weakened significantly by the presence of the slots. For downstream distances greater than about 20 diameters, the effect of the slots on the overall mixing appears to be minimal. Author

A89-41049*

National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

NASA/AHS ROTORCRAFT NOISE REDUCTION PROGRAM - NASA LANGLEY ACOUSTICS DIVISION CONTRIBUTIONS

RUTH M. MARTIN (NASA, Langley Research Center, Hampton, VA) Vertiflite (ISSN 0042-4455), vol. 35, May-June 1989, p. 48-52.

An account is given of the contributions made by NASA-Langley's rotorcraft noise research programs over the last five years. Attention has been given to the broadband and

blade-vortex interaction noise sources; both analytical and empirical noise-prediction codes have been developed and validated for several rotor noise sources, and the 'Rotonet' comprehensive system-noise prediction capability has been instituted. Among the technologies explored for helicopter noise reduction have been higher harmonic control and active vibration-suppression. O.C.

A89-41830#

A CFD-BASED FINITE-VOLUME PROCEDURE FOR COMPUTATIONAL ELECTROMAGNETICS - INTERDISCIPLINARY APPLICATIONS OF CFD METHODS

VIJAYA SHANKAR, WILLIAM HALL, and ALIREZA H. MOHAMMADIAN (Rockwell International Science Center, Thousand Oaks, CA) IN: AIAA Computational Fluid Dynamics Conference, 9th, Buffalo, NY, June 13-15, 1989, *Technical Papers*. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 551-564. refs (AIAA PAPER 89-1987)

The electromagnetic scattering from layered objects has been computed by casting the differential form of the time-domain Maxwell equations in a conservation form and then solving the resultant equations using a finite-volume discretization procedure derived from CFD methods. In order to treat complex internal/external structures with many material layers, a multizone framework capable of handling any type of zonal boundary conditions has been implemented. Two-dimensional results obtained for both the transverse magnetic and transverse electric wave forms of Maxwell's equations demonstrate the feasibility of the method. R.R.

N89-24138*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NOISE OF A MODEL COUNTERROTATION PROPELLER WITH SIMULATED FUSELAGE AND SUPPORT PYLON AT TAKEOFF/APPROACH CONDITIONS

RICHARD P. WOODWARD and CHRISTOPHER E. HUGHES Apr. 1989 26 p Presented at the 12th Aeroacoustics Conference, San Antonio, TX, 10-12 Apr. 1989; sponsored by AIAA (NASA-TM-101996; E-4700; NAS 1.15:101996; AIAA-89-1143) Avail: NTIS HC A03/MF A01 CSCL 20/1

Two modern high-speed advanced counterrotation propellers, F7/A7 and F7/A3 were tested in the NASA Lewis Research Center's 9- by 15-foot Anechoic Wind Tunnel at simulated takeoff/approach conditions of 0.2 Mach number. Both rotors were of similar diameter on the F7/A7 propeller, while the aft rotor diameter of the F7/A3 propeller was 85 percent of the forward propeller to reduce tip vortex-aft rotor interaction. The two propellers were designed for similar performance. The propellers were tested in both the clean configuration, and installed configuration consisting of a simulated upstream nacelle support pylon and fuselage section. Acoustic measurements were made with an axially translating microphone probe, and with a polar microphone probe which was fixed to the propeller nacelle and could make both sideline and circumferential acoustic surveys. Aerodynamic measurements were also made to establish propeller operating conditions. The propellers were run at blade setting angles (from angle/rear angle) of 41.1/39.4 deg for the F7/A7 propeller, and 41.1/46.4 deg for the F7/A3 propeller. The forward rotors were tested over a range of tip speeds from 165 to 259 m/sec (540 to 850 ft/sec), and both propellers were tested at the maximum rotor-rotor spacing, based on pitch change axis separation, of 14.99 cm (5.90 in.). The data presented in this paper are for 0 deg propeller axis angle of attack. Results are presented for the baseline, pylon-alone, and strut + fuselage configurations. The presence of the simulated fuselage resulted in higher rotor-alone tone levels in a direction normal to the advancing propeller blade near the fuselage. A corresponding rotor-alone tone reduction was often observed 180 deg circumferentially from this region of increased noise. A significant rotor-alone increase for both rotors was observed diametrically opposite the fuselage. In some cases, interaction tone levels were likewise affected by the simulated installation. Author

N89-24139*# General Electric Co., Cincinnati, OH. Advanced Engineering Technologies Dept.

HIGH SPEED TURBOPROP AEROACOUSTIC STUDY (SINGLE ROTATION). VOLUME 1: MODEL DEVELOPMENT Final Report C. E. WHITFIELD, P. R. GLIEBE, R. MANI, and P. MUNGUR May 1989 185 p (Contract NAS3-23721) (NASA-CR-182257-VOL-1; NAS 1.26:182257-VOL-1) Avail: NTIS HC A09/MF A01 CSCL 20/1

A frequency-domain noncompact-source theory for the steady loading and volume-displacement (thickness) noise of high speed propellers has been developed and programmed. Both near field and far field effects have been considered. The code utilizes blade surface pressure distributions obtained from three-dimensional nonlinear aerodynamic flow field analysis programs as input for evaluating the steady loading noise. Simplified mathematical models of the velocity fields induced at the propeller disk by nearby wing and fuselage surfaces and by angle-of-attack operation have been developed to provide estimates of the unsteady loading imposed on the propeller by these potential field type interactions. These unsteady blade loadings have been coupled to a chordwise compact propeller unsteady loading noise model to provide predictions of unsteady loading noise caused by these installation effects. Finally, an analysis to estimate the corrections to be applied to the free-field noise predictions in order to arrive at the measurable fuselage sound pressure levels has been formulated and programmed. This analysis considers the effects of fuselage surface reflection and diffraction together with surface boundary layer refraction. The steady loading and thickness model and the unsteady loading model have been verified using NASA-supplied data for the SR-2 and SR-3 model propfans. In addition, the steady loading and thickness model has been compared with data from the SR-6 model propfan. These theoretical models have been employed in the evaluation of the SR-7 powered Gulfstream aircraft in terms of noise characteristics at representative takeoff, cruise, and approach operating conditions. In all cases, agreement between theory and experiment is encouraging. Author

N89-24141*# Douglas Aircraft Co., Inc., Long Beach, CA. **INTERIOR NOISE CONTROL GROUND TEST STUDIES FOR ADVANCED TURBOPROP AIRCRAFT APPLICATIONS Final Report**

MYLES A. SIMPSON, MARK R. CANNON, PAUL L. BURGE, and ROBERT P. BOYD Apr. 1989 149 p (Contract NAS1-18037) (NASA-CR-181819; NAS 1.26:181819) Avail: NTIS HC A07/MF A01 CSCL 20/1

The measurement and analysis procedures are documented, and the results of interior noise control ground tests conducted on a DC-9 aircraft test section are summarized. The objectives of these tests were to study the fuselage response characteristics of treated and untreated aircraft with aft-mount advanced turboprop engines and to analyze the effectiveness of selected noise control treatments in reducing passenger cabin noise on these aircraft. The results of fuselage structural mode surveys, cabin cavity surveys and sound intensity surveys are presented. The performance of various structural and cabin sidewall treatments is assessed, based on measurements of the resulting interior noise levels under simulated advanced turboprop excitation. Author

N89-24886*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CRUISE NOISE OF THE SR-2 PROPELLER MODEL IN A WIND TUNNEL

JAMES H. DITTMAR Apr. 1989 29 p (NASA-TM-101480; E-4606; NAS 1.15:101480) Avail: NTIS HC A03/MF A01 CSCL 20/1

Noise data on the SR-2 model propeller were taken in the NASA Lewis Research Center 8- by 6-Foot Wind Tunnel. The maximum blade passing tone rises with increasing helical tip Mach number to a peak level at a helical tip Mach number of about 1.05; then it remains the same or decreases at higher helical tip Mach numbers. This behavior, which has been observed with other

propeller models, points to the possibility of using higher propeller tip speeds to limit airplane cabin noise while maintaining high flight speed and efficiency. Noise comparisons of the straight-blade SR-2 propeller and the swept-blade SR-7A propeller showed that the tailored sweep of the SR-7A appears to be the cause of both lower peak noise levels and a slower noise increase with increasing helical tip Mach number. Author

N89-24887# Max-Planck-Institut fuer Stroemungsforschung, Goettingen (Germany, F.R.).

CALCULATION OF AIRCRAFT NOISE IN THE VICINITY OF CIVIL AIRPORTS BY A SIMULTION PROCEDURE Thesis

ULLRICH ISERMANN Feb. 1988 100 p In GERMAN; ENGLISH summary

(MPIS-7/1988; ISSN-0436-1199; ETN-89-94384) Avail: NTIS HC A05/MF A01; Max-Planck Institut fuer Stroemungsforschung, Boettinger Strasse 6-8, 3400 Goettingen, Federal Republic of Germany, 22 deutsche marks

Boeing 737 and Airbus A310 noise durations for takeoff, level flight, and curved flight paths are analyzed. Theoretical models are used for the analysis of the effects of flights on curved flight paths in order to calculate maximum sound levels and single event noise levels. The calculated results are confirmed by the simulation. Maximum sound levels within a turn are decreased as compared to those from flights on straight flight path and are increased outside of a turn. The single event noise levels depend on the directional characteristics of the noise source. For curved flights, the direction of maximum sound radiation forms a circular caustic with a center coinciding with the center of the curve. The area within this caustic represents an acoustic shadow zone where maximum sound levels, and single event noise levels, are decreased. ESA

N89-24888*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

ADVANCED TURBOPROP AIRCRAFT FLYOVER NOISE: ANNOYANCE TO COUNTER-ROTATING-PROPELLER CONFIGURATIONS WITH A DIFFERENT NUMBER OF BLADES ON EACH ROTOR: PRELIMINARY RESULTS

DAVID A. MCCURDY Jul. 1988 33 p (NASA-TM-100638; NAS 1.15:100638) Avail: NTIS HC A03/MF A01 CSCL 20/1

A laboratory experiment was conducted to quantify the annoyance of people to the flyover noise of advanced turboprop aircraft with counter-rotating propellers (CRP) having a different number of blades on each rotor (nxm, e.g., 10 x 8, 12 x 11). The objectives were: (1) compare annoyance to nxm CRP advanced turboprop aircraft with annoyance to conventional turboprop and jet aircraft; (2) determine the effects of tonal content on annoyance; and (3) determine the ability of aircraft noise measurement procedures and corrections to predict annoyance for this new class of aircraft. A computer synthesis system was used to generate 35 realistic, time-varying simulations of advanced turboprop takeoff noise in which the tonal content was systematically varied to represent combinations of 15 fundamental frequency (blade passage frequency) combinations and three tone-to-broadband noise ratios. The fundamental frequencies, which represented blade number combinations from 6 x 5 to 13 x 12 and 7 x 5 to 13 x 11, ranged from 112.5 to 292.5 Hz. The three tone-to-broadband noise ratios were 0, 15, and 30 dB. These advanced turboprop simulations along with recordings of five conventional turboprop takeoffs and five conventional jet takeoffs were presented at D-weighted sound pressure levels of 70, 80, and 90 dB to 64 subjects in an anechoic chamber. Analyses of the subjects' annoyance judgments compare the three categories of aircraft and examine the effects of the differences in tonal content among the advanced turboprop noises. The annoyance prediction ability of various noise measurement procedures and corrections is also examined. Author

N89-24901# National Aeronautical Lab., Bangalore (India), Systems Engineering Div.

AN INTELLIGENT FIBEROPTIC DATA BUS FOR

FLY-BY-LIGHT APPLICATIONS

L. C. MANOHARAN and S. MUTHUVEL Nov. 1987 11 p (NAL-TM-SE-8707) Avail: NTIS HC A03/MF A01

An active Fiberoptic Data Bus compatible with MIL-STD-1553B which could be used for Fly-by-light, stores management, AEW etc., on an aircraft is described. The data bus is considered intelligent because it can automatically sense which station is in the transmit mode and control the active interface accordingly, so that smooth flow of data takes place on the bus. The tests that were done on the bus to check its validity are also described. As no software is involved in the operation this could be used on any aircraft with its own software. 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.

A89-41654

U.S. GOVERNMENT POLICIES AND HYPERSONIC FLIGHT IN THE 21ST CENTURY

THOMAS R. GOLDBERG (Radian Corp., Herndon, VA) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 4, May 1989, p. 26-31. refs

The author examines the potentially negative impact of the U.S. regulations on the development of advanced materials, components, and systems. High priority is given to modification of US antitrust laws if the U.S. is to have the best possible opportunity to compete with more aggressive economies abroad. Export controls are identified as limiting the availability of data to U.S. firms engaged in developing commercial applications. It is asserted that policies must also be enacted to better protect intellectual property rights. I.E.

A89-41655

HYPERSONIC FLIGHT - THE NEED FOR A NEW LEGAL REGIME

F. KENNETH SCHWETJE and DONALD E. WALSH (USAF, International Law Div., Washington, DC) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 4, May 1989, p. 32-36. refs

The author briefly examines the question, 'where does space begin?' He discusses how certain principles, such as overflight, meet the respective needs of the air law and space law regimes. He then focuses on the existing laws that might regulate the proposed Transatmospheric Vehicle (TAV). I.E.

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ACADEMICIAN B. S. STECHKIN'S WORK IN THE DEVELOPMENT OF JET ENGINES [O RABOTNIH AKADEMIKA B. S. STECHKINA PO SOZDANIU VOZDUSHNO-REAKTIVNYKH DVIGATELEI]

V. A. ZHURAVLEV IN: Pioneers of space and the present age. Moscow, Izdatel'stvo Nauka, 1988, p. 5-9. In Russian.

A89-42453

SCIENTIFIC AND PEDAGOGICAL WORK OF ACADEMICIAN B. S. STECHKIN AT THE ZHUKOVSKII AIR FORCE ENGINEERING ACADEMY [O NAUCHNOI I PEDAGOGICHESKOI DEIATEL'NOSTI AKADEMIKA B. S. STECHKINA V VOENNO-VOZDUSHNOI INZHENERNOI AKADEMII IM. PROFESSORA N. E. ZHUKOVSKOGO]

IU. N. NECHAEV IN: Pioneers of space and the present age. Moscow, Izdatel'stvo Nauka, 1988, p. 10-16. In Russian. refs

A89-42537

S. P. KOROLEV IN AVIATION. IDEAS. PROJECTS. DESIGNS [S. P. KOROLEV V AVIATSII. IDEI. PROEKTY. KONSTRUKTSII]

GEORGII S. VETROV Moscow, Izdatel'stvo Nauka, 1988, 160 p. In Russian. refs

The early work of Korolev, the chief designer of Soviet space systems, is reviewed. The book, which makes extensive use of new documents from the personal archive of the designer, is mainly concerned with the development of glider and aircraft designs. The ideas and technical principles, concepts, and solutions underlying these designs are examined. V.L.

A89-42926

RESEARCH AND DEVELOPMENT: TECHNICAL AND SCIENTIFIC PUBLICATIONS 1988 [FORSCHUNG UND ENTWICKLUNG: TECHNISCH-WISSENSCHAFTLICHE VEROFFENTLICHUNGEN 1988]

Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, 372 p. In German and English. For individual items see A89-42927 to A89-42945.

Various papers on fighter aircraft, transport aircraft, helicopter, defense technology, and space travel are presented. Individual topics addressed include: new developments in air and space research of the German aircraft and space industry, modular avionics architecture for modern fighter aircraft, threat management for modern fighter aircraft, development of a monolithic fuselage shell using CFRP, and Cabin Intercommunication Data System. Also discussed are: system testing in the A320-landing flap flight control system, project for an advanced regional civil aircraft, airborne imaging radar systems for monitoring sea pollution, recent theoretical studies of missiles, validation of missile simulation, modern terrain following and flight control system, characterization of radar backscattering measurements using scaled time models, the German Saenger space transportation system concept. C.D.

A89-42927

NEW DEVELOPMENTS IN AIR AND SPACE RESEARCH - CONTRIBUTIONS OF THE GERMAN AIRCRAFT AND SPACE INDUSTRY TO ADVANCED PROGRAMS AND INTERNATIONAL COOPERATION

OTHMAR HEISE (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) (Technogerma '88 - Scientific-Technological Conference, New Delhi, India, Mar. 15, 1988) IN: Research and development: Technical and scientific publications 1988. Munich, Federal Republic of Germany, Messerschmitt-Boelkow-Blohm GmbH, 1988, p. 11-20. (MBB-Z-177-88-PUB)

Some of the new developments in the German air and space industry are examined, highlighting those programs which are in cooperation with European countries and with India. Transportation projects involving winged aircraft, helicopters, advanced surface transportation, and space transportation are addressed, including the Airbus, MPC-75 aircraft, Advanced Light Helicopter, European Future Advanced Rotorcraft, Maglev transportation systems, Ariane, and others. Projects involving communication, remote sensing, and regenerative energy are examined. C.D.

N89-25112*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

LANGLEY AEROSPACE TEST HIGHLIGHTS, 1988

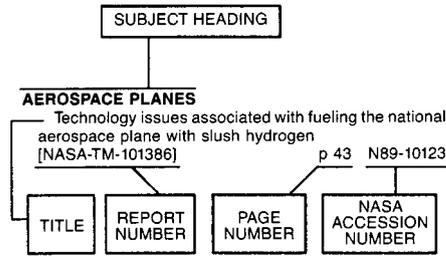
May 1989 166 p

(NASA-TM-101579; NAS 1.15:101579) Avail: NTIS HC A08/MF A01 CSCL 05/4

The role of the Langley Research Center is to perform basic and applied research necessary for the advancement of aeronautics and space flight, to generate new and advanced concepts for the accomplishment of related national goals, and to provide research advice, technological support, and assistance to other NASA installations, other government agencies, and industry. Some of the significant tests which were performed during calendar year 1988 in Langley test facilities, a number of which are unique in the world are highlighted. Both the broad range of the research and technology activities at the Langley Research Center and the contributions of this work toward maintaining United States leadership in aeronautics and space research are illustrated.

Author

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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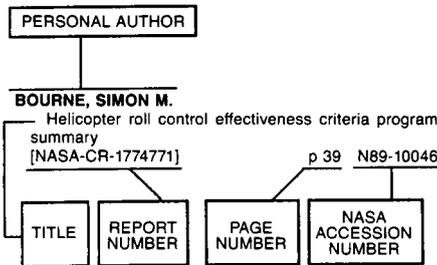
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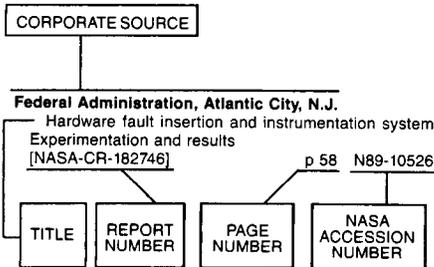
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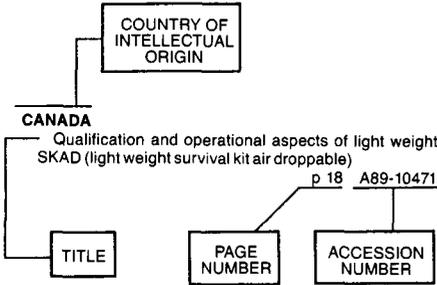
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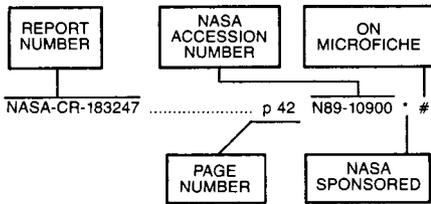
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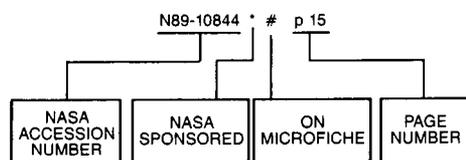
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