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Aeronautical Engineering
A Continuing Bibliography with Indexes

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National Aeronautics and
Space Administration

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NASA SP-7037(225)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 225)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in March 1988 in

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

Scientific and Technical Information Division 1988
National Aeronautics and Space Administration
Washington, DC

This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, price code A07.

INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 429 reports, journal articles and other documents originally announced in March 1988 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

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

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

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

An annual cummulative index will be published.

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

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Category 10	**Astronautics** Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.	**171**
Category 11	**Chemistry and Materials** Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.	**171**

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Category 12 Engineering 176
Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

Category 13 Geosciences 183
Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

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

Category 15 Mathematical and Computer Sciences 184
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 186
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

Category 17 Social Sciences 191
Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

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

Category 19 General N.A.

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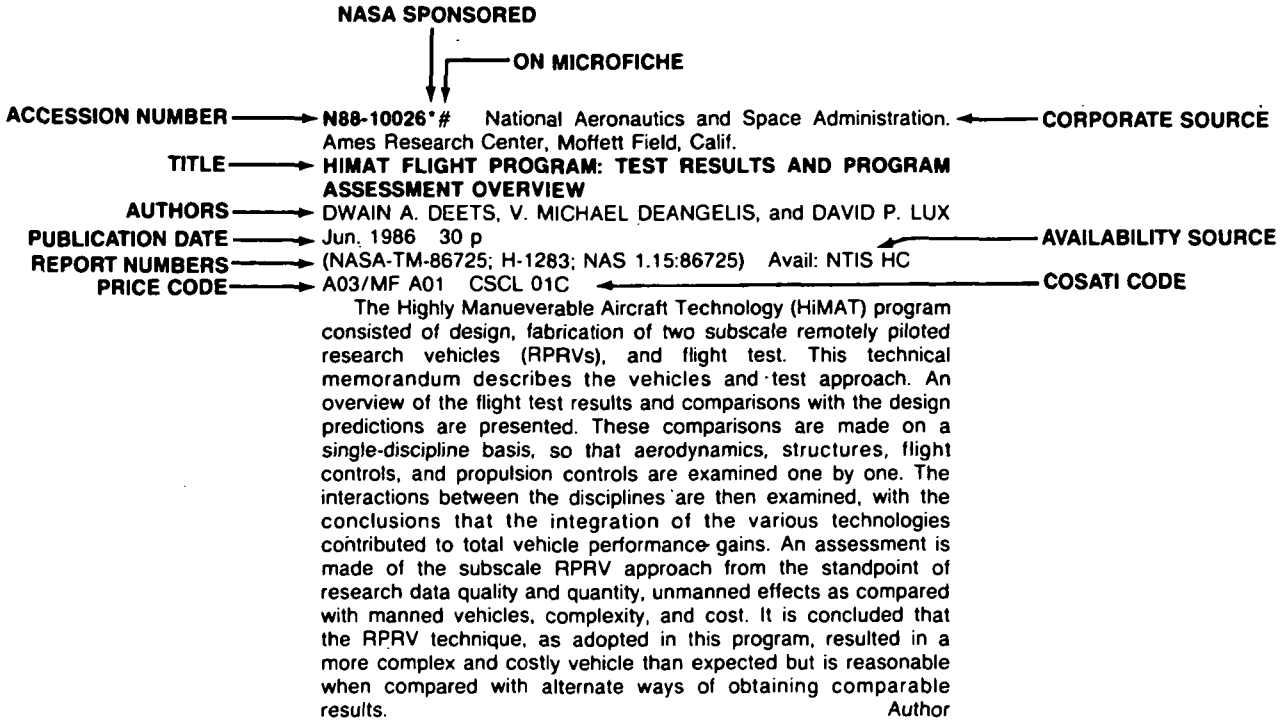
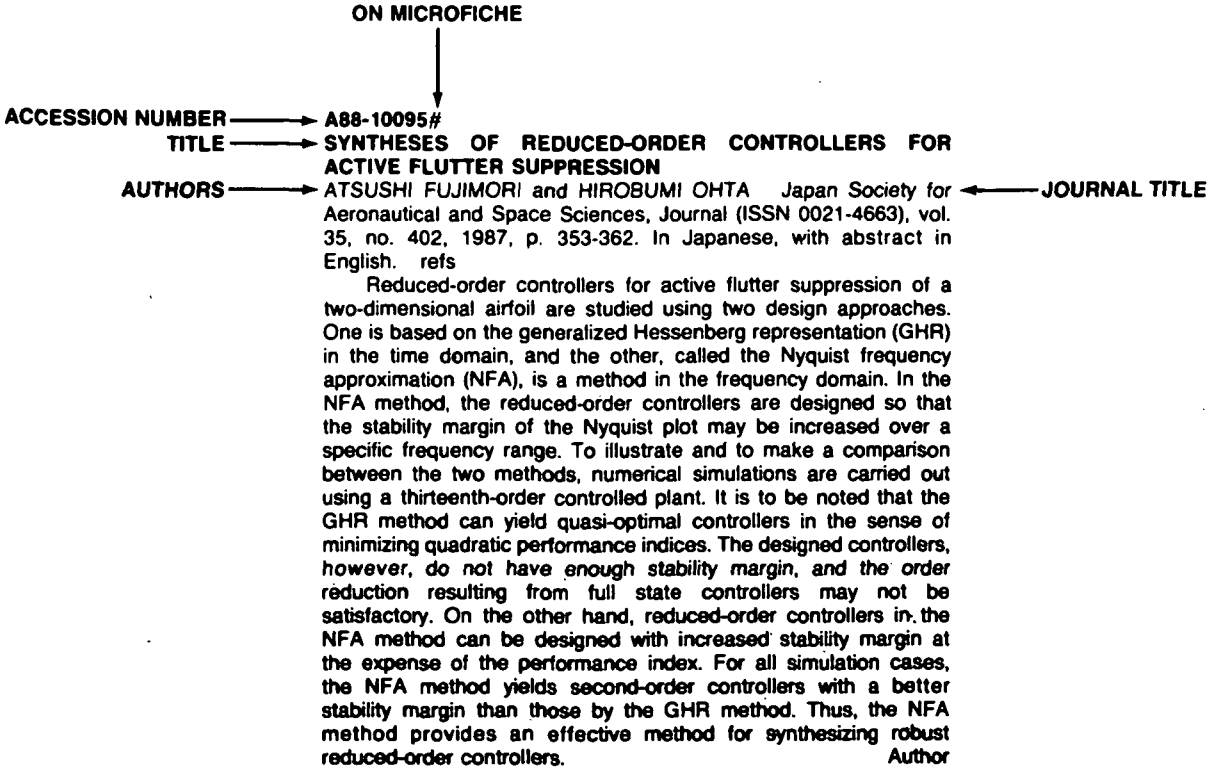
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 225)

APRIL 1988

01

AERONAUTICS (GENERAL)

A88-17308
PROJECTIONS OF FUTURE NEEDS IN RESEARCH AND TECHNOLOGY DEVELOPMENT
D. T. BALCH (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 6 p. refs

The current status of helicopter R&D is surveyed, and recommendations for future efforts are presented. Topics addressed include rotor airfoils, experimental aerodynamics, rotor aerodynamics, computational fluid dynamics, vortices and wakes, aeroacoustics, and panel methods. The apparent potential for economic return and innovation is assessed in each case; and a number of unsolved problems and neglected areas are discussed. T.K.

A88-17309
FUTURE DIRECTIONS IN HELICOPTER ROTOR DEVELOPMENT
LEO DADONE (Boeing Vertol Co., Philadelphia, PA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 7 p. refs

Recent advances in the analysis and design of helicopter rotors are reviewed, and general objectives for future research are indicated. Topics examined include LF, IF, and HF airloads; modeling techniques for rotor wakes and blade-vortex interactions; coupling of CFD codes to lifting-line rotor codes; and the limits of rotor testing. Zero noise at key descent rates, level-flight cruising speeds above 220 kts, low vibration in all flight regimes, elimination of aerodynamic interference penalties (including blade-vortex interaction), and suppression of adverse transonic effects throughout the specified range of conditions are identified as design goals. It is predicted that numerical models will give key insights into design problems long before they can provide complete, accurate results. T.K.

A88-19049
IN THE FLIGHT DECK OVER THE NORTH ATLANTIC - REVIEW OF FLIGHT TECHNIQUE ABOARD AIR FRANCE [EN POSTE SUR L'ATLANTIQUE NORD - COMPTE RENDU DE VOL TECHNIQUE SUR AIR FRANCE]
PHILIPPE RENAULT (Centre Regional de la Navigation Aerienne-Nord, Athis-Mons, France) Navigation (Paris) (ISSN 0028-1530), vol. 35, Oct. 1987, p. 444-456. In French.

Pilot flight technique during a Paris-Montreal flight of a B 747 aircraft is discussed in detail. Parameters involved in the selection of the flight path are identified. The fuel calculation is based on determination of the load relief as a function of the effective wind and the landing mass value. Pilot checklists are given for all flight phases (preflight, taxiing, before and after takeoff, climbing, descent, approach, before and after landing, and parking). Fuel consumption and static temperatures are given for various way-points of the flight. R.R.

A88-19268
FIBRE COMPOSITE REPAIR OF CRACKED METALLIC AIRCRAFT COMPONENTS - PRACTICAL AND BASIC ASPECTS
A. A. BAKER (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) (NATO, AGARD, Meeting on the Repair of Aircraft Structures Involving Composite Materials', Oslo, Norway, Apr. 13-18, 1986) Composites (ISSN 0010-4361), vol. 18, Sept. 1987, p. 293-308. refs

The use of advanced fiber-reinforced composite patches bonded with structural film adhesives in the repair of metallic aircraft component cracks constitutes a novel and significant aircraft maintenance technology. An account is presently given of Australian experience with these structural repair procedures, and a preliminary design approach is presented for the estimation of minimum patch thickness for a given repair. Attention is given to the case study of a repair of this type on a Mirage III aircraft wing skin, with a view to the evaluation of minimum cure and surface treatment conditions for adhesive bonding in repair situations, and thermal and residual stress problems resulting from the repair. O.C.

A88-19931
SCIENTIFIC BALLOONING - V; PROCEEDINGS OF SYMPOSIUM 10 OF THE TWENTY-SIXTH COSPAR PLENARY MEETING, TOULOUSE, FRANCE, JUNE 30-JULY 11, 1986
W. RIEDLER, ED. and K. TORKAR, ED. (Oesterreichische Akademie der Wissenschaften, Institut fuer Weltraumforschung, Graz, Austria) Symposium sponsored by COSPAR. Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, 139 p. In English and French. For individual items see A88-19932 to A88-19952.

Papers are presented on the status of the NASA continuing investigation of catastrophic balloon failures, a stress index model for balloon design, progress in scientific balloon materials and manufacturing technology, and an improved shape for zero-pressure balloons. Also considered are a remote data communications and command system, remote control for long distance balloons, the use of a telephone data link in stratospheric balloon flights, and power considerations for long duration balloon flights. Other topics include stratospheric water vapor in-situ measurements from the IR hot-air balloon, a three-axis stabilized balloon platform for use during daytime and nighttime flights, and the fabrication and flight performance of a large area balloon borne hard X-ray telescope. R.R.

A88-19939
THE IR HOT-AIR BALLOON - CURRENT STATUS AND FUTURE PROSPECTS [LE MONTGOLFIERE INFRAROUGE - ACQUIS ET FUTUR]
P. MALATERRE (CNES, Division Ballons, Toulouse, France) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 59-61. In French.

The operational characteristics and flight experiences of the IR hot-air balloon are discussed. The IR hot-air balloon is heated

by absorption of IR radiation emitted from the earth surface. Employing a volume of 36,000 cu m, the balloon attains altitudes of 18-23 km during the night and 28-29 km during the day. The ability of the IR hot-air ballon to obtain realistic stratospheric water vapor measurements constitutes an advantage over the stratospheric balloon. Future developments are also considered. R.R.

A88-19940
DEVELOPMENT OF HIGH ALTITUDE BALLOONS [DEVELOPPEMENT DES BALLONS HAUTE ALTITUDE]
R. REGIPA (CNES, Division Ballons, Toulouse, France) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 63-70. In French.

The development of a cylindrical high-altitude balloon is discussed. The cylindrical form makes possible the fabrication of balloons with homogeneous structure using high-resistant polyesters. Employing ultrathin 3.5-micron films for the balloon material, flights at altitudes of 55 km with loads of several hundred kilograms should be possible if the problem of the excess-pressure behavior of the balloon-reservoir is solved. Theoretical calculations have been used to determine the balloon dimensions as a function of the desired specific tension. R.R.

A88-19942
AN EXPERIMENTAL SYSTEM USING CONSTANT-ALTITUDE BALLOONS FOR THE STUDY OF THE ATMOSPHERIC BOUNDARY LAYER [UN DISPOSITIF EXPERIMENTAL UTILISANT DES BALLONS PLAFONNANTS POUR L'ETUDE DE LA COUCHE LIMITE ATMOSPHERIQUE]
B. BENECH, A. DRUILHET, J. C. MESNAGER, P. DURAND (Toulouse III, Universite, Lannemezan, France), R. CORDESSE (Puy-de-Dome, Institut et Observatoire de Physique du Globe, Clermont-Ferrand, France) et al. (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 77-83. In French. refs

A system which allows the simultaneous position finding of up to 32 constant-altitude balloons is proposed for the study of the dynamical and thermodynamic properties of the tropospheric boundary layer. Balloons are equipped with radar and telemetering equipment to obtain information each second on pressure, humidity, and temperature. A nontracking S-band radar is used to determine balloon trajectories, and a hardware processing unit makes possible the real-time elimination of most ground clutter. Results of field experiments are reported. R.R.

A88-20563
LHX PRODUCT SUPPORT - A STEP INTO THE FUTURE
ARNOLD WEAND, E., JR. (U.S. Army, Program Manager's Office, Saint Louis, MO) Vertiflite (ISSN 0042-4455), vol. 33, Nov.-Dec. 1987, p. 14-21.

Technological and organizational aspects of the U.S. Army LHX advanced helicopter program are discussed in a general overview. The history of Army helicopter development is recalled; the mission requirements on the scout/attack and assault versions of the LHX are summarized; the importance of the reliability, availability, and maintainability specifications is stressed; the approach being taken in specifying the built-in test equipment is outlined; and the integrated logisitic support organization (including MANPRINT analysis of the demands on pilots and maintenance personnel and an integrated training system) is examined in detail. The prescribed 70-percent commonality between the scout/attack and assault LHX versions is shown to offer a 48-percent decrease (relative to current helicopters) in the number of parts to be managed at the wholesale and retail levels. T.K.

A88-20564
THE UH-60 BLACK HAWK - POSTURING FOR THE FUTURE
WILLIAM E. TURNER (U.S. Army, Aviation Systems Command, Saint Louis, MO) Vertiflite (ISSN 0042-4455), vol. 33, Nov.-Dec. 1987, p. 22-25.

Improvements recently made to the U.S. Army UH-60A helicopter are reviewed, and further modifications being considered for an advanced version, the UH-60B, are discussed and illustrated with drawings and diagrams. UH-60A changes included a hover IR-suppression system, a wire-strike protection system, crashworthy flight-data recorders, a cockpit lighting system compatible with night-vision goggles, and an external-stores support system. Among the objectives for the UH-60B are advanced composite main and tail rotors, upgraded engines, a 3400-SHP improved-durability gearbox, stronger flight controls, greater cockpit visibility, a bus-based integrated cockpit with CRT displays, digital AFCS with collective trim and automatic hover, dual digital stabilator control, larger fuel tanks, and improved EMI protection. T.K.

A88-20565
CH-47D/ARMY V-22 AIRCRAFT PROGRAMS UPDATE
ROBERT ATWELL and JESS RAWLS (U.S. Army, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 33, Nov.-Dec. 1987, p. 30-32.

Organizational and logistics aspects of the fielding of the U.S. Army CH-47 and CH-47D helicopters in the continental U.S. and in Europe are reviewed, taking configuration improvements and transportation problems into account. Also discussed are the design, projected performance, and procurement process for the Army version of the V-22 tilt-rotor aircraft (scheduled for deployment beginning in late 1993). The V-22 will feature a mainly composite airframe, cross-connected propulsion systems, cruising speed 275 kts, cargo compartment size 6 x 6 x 24 ft, vertical takeoff weight 49,961 lbs, and short-field takeoff weight 54,171 lbs. The aircraft will be self-deployable worldwide and capable of transporting 15,000 lbs of cargo or 24 equipped personnel within a 200-nmi radius (or 12 personnel within a 520-nmi radius). The V-22 is the first U.S. military aircraft to be (1) fully CAD/CAM designed, (2) developed for use by all four service branches, and (3) built jointly by two manufacturers. T.K.

A88-20567
ARMY SPECIAL OPERATIONS FORCES AIRCRAFT (SOF AIRCRAFT) PROGRAM
JAMES K. MARSTILLER (U.S. Army, Aviation Systems Command, Saint Louis, MO) Vertiflite (ISSN 0042-4455), vol. 33, Nov.-Dec. 1987, p. 40-43.

Technical, development, and management aspects of the U.S. Army SOF helicopter program (based on modifications to the UH-60A and CH-47) are reviewed. Consideration is given to the mission profiles of the two helicopters, the acquisition strategy, the program schedule, and the management structure. The subsystems making up the two aircraft are listed and briefly characterized, and some drawings are provided. T.K.

N88-13215# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
THE A320 AIRBUS PROGRAM [LE PROGRAMME AIRBUS A320]
ROGER BERGOEND 1987 8 p In FRENCH
(SNIAS-872-111-105; ETN-88-91187) Avail: NTIS HC A02/MF A01

The A320 program including aircraft characteristics, program time table, history, and financial aspects is described. ESA

N88-13216# Societe Nationale Industrielle Aerospatiale, Paris (France).

A PROJECT OF AN INTELLIGENT SYSTEM TO HELP ON-LINE TROUBLE SHOOTING

P. CHANET and J. P. FOURNIER 1987 15 p In FRENCH and ENGLISH

(SNIAS-872-111-106; ETN-88-91188) Avail: NTIS HC A03/MF A01

Aircraft maintenance problems and the possible applications of artificial intelligence to solve them are discussed. Artificial intelligence techniques seem able to help trouble shooting on commercial aircraft. The ideal system should be on board and able to dialog with the technician, providing intelligent reports, diagnoses, or action proposals. Such a system is being developed. ESA

N88-13217# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.

DESIGN AND CONTROL OF REPAIRS OF CARBON FIBER LIFT AUGMENTATION FLAPS IN THE ATR42 AIRCRAFT [LA CONCEPTION ET LE CONTROLE DES REPARATIONS DES VOLETS HYPERSUSTENTATEURS DE L'ATR42 EN CARBONE]

GUY HELLARD 1987 6 p In FRENCH

(SNIAS-872-111-112; ETN-88-91193) Avail: NTIS HC A02/MF A01

A simplified repair techniques was developed to solve the possibility of occurrences of maintenance problems due to lack of experience and equipment to deal with carbon fiber composites. Dry carbon fabric is used. The strength of the element after repair was tested, reproducing experimentally the most frequent damage cases. ESA

N88-14064*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

A NUMERICAL MODEL OF UNSTEADY, SUBSONIC AEROELASTIC HEHAVIOR Ph.D. Thesis - Virginia Polytechnic Inst. and State Univ.

THOMAS WILLIAM STRGANAC Dec. 1987 121 p

(NASA-TM-100487; NAS 1.15:100487) Avail: NTIS HC A06/MF A01 CSCL 01B

A method for predicting unsteady, subsonic aeroelastic responses has been developed. The technique accounts for aerodynamic nonlinearities associated with angles of attack, vortex-dominated flow, static deformations, and unsteady behavior. The angle of attack is limited only by the occurrence of stall or vortex bursting near the wing. The fluid and the wing together are treated as a single dynamical system, and the equations of motion for the structure and the flow field are integrated simultaneously and interactively in the time domain. The method employs an iterative scheme based on a predictor-corrector technique. The aerodynamic loads are computed by the general unsteady vortex-lattice method and are determined simultaneously with the motion of the wing. Because the unsteady vortex-lattice method predicts the wake as part of the solution, the history of the motion is taken into account; hysteresis is predicted. Two models are used to demonstrate the technique: a rigid wing on an elastic support experiencing plunge and pitch about the elastic axis, and a continuous wing rigidly supported at the root chord experiencing spanwise bending and twisting. The method can be readily extended to account for structural nonlinearities and/or substitute aerodynamic load models. The time domain solution coupled with the unsteady vortex-lattice method provides the capability of graphically depicting wing and wake motion. Author

02

AERODYNAMICS

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

A88-17276

NATIONAL SPECIALISTS' MEETING ON AERODYNAMICS AND AEROACOUSTICS, ARLINGTON, TX, FEB. 25-27, 1987, PROCEEDINGS

Meeting sponsored by AHS. Alexandria, VA, American Helicopter Society, 1987, 671 p. For individual items see A88-17277 to A88-17313.

Problems in the aerodynamics and aeroacoustics of helicopters are examined in reviews and reports of recent theoretical and experimental investigations. Topics addressed include numerical studies of two-dimensional blade-vortex interaction, 0.15-scale model studies of main and tail rotor interaction, rotor-airframe aerodynamic interference on the V-22 tilt rotor, unsteady Euler solutions of transonic helicopter-rotor flow, and frequency doubling of rotor noise due to retreating blade stall. Consideration is given to lift distributions for a three-dimensional steady blade-vortex interaction, rotor broadband noise predictions, future directions in helicopter rotor development, fundamental issues in the calculation of rotor wakes, and rotorcraft applications of numerical solutions of the Navier-Stokes equations. T.K.

A88-17277

ROTARY WING AERODYNAMICS - HISTORICAL PERSPECTIVE AND IMPORTANT ISSUES

FRANKLIN D. HARRIS (Bell Helicopter Textron, Fort Worth, TX) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings Alexandria, VA, American Helicopter Society, 1987, 170 p. refs

The current status of helicopter aerodynamics is surveyed, with an emphasis on the fundamental principles involved and on outstanding design challenges. Problem areas addressed include hover, vertical climb rate, longitudinal and lateral flapping and feathering, rotor thrust, high-speed performance, rotor profile drag, rotor-induced drag, blade stall onset, and approaches to improving rotor performance. Numerical data are presented in extensive tables and graphs. The need for more widespread use of free-wake methods and for broadly based correlation studies to validate them is indicated. T.K.

A88-17281

NUMERICAL INVESTIGATION OF TWO-DIMENSIONAL BLADE VORTEX INTERACTION

STEPHEN J. OWEN and RAJARAMA K. SHENOY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 15 p. refs

The off-surface pressure field due to a vortex passing over a helicopter-blade airfoil is investigated by means of numerical simulations, using specially adapted versions of the two-dimensional unsteady computer codes ATRAN2 and EULER2. The study focuses on the effects of Mach number, angle of attack, vortex miss distance, and grid size. The implementation of the methods is described, and the results are presented in extensive graphs and characterized in detail. The off-surface pressure changes are found to be good indicators of airfoil sensitivity to blade-vortex interaction, although a finer 727 grid must be used to obtain detailed results. It is shown that any parameter which increases steady-state velocity at the lower-surface leading edge also increases the propagated pressure changes, with significant differences as sonic speed is attained. The design implications of these findings are discussed. T.K.

A88-17283
THE UNSTEADY FORCES AND MOMENTS INDUCED BY BLADE-VORTEX INTERACTION
J. C. WU (Georgia Institute of Technology, Atlanta) and T. M. HSU IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 17 p. Army-supported research. refs
(Contract AF-AFOSR-86-0121)

The two-dimensional attached blade-vortex interaction problem is analyzed using two flow models: a theoretical model and a vortex flow model. In the theoretical study, a general viscous aerodynamic theory is applied to give a set of closed form formulas for the unsteady forces and moment induced by the blade-vortex interaction. These formulas are used to explain physical phenomena present in the blade-vortex interaction and to identify important parameters in unsteady load generation. The analytical formulas are also applied to the study of the noise generation mechanism of the blade-vortex interaction. The vortex flow model combines the theoretical analysis with a discrete vortex wake model. This new approach is extremely efficient and produces highly accurate results for attached blade-vortex interaction problems. Author

A88-17285
.15 SCALE MODEL STUDIES OF MAIN AND TAIL ROTOR INTERACTION
BRYAN D. EDWARDS, MARTIN A. PERYEA, and JOHN T. BRIEGER (Bell Helicopter Textron, Fort Worth, TX) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 8 p.

The role of wake interaction in the generation of helicopter tail-rotor noise is investigated experimentally in wind-tunnel tests of a 0.15-scale model, varying the configuration of main rotor, tail rotor, and vertical fin. Results for simulations of climb, level flight, and descent are presented in extensive graphs and compared with the predictions of the CAMRAD aerodynamics computer program (Johnson, 1980). It is found that individual tail-rotor harmonics and summated discrete-frequency noise can be reduced by 7 and 4 dB, respectively, by placing the rotor outside the main-rotor wake; reductions of 4 and 1 dB, respectively, are achieved (although only in level flight) by increasing the separation between vertical fin and tail rotor. It is pointed out that the configurations with lower noise are already in use in current helicopters. T.K.

A88-17286* United Technologies Research Center, East Hartford, Conn.
AN UNSTEADY ROTOR/FUSELAGE INTERACTION METHOD
T. ALAN EGOLF and PETER F. LORBER (United Technologies Research Center, East Hartford, CT) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 12 p. Army-supported research. refs
(Contract NAS1-17469)

An analytical method has been developed to treat unsteady helicopter rotor, wake, and fuselage interaction aerodynamics. An existing lifting line/prescribed wake rotor analysis and a source panel fuselage analysis were modified to predict vibratory fuselage airloads. The analyses were coupled through the induced flow velocities of the rotor and wake on the fuselage and the fuselage on the rotor. A prescribed displacement technique was used to distort the rotor wake about the fuselage. Sensitivity studies were performed to determine the influence of wake and body geometry on the computed airloads. Predicted and measured mean and unsteady pressures on a cylindrical body in the wake of a two-bladed rotor were compared. Initial results show good qualitative agreement. Author

A88-17288
DYNAMIC BLADE RESPONSE CALCULATIONS USING IMPROVED AERODYNAMIC MODELING
ANDRE DESOPPER (ONERA, Chatillon-sous-Bagneux, France), INDERJIT CHOPRA (Maryland, University, College Park), and KI-CHUNG KIM IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 17 p. refs
(Contract DAAG29-83-K-0002)

Numerical techniques are developed to predict the bending and aerodynamic loads on an advanced-geometry SA349/2 helicopter rotor blade for level flight at 200, 260, and 290 km/h. The numerical method combines (1) a comprehensive FEM rotor dynamic analysis code (Sivaneri and Chopra, 1984) for the vehicle trim and steady response with (2) a three-dimensional unsteady transonic small-disturbance finite-difference aerodynamics code (Desopper, 1985); the results are presented in extensive graphs and compared with flight-test data. Good agreement is found for the collective pitch, but the longitudinal and lateral cyclic pitch differs by about 1 deg, and the high-frequency component of bending and the lift at the retreating side of the disk are poorly predicted. It is suggested that better results could be obtained by including a prescribed wake model and a dynamic stall model in the computations. T.K.

A88-17289
ROTOR/AIRFRAME AERODYNAMIC INTERFERENCE ON THE V-22 TILT ROTOR
JOHN SCHILLINGS and RICK REINESCH (Bell Helicopter Textron, Fort Worth, TX) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 10 p. refs

The velocity field at the plane of the rotor disk of the V-22 tilt rotor is analyzed using a detailed fuselage/wing/nacelle panel method. Rotor inflow velocities are input to an aeroelastic rotor analysis to determine the aerodynamic proprotor loads induced by the wing during airplane mode flight. It is shown that by including the wing/rotor interference effects in conventional aeroelastic rotor analyses, higher frequency blade loads are accurately predicted. Sensitivities to parameters such as airspeed, angle of attack, and proprotor to wing spacing are discussed. Correlation of oscillatory blade loads is shown between theory and wind tunnel data for the 0.2 scale V-22 aeroelastic model. Comparisons are also shown with an analysis which uses a Joukowsky transformation technique to calculate the induced flow field by superimposing the effects of wing thickness and circulation. The latter method is shown to be a good approximation to the complex flow conditions. Author

A88-17290
USE OF COMPUTER MODELS IN HELICOPTER DRAG PREDICTION
DAVID R. CLARK and BRIAN MASKEW (Analytical Methods, Inc., Redmond, WA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 13 p. Army-supported research. refs

The development of numerical techniques for helicopter airframe-drag prediction during the period 1977-1987 is reviewed, and preliminary results obtained with a new method are presented. It is shown that neither first- nor second-generation panel methods, despite significant improvements, were able to predict absolute drag values. Particular attention is then given to VSAERO, an unsteady time-stepping panel-method program with interactive schemes for wake relaxation and viscous effects (Strash et al., 1984; Maskew et al., 1984). Calculated and measured results are compared in extensive graphs, and VSAERO is found to give good predictions of drag/download on helicopter tail-boom sections, including driveshaft and spoiler effects. T.K.

A88-17291* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HELICOPTER ROTOR INDUCED VELOCITIES THEORY AND EXPERIMENT
JOHN D. BERRY, DANNY R. HOAD, JOE W. ELLIOTT, and SUSAN L. ALTHOFF (NASA, Langley Research Center; U.S. Army, Rotorcraft Aerodynamics Office, Hampton, VA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 10 p. refs

An investigation has been performed to assess methods used for rotor inflow modeling. A key element of this assessment has been the recent acquisition of high quality experimental measurements of inflow velocities taken in the proximity of a lifting rotor in forward flight. Widely used rotor performance predictive methods are based on blade element strip theory coupled with an inflow model. The inflow prediction models assessed in this paper include the uniform inflow based on momentum, a skewed disk model, and two methods based on a vortex wake structure. Author

A88-17292
SOLUTIONS OF THE NAVIER-STOKES EQUATIONS FOR THE FLOW ABOUT A ROTOR BLADE
LAKSHMI N. SANKAR (Georgia Institute of Technology, Atlanta) and BRIAN E. WAKE IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 15 p. Army-supported research. refs

A numerical solution procedure for solving the three-dimensional unsteady Navier-Stokes equations is described and applied to the flow over a helicopter rotor blade. This procedure solves the Navier-Stokes equations in a time-accurate manner. Steady solutions are obtained by marching through time and asymptotically converging to steady state. The procedure is a hybrid ADI scheme that has previously been applied to the solution of the Euler equations for fixed and rotary wings. The present hybrid procedure results in an efficient method, capable of handling relatively large time steps. The influence of the rotor wake is included by the transpiration-velocity technique. For turbulence, a two-layer algebraic model is used. The method is applied to the subsonic flow of a hovering rotor blade with encouraging results. Unsteady calculations for a high-speed nonlifting rotor have also been made and compared with experimental data and Euler results. Author

A88-17293* Continuum Dynamics, Inc., Princeton, N. J.
COMPUTATIONAL STUDIES IN LOW SPEED ROTOR AERODYNAMICS
TODD R. QUACKENBUSH (Continuum Dynamics, Inc., Princeton, NJ) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 14 p. refs
(Contract NAG2-244)

Recently, curved vortex elements have been developed for use in helicopter free wake calculations. As previously documented, these elements allow more efficient and accurate calculation of the wake-on-wake interactions than do traditional straight vortex elements. Curved elements have been applied here to the prediction of the rotor wake geometry and its associated inflow distribution in low speed forward flight. By coupling the wake model to a blade dynamic analysis, a simulation capable of predicting blade motion and hub moments in forward flight has been developed. The resulting code has been validated by successful predictions of the lateral flapping of articulated rotors in low speed level flight, and additional simulators of climb and descent have been undertaken. Successful correlation of other experimental data, including moments due to cyclic on hingeless rotors and transient thrust response in hover, has given encouraging evidence of the capabilities of this code as a tool for analysis of the low speed regime. Author

A88-17294
A NEAR WAKE DYNAMIC MODEL
T. S. BEDDOES (Westland Helicopters, Ltd., Yeovil, England) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 9 p. refs

A near wake model has been developed to meet the requirements of three- dimensional blade/vortex interaction computation. The use of indicial lift functions means that shed vorticity is implicitly accounted for, thus only the time varying trailing system remains to be evaluated. The basic calculation for the velocity induced by a line vortex has been reformulated in such a manner that the integrated effect of time varying strength may be readily accommodated within a simple and efficient numerical solution. Some idealized applications to time varying lift on a wing are used to illustrate the implications of the approach and extended to coupled lift/downwash solutions to demonstrate the satisfactory implementation of the numerical procedures. Comparison is made with a wind tunnel test of blade/vortex interaction to show the three-dimensional and temporal effects in a rotating system. Finally, the results are shown of a rotor loads calculation which involves interaction with the far wake so as to produce a 'blade slap' signal. Author

A88-17295* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
UNSTEADY EULER SOLUTION OF TRANSONIC HELICOPTER ROTOR FLOW
I-CHUNG CHANG (NASA, Ames Research Center, Moffett Field, CA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 8 p. refs

A new time-accurate Euler method is presented for calculating the transonic flow over a lifting or nonlifting rotor blade in both hover and forward flight. The approach is to solve the conservative Euler equations in a rotor-fixed frame of reference using a finite-volume method. The discretized equations are solved by using a Runge-Kutta multistage scheme with a new higher-order implicit residual smoothing procedure. Preliminary results were compared with wind-tunnel data. In all the cases considered, good agreement was found with experimental data. Author

A88-17296* Duke Univ., Durham, N. C.
PREDICTION OF TIP VORTEX SELF-INDUCED MOTION PARAMETERS IN TERMS OF ROTOR BLADE LOADING
DONALD B. BLISS (Duke University, Durham, NC) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 15 p. Army-supported research. refs
(Contract NAS2-11295)

The self-induced motion of curved vortex filaments at the tip of a helicopter rotor blade is investigated analytically. The derivation of a method for inviscid roll-up (IRU) is presented in detail, with attention to the cutoff-distance reformulation of the problem, a control-volume analysis of the self-induction properties of the vortex core, the adaptation of the roll-up method of Betz (1932) to IRU in three dimensions, the treatment of linear and elliptic loading, vortices with turbulent central cores, and the effect of cutoff distance on helicopter free-wake computations. Numerical results showing the significant effect of core properties on the geometry of a rotor wake in hover are presented in graphs and briefly characterized. T.K.

A88-17297* Boston Univ., Mass.
UNSTEADY THREE-DIMENSIONAL COMPRESSIBLE POTENTIAL AERODYNAMICS OF HELICOPTER ROTORS - A BOUNDARY-ELEMENT FORMULATION
LUIGI MORINO, MARVIN I. FREEDMAN (Boston University, MA), and KADIN TSENG (United Technologies Research Center, East Hartford, CT) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 6 p. refs
(Contract NAS1-17317)

A new general boundary-element methodology for the analysis of helicopter rotors in potential compressible flows is presented. The methodology is based on the use of the velocity potential (instead of the more common acceleration potential). The derivation of the integral equation is outlined, along with the boundary-element algorithm used for the computational implementation. In addition, numerical results for a helicopter rotor in hover are studied in detail, with particular emphasis on the convergence analysis. The numerical resutls are in excellent agreement with existing results by Rao and Schatzle (1977). Author

A88-17304* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LIFT DISTRIBUTIONS FOR A 3-DIMENSIONAL STEADY BLADE-VORTEX INTERACTION
STEPHEN E. DUNAGAN and THOMAS R. NORMAN (NASA, Ames Research Center, Moffett Field, CA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 11 p. refs

The interaction of a horizontally mounted V23010-1.58 semispan airfoil (simulating a helicopter rotor blade) with a tip vortex shed by a vertically mounted upstream vortex-generating wing (VGW) is investigated experimentally at 60 m/s (dynamic pressure 2.2 kPa, Reynolds number 850,000, and Mach number 0.17) in the NASA Ames 7 x 10-ft wind tunnel. The velocity field near the blade is determined using a three-dimensional zoom LDV; the spanwise lift distribution is measured by strain gages; and the results are compared with the predictions of the panel computer code VSAERO (Maskew, 1982) in graphs. Features noted include localized loss of lift due to the presence of residual VGW wake, loss of lift far inboard on the blade (indicating the large domain of VGW vorticity), little change in total lift with variations in vortex strength, and good agreement between VSAERO and experiment in overall lift distribution but not in all geometric variations). T.K.

A88-17310* Massachusetts Inst. of Tech., Cambridge.
FUNDAMENTAL ISSUES IN THE CALCULATION OF ROTOR WAKES
SHEILA WIDNALL (MIT, Cambridge, MA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 9 p. refs
(Contract NAG2-251)

The structure of a helicopter rotor wake and its effects on the aircraft aerodynamics and aeroacoustics are characterized, reviewing the results of recent analytical investigations. The focus is on the role of vortex structure and stability, and consideration is given to Lagrangian computational approaches, two-dimensional and three-dimensional representations of rotor wakes, vortex-sheet rollup computations, and the role of flow instability in the calculation of three-dimensional vortex sheets. Sample results from the author's studies (Sugioka and Widnall, 1985; Kantelis and Widnall, 1986) are presented in graphs and briefly discussed. T.K.

A88-17311
USE OF PANEL METHODS IN HELICOPTER AERODYNAMICS
BRIAN MASKEW (Analytical Methods, Inc., Redmond, WA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 8 p. refs

The paper presents a brief review of the application of surface singularity panel methods to helicopter aerodynamics. Special developments such as modeling techniques for drag prediction and coupled calculations for rotor/body mutual interference effects are included. Ongoing extensions of panel methods in the direction of unsteady flows and transonic flows are discussed. These are seen as key developments that will ensure a place for panel methods in future predictions of helicopter aerodynamics. Author

A88-17312* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS WITH EMPHASIS ON ROTORCRAFT APPLICATIONS
TERRY L. HOLST (NASA, Ames Research Center, Moffett Field, CA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings Alexandria, VA, American Helicopter Society, 1987, 16 p. refs

Recent advances in CFD are surveyed, with a focus on the applicability of codes based on the Navier-Stokes (NS) equations to helicopter aerodynamics. The developmental history of two- and three-dimensional NS codes is recalled; the formulations employed by codes of increasing complexity are outlined; and previous reviews are noted. Particular attention is given to Reynolds-averaged NS methods and their use in analyzing subsonic, transonic, and vortex-dominated flows. Typical numerical results are compared with experimental data in diagrams and graphs, and a number of outstanding problems are considered. T.K.

A88-17313* Massachusetts Inst. of Tech., Cambridge.
PROSPECTS FOR EULERIAN CFD ANALYSIS OF HELICOPTER VORTEX FLOWS
MARK DRELA and EARLL M. MURMAN (MIT, Cambridge, MA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings Alexandria, VA, American Helicopter Society, 1987, 10 p. refs
(Contract NAG2-421)

The applicability of current finite-volume CFD algorithms based on the Euler equations to the vortex flow over a helicopter in forward flight is investigated analytically. The general characteristics of the flow are reviewed; existing Euler, Navier-Stokes, perturbation, high-order, and adaptive methods are briefly characterized; and a novel Eulerian/Lagrangian approach with entropy and vorticity corrections is presented in detail. Numerical results for simple convection of a finite-core Lamb vortex moving downstream with its axis perpendicular to the flow are presented in graphs, and the possibility of extending the method to three-dimensional, viscous, and shock flows is discussed. T.K.

A88-17730
EFFECT OF ANGLE OF ATTACK ON SUPERSONIC FLOW PAST AXISYMMETRIC BLUNT BODIES IN THE PRESENCE OF INJECTION FROM THE SURFACE [VLIIANIE UGLA ATAKI NA SVERKHZVUKOVOE OBTEKANIE OSESIMMETRICHNYKH ZATUPLENNYKH TEL PRI NALICHII VDUVA S POVERKHNOSTI]
V. A. ANTONOV, A. M. GRISHIN, and F. M. PAKHOMOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1987, p. 95-101. In Russian. refs

The effect of the angle of attack in the range 0-40 degrees on the flow pattern and aerodynamic characteristics of a power-law body under conditions of supersonic flow is investigated numerically for the case of strong localized subsonic injection from the surface and in the absence of injection. The problem is solved using Godunov's finite difference scheme. It is found that strong gas injection significantly reduces the aerodynamic drag of the body without any deterioration of its static stability. V.L.

A88-17731
FORCE AND MOMENT CHARACTERISTICS OF SUPERSONIC FLOW PAST A CYLINDRICAL BODY OF REVOLUTION WITH A FLUID WING [SILOVYE I MOMENTNYE KHARAKTERISTIKI SVERKHZVUKOVOGO OBTEKANIIA TSILINDRICHESKOGO TELA VRASHCHENIIA S ZHIDKIM KRYLOM]
V. F. ZAKHARCHENKO, IU. KH. KARDANOV, and P. V. SIDOROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1987, p. 102-106. In Russian. refs

Jet interaction in a 'fluid-wing' injection scheme is examined with reference to results of wind tunnel studies. Particular attention is given to the contribution of the surface areas of the body behind the injected jets to the generation of controlling and stabilizing forces and moments. Results of approximate calculations of the force and moment characteristics of flow past a cylindrical body of revolution with a 'fluid wing' are also presented. V.L.

A88-17732
AERODYNAMIC CHARACTERISTICS OF LONG BLUNTED CONES UNDER CONDITIONS OF INTENSE MASS TRANSFER [AERODINAMICHESKIE KHARAKTERISTIKI DLINNYKH ZATUPLENNYKH KONUSOV PRI INTENSIVNOM MASSOOBMENE]
V. N. KARLOVSKII, V. A. LEVIN, and V. I. SAKHAROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1987, p. 107-113. In Russian. refs

The effect of injection from the spherical blunt surface of long blunted cones on their aerodynamic characteristics in supersonic flow of an ideal gas at angle of attack is investigated numerically. The problem is divided into two consecutive problems. First, the flow field near the blunt part is calculated up to the supersonic region using a finite difference scheme; then, beginning with the supersonic region, a Cauchy problem for a stationary system of gas dynamic equations is formulated and solved. For all the cases considered here, injection from the spherical blunt surface is shown to reduce the lifting force acting on the cone and, in comparison with the case of a nonporous body, reduces the pitching moment and increases the stability of the cone. V.L.

A88-17733
VISCOUS BOUNDARY LAYER NEAR THE CRITICAL POINT OF A ROTATING BODY UNDER CONDITIONS OF NONSTATIONARY INJECTION AND SURFACE COOLING [VIAZKII UDARNYI SLOI OKOLO KRITICHESKOI TOCHKI VRASHCHAIUSHCHEGOSIA TELA PRI NESTATSIONARNOM VDUVE I OKHLAZHDENII POVERKHNOSTI]
A. A. MARKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1987, p. 114-122. In Russian. refs

Nonstationary regimes of supersonic flow in the vicinity of a stagnation point are investigated analytically using a system of equations of the viscous shock layer containing all the terms of Euler and boundary layer equations. For the case of strong injection, an analytical solution to the nonstationary equations is obtained which is valid near the surface of the body. The nonstationary equations of the viscous shock layer are solved numerically using a second-order divergent implicit scheme across the shock layer. Some calculation results are presented to illustrate the effect of injection, surface cooling, outer flow twisting, and angular velocity of the body on the structure of stationary and nonstationary viscous shock layers. V.L.

A88-17737
A NUMERICAL STUDY OF THE STRUCTURE OF NONEQUILIBRIUM THREE-DIMENSIONAL HYPERSONIC FLOW PAST BLUNT BODIES [CHISLENNOE ISSLEDOVANIE STRUKTURY NERAVNOVESNOGO TECHENIIA OKOLO ZATUPLENNYKH TEL PRI GIPERZVUKOVOM PROSTRANSTVENNOM OBTEKANII]
V. G. SHCHERBAK Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1987, p. 143-150. In Russian. refs

Three-dimensional flow of a dissociating air around blunt bodies is investigated using parabolized Navier-Stokes equations. The analysis allows for multicomponent diffusion and homogeneous chemical reactions, including dissociation-recombination and exchange reactions. The boundary conditions are specified in the unperturbed flow and on the body surface, with allowance made for heterogeneous catalytic reactions and slip effects. The results obtained are compared with calculations based on a model of a thin viscous shock layer. V.L.

A88-17739
AN EXPERIMENTAL STUDY OF SUPERSONIC THREE-DIMENSIONAL SEPARATED FLOW BETWEEN A PLANE HEAD AND A SPHERE [EKSPERIMENTAL'NOE ISSLEDOVANIE SVERKHZVUKOVOGO TREKHMERNOGO OTRYVNOGO TECHENIIA MEZHDU PLOSKIM NASADKOM I SFEROI]
V. S. KHLEBNIKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1987, p. 166-170. In Russian. refs

Experimental data are presented for supersonic separated flows developing near a sphere (diameter, 60 mm) with a spike (diameter, 3 mm; lengths, 21, 41, 61, 81, and 101 mm) having a wedge-shaped (10x10x3 mm) or plane rounded head (10x10x3 mm or 10x15x3 mm) mounted at its end. The experiments were carried out in a supersonic wind tunnel with an axisymmetric test section at Mach 3 and Re (1.5-1.6) x 10 to the 6th; flow patterns were recorded by a motion picture camera at 30 frames/s. Characteristics of separated flow are examined for spike lengths less than, approximately equal to, and greater than the critical distance at which the separation point shifts from the head to the spike. V.L.

A88-18481#
TURBULENCE MODELING IN SHOCK/BOUNDARY-LAYER INTERACTIONS
BEATRICE ESCANDE (ONERA, Chatillon-sous-Bagneux, France) (International Conference on Numerical Methods in Laminar and Turbulent Flow, 5th, Montreal, Canada, July 6-10, 1987) ONERA, TP, no. 1987-96, 1987, 11 p. refs
(ONERA, TP NO. 1987-96)

Two turbulence models (a zero-equation and a two-equation eddy-viscosity model) are used to model the turbulence in shock-wave/boundary-layer interactions for two-dimensional transonic channel flows. Numerical results are obtained by solving the averaged Navier-Stokes equations. Previous experimental LDV results are analyzed in order to characterize the behavior of the turbulent stresses along the mean flow streamlines. The correlation coefficient is found to undergo a large decrease through the interaction region, and it is suggested that this behavior is related to the pressure-strain correlation term. R.R.

A88-18482#
A PARALLEL ALGORITHM FOR THE NUMERICAL SIMULATION OF THE UNSTEADY NAVIER-STOKES EQUATIONS AT HIGH REYNOLDS NUMBERS AROUND AN AIRFOIL
L. MANE (ONERA, Chatillon-sous-Bagneux, France) and PHUOC LOC TA (CNRS, Laboratoire d'Informatique pour la Mecanique et les Sciences de l'Ingenieur, Orsay, France) (International Conference on Numerical Methods in Laminar and Turbulent Flow, 5th, Montreal, Canada, July 6-10, 1987) ONERA, TP, no. 1987-97, 1987, 12 p. refs
(ONERA, TP NO. 1987-97)

The unsteady Navier-Stokes equations at high Reynolds numbers are solved to study laminar or turbulent flow problems for unsteady viscous flows around bodies. A highly accurate method which is based on ADI techniques is employed, using an outflow condition on the downstream boundary. The method is implemented on a multiprocessor system in order to take advantage of the algorithm parallelism. Good results have been obtained for impulsively started airfoils at Reynold numbers up to 100,000.
R.R.

A88-18489#
ON THE BREAKDOWN OF THE VORTEX INDUCED BY A DELTA WING
J. DELERY, D. PAGAN, and J.-L. SOLIGNAC (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1987-105, 1987, 26 p. refs
(ONERA, TP NO. 1987-105)

A vortex generated by a delta wing and subjected to an adverse pressure gradient inducing its breakdown has been experimentally investigated. Firstly, the limit of breakdown has been determined as a function of the vortex strength and of the intensity of the adverse pressure gradient. Secondly, a burst configuration has been probed in detail by using a three-component LDV system. The flowfield structure comprises a large recirculation zone in which the swirl motion has significantly slowed down. Furthermore, the flow is the seat of large scale low-frequency fluctuations affecting principally the origin of breakdown. A numerical simulation of breakdown has been made by solving the time-dependent Navier-Stokes equations for a laminar, incompressible and axisymmetric flow. The code has been used to make a parametric study of the breakdown limit involving the shape of the velocity distributions of the incoming vortex, the Reynolds number and the intensity of the adverse pressure gradient. Author

A88-18626*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTED AND EXPERIMENTAL SURFACE PRESSURE AND HEATING ON 70-DEG SPHERE CONES
K. JAMES WEILMUENSTER and H. HARRIS. HAMILTON, II (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Sept.-Oct. 1987, p. 385-393. Previously cited in issue 07, p. 838, Accession no. A86-19956. refs

A88-18645
APPLICATION OF AN INVERSE CASCADE DESIGN METHOD TO AN AXIAL FAN
AKIRA GOTO (Ebara Research Co., Ltd., Kanagawa, Japan) JSME International Journal (ISSN 0913-185X), vol. 30, Sept. 1987, p. 1414-1422. refs

In order to demonstrate the applicability of an inverse cascade design method for blade design for an axial turbomachine, rotor and stator blades of a single stage axial fan are designed and tested. This design concept, proposed in the previous reports, is based on an inverse boundary layer method and an inverse cascade method. The overall performance and the rotor exit flow are measured and are compared with those of a conventional fan designed using an NACA 65 series cascade. The inversely designed fan obtains higher efficiency and a wider operating range compared with the conventional one. The rotor blade midspan wake in the trailing edge region reveals an extremely low velocity defect, a low wake shape factor, and low momentum thickness. Boundary layer separation on the rotor blade surface seems to be avoided and the losses are low. The experimental results show the validity of the practical application of the inverse design concept, especially for rotating blades. Author

A88-18654*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ON THE CORRELATION OF PLUME CENTERLINE VELOCITY DECAY OF TURBULENT ACOUSTICALLY EXCITED JETS
UWE H. VON GLAHN (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 35 p. refs
(AIAA PAPER 87-2692)

Acoustic excitation has been shown to alter the velocity decay and spreading characteristics of jet plumes by modifying the large-scale structures in the plume shear layer. The present work consists of reviewing and analyzing available published and unpublished experimental data in order to determine the importance and magnitude of the several variables that contribute to plume modification by acoustic excitation. Included in the study were consideration of the effects of internal or external acoustic excitation, excitation Strouhal number, acoustic excitation level, nozzle size and flow conditions. The last include jet Mach number and jet temperature. The effects of these factors on the plume centerline velocity decay are then summarized in an overall empirical correlation. Author

A88-18655*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADVANCED TURBOPROP WING INSTALLATION EFFECTS MEASURED BY UNSTEADY BLADE PRESSURE AND NOISE
LAURENCE J. HEIDELBERG and RICHARD P. WOODWARD (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 23 p. Previously announced in STAR as N88-10008. refs
(AIAA PAPER 87-2719)

A single rotation model propeller (SR-7A) was tested at simulated takeoff/approach conditions (Mach 0.2), in the NASA Lewis 9- by 15-Ft Anechoic Wind Tunnel. Both unsteady blade surface pressures and noise measurements were made for a tractor configuration with propeller/straight wing and propeller alone configurations. The angle between the wing chord and propeller axis (droop angle) was varied along with the wing angle of attack to determine the effects on noise and unsteady loading. A method was developed that uses unsteady blade pressure measurements to provide a quantitative indication of propeller inflow conditions, at least for a uniform (across the propeller disk) inflow angle. The wing installation caused a nearly uniform upwash at the propeller inlet as evidenced by the domination of the pressure spectra by the first shaft order. This inflow angle increased at a rate of almost 150 percent of that of the wing angle-of-attack for a propeller-wing spacing of 0.54 wing chords at a constant droop angle. The flyover noise, as measured by the maximum blade passing frequency level, correlates closely with the propeller inflow angle (approx. 0.6 dB per degree of inflow angle) for all droop angles and wing angles of attack tested, including the propeller alone data. Large changes in the unsteady pressure responses on the suction surface of the blade were observed as the advance ratio was varied. The presence of a leading edge vortex may explain this behavior since changes in the location of this vortex would change with loading (advance ratio). Author

A88-18656*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL OBSERVATIONS OF TWO DIMENSIONAL BLADE-VORTEX INTERACTION
E. R. BOOTH, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 15 p. refs
(AIAA PAPER 87-2745)

Blade-vortex interaction (BVI) is the source mechanism for a prominent impulsive noise created by rotorcraft. An experimental study of two dimensional BVI, a simplified case representing the

most intense and impulsive noise generation condition, was performed to explore the fundamental physics associated with the blade-vortex interaction process. The purpose of this paper is to report cumulative results from this experimental study. The interaction process is shown to involve a combination of effects on the vortex including changes in trajectory and distortion of the vortex core shape. The blade involved undergoes significant transient loading. The effects of the interaction process on the blade and the vortex are shown to be increased by both reduction of blade-to-vortex spacing and increase in blade loading. Calculations of the acoustic field produced by the interaction using measured unsteady blade surface pressure data are presented and show acoustic waveforms similar to those obtained from model helicopter acoustic tests. Author

A88-18660*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEASUREMENTS OF THE UNSTEADY FLOW FIELD WITHIN THE STATOR ROW OF A TRANSONIC AXIAL-FLOW FAN. I - MEASUREMENT AND ANALYSIS TECHNIQUE
K. L. SUDER, A. J. STRAZISAR, J. J. ADAMCZYK (NASA, Lewis Research Center, Cleveland, OH), M. D. HATHAWAY (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH), and T. H. OKIISHI (Iowa State University of Science and Technology, Ames) ASME, Gas Turbine Conference and Exhibition, Anaheim, CA, May 31-June 4, 1987. 9 p. Previously announced in STAR as N87-16789. refs
(ASME PAPER 87-GT-226)

This two-part paper presents laser anemometer measurements of the unsteady velocity field within the stator row of a transonic axial-flow fan. The objective is to provide additional insight into unsteady blade-row interactions within highspeed compressors which affect stage efficiency, energy transfer, and other design considerations. Part 1 describes the measurement and analysis techniques used for resolving the unsteady flow field features. The ensemble-average and variance of the measured velocities are used to identify the rotor wake generated and unresolved unsteadiness, respectively. (Rotor wake generated unsteadiness refers to the unsteadiness generated by the rotor wake velocity deficit and the term unresolved unsteadiness refers to all remaining contributions to unsteadiness such as vortex shedding, turbulence, mass flow fluctutions, etc.). A procedure for calculating auto and cross correlations of the rotor wake generated and unresolved unsteady velocity fluctuations is described. These unsteady-velocity correlations have significance since they also result from a decomposition of the Navier-Stokes equations. This decomposition of the Navier-Stokes equations resulting in the velocity correlations used to describe the unsteady velocity field will also be outlined in this paper. Author

A88-18661*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEASUREMENTS OF THE UNSTEADY FLOW FIELD WITHIN THE STATOR ROW OF A TRANSONIC AXIAL-FLOW FAN. II - RESULTS AND DISCUSSION
M. D. HATHAWAY (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH), K. L. SUDER, A. J. STRAZISAR, J. J. ADAMCZYK (NASA, Lewis, Research Center, Cleveland, OH), and T. H. OKIISHI (Iowa State University of Science and Technology, Ames) ASME, Gas Turbine Conference and Exhibition, Anaheim, CA, May 31-June 4, 1987. 13 p. Previously announced in STAR as N87-16790. refs
(ASME PAPER 87-GT-227)

Unsteady velocity field measurements made within the stator row of a transonic axial-flow fan are presented. Measurements were obtained at midspan for two different stator blade rows using a laser anemometer. The first stator row consists of double circular-arc airfoils with a solidity of 1.68. The second features controlled-diffusion airfoils with a solidity of 0.85. Both were tested at design-speed peak efficiency conditions. In addition, the controlled-diffusion stator was also tested at near stall conditions. The procedures developed here are used to identify the rotor wake generated and unresolved unsteadiness from the velocity measurements (rotor wake generated unsteadiness refers to the unsteadiness generated by the rotor wake velocity deficit and unresolved unsteadiness refers to all remaining unsteadiness which contributes to the spread in the distribution of velocities such as vortex shedding, turbulence, etc.). Auto and cross correlations of these unsteady velocity fluctuations are presented to show their relative magnitude and spatial distributions. Amplification and attenuation of both rotor wake generated and unresolved unsteadiness are shown to occur within the stator blade passage. Author

A88-19191
THE FAR FIELD OF AN OSCILLATING AIRFOIL IN SUPERSONIC FLOW
A. F. MESSITER and S. L. WOODRUFF (Michigan, University, Ann Arbor) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 183, Oct. 1987, p. 175-183. refs

An approach utilizing multiple scales and matched asymptotic expansions is developed for the description of small perturbations at large distances from a thin airfoil oscillating harmonically in a uniform supersonic flow. The problem of determining the unsteady perturbation potential is formulated in general, and an analytical solution is derived for an airfoil with parabolic or flat surfaces. The results describe the flow ahead of the region influenced by the trailing edge. The variation in the pressure jump across an attached leading-edge shock wave is also obtained. Author

A88-19226#
DISCRETE VORTEX COMPUTATION OF SEPARATED AIRFOIL FLOW
J. BASUKI (Indonesian Aircraft Industries, Bandung, Indonesia) and J. M. R. GRAHAM (Imperial College of Science and Technology, London, England) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1409, 1410. refs

The viscid cloud-in-cell method, which is a mixed Eulerian-Lagrangian method in which discrete vortices are tracked through a grid on which the velocity field is computed by the finite difference method, is presently used to treat low speed, unsteady, separated airfoil flow. This method has the advantage of faster computation when large numbers of vortices are present, at the expense of poorer velocity field resolution. In the case of 30-deg airfoil incidence, the method predicts too strong a roll-up of the trailing vortex sheet and thereby yields an unrealistic suction peak on the rear upper surface, as well as excessively large lift fluctuations. O.C.

A88-19227#
EXPERIMENTAL INVESTIGATIONS OF THE FLOWFIELD OF AN AIRFOIL WITH SPOILER
CHYANG S. LEE (Stanford University, CA) and SATYA BODAPATI (U.S. Naval Postgraduate School, Monterey, CA) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1411-1416. Research supported by the Boeing Airplane Co. refs

An experiment was performed on the flowfields of an airfoil with deflected spoiler at low speed. Surface pressure distributions and boundary-layer and wake profiles were measured systematically to evaluate the effects of angle of attack and spoiler deflection on mean and fluctuating quantities. Boundary-layer and base pressure characteristics were analyzed. The development of wake with angle of attack is hypothesized by the variation of base pressure. The location of hinge bubble depends on boundary-layer characteristics. The wake is self-preserved if a virtual origin is introduced. Author

A88-19228*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VORTEX SIMULATION OF FORCED/UNFORCED MIXING LAYERS
OSAMU INOUE (NASA, Ames Research Center, Moffett Field, CA) and ANTHONY LEONARD (California Institute of Technology, Pasadena) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1417, 1418. Abridged. Previously cited in issue 08, p. 1036, Accession no. A87-22536. refs

A88-19229*# Lockheed-Georgia Co., Marietta.
COHERENT LARGE-SCALE STRUCTURES IN HIGH REYNOLDS NUMBER SUPERSONIC JETS
J. LEPICOVSKY, K. K. AHUJA, W. H. BROWN, and R. H. BURRIN (Lockheed-Georgia Co., Marietta) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1419-1425. Previously cited in issue 22, p. 3219, Accession no. A86-45428. refs
(Contract NAS1-17442)

A88-19230#
INFLUENCE OF NUMERICAL DISSIPATION ON COMPUTATIONAL EULER EQUATIONS FOR VORTEX-DOMINATED FLOWS
OSAMA A. KANDIL and ANDREW H. CHUANG (Old Dominion University, Norfolk, VA) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1426-1434. refs

Steady, supersonic vortex-dominated flows are solved using the unsteady Euler equations for conical flows around sharp- and round-edged delta wings. A finite-volume scheme with a four-stage Runge-Kutta time stepping and explicit second- and fourth-order dissipation terms has been developed to obtain the steady flow solution through psuedo time stepping. The grid is generated by using a modified Joukowski transformation. The scheme has been applied to flat-plate and elliptic-section delta wings at different angles of attack, freestream Mach numbers, and grid sizes. For the sharp-edged wings, separated-flow solutions are always obtained, while for round-edged wings both separated- and attached-flow solutions can be obtained, depending on the level of numerical dissipation. The round-edged results also show that the solutions are independent of the way time stepping is done - local time stepping and global minimum time stepping produce the same solutions. Author

A88-19232#
ARBITRARY MOTION AERODYNAMICS USING AN AEROACOUSTIC APPROACH
LYLE N. LONG and GEORGE A. WATTS (Lockheed California Co., Burbank) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1442-1448. refs

This paper describes a new unsteady aerodynamics method that uses time-domain aeroacoustic integral equations. Recent advances in theoretical aeroacoustics permit the development of general unsteady aerodynamics methods. The effects of thickness, compressibility, and arbitrary motions may be calculated for subsonic and supersonic flows. Most linearized unsteady aerodynamics methods today are limited to zero-thickness airfoils and sinusoidal motions. The method outlined in this report has applications to super-maneuverable aircraft and rotating blades. Panel methods for steady aerodynamics are widely used in the aircraft industry for steady flow, and the present method should permit equally general configurations to be solved in unsteady motion using a time-stepping procedure. Author

A88-19234*# California Univ., Davis.
IMPROVED FINITE-DIFFERENCE SCHEMES FOR TRANSONIC POTENTIAL FLOW CALCULATIONS
M. HAFEZ (California, University, Davis), W. WHITLOW, JR. (NASA, Langley Research Center, Hampton, VA), and S. OSHER (California, University, Los Angeles) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1456-1462. Previously cited in issue 06, p. 715, Accession no. A84-19231. refs

A modified artificial density method based on flux biasing is used to solve the full potential equation in conservation form. It is shown that expansion shocks are not allowed with the present scheme. Typical numerical results are presented. Author

A88-19242#
HYSTERESIS OF VORTEX DEVELOPMENT AND BREAKDOWN ON AN OSCILLATING DELTA WING
R. ATTA and D. ROCKWELL (Lehigh University, Bethlehem, PA) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1512, 1513. refs
(Contract AF-AFOSR-86-0177)

Characterization of the unsteadiness of a high angle-of-attack delta wing's leading edge vortex core breakdown, when the vortex is subjected to periodic excitation, remains unresolved; it is expected that the location of vortex breakdown will exhibit a hysteresis loop as the angle-of-attack is varied. Attention is presently given to the development and breakdown of the vortex core, as defined by the vorticity fed into the vortex at and near the tip of the wing. O.C.

A88-19244#
STABILITY OF NORMAL SHOCK WAVES IN DIFFUSERS
KAZUYASU MATSUO, HIROAKI MOCHIZUKI (Kyushu University, Fukuoka, Japan), and MINORU YAGA AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1515-1517. refs

The present analysis of the behavior of a shock wave in a diffuser in response to small-amplitude pressure disturbances indicates that shock wave stability depends not only on the Mach number immediately upstream of the shock, but also on diffuser efficiency for subsonic flow downstream of the shock wave. The neutral stability curve relating the diffuser efficiency to the Mach number is obtained. The maximum diffuser efficiency causing instability decreases as the Mach number increases from 1.0 to 1.48. O.C.

A88-19246*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXTENSION OF HYPERSONIC, HIGH-INCIDENCE, SLENDER-BODY SIMILARITY
RICHARD W. BARNWELL (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1519-1522. refs

The Sychev (1960) analysis for inviscid hypersonic flow past slender bodies at large angle of attack is shown to be applicable to all slender-body flows whose crossflow Mach numbers are greater than sonic; it is therefore not restricted to flows with hypersonic crossflow Mach number values, as indicated elsewhere in the literature. It is also noted that the Sychev similarity applies to a number of slender-body flows with subsonic crossflow Mach numbers, including incompressible flow. O.C.

A88-19247*# Old Dominion Univ., Hampton, Va.
SIMILARITY RULE FOR SIDEWALL BOUNDARY-LAYER EFFECTS IN AIRFOIL TESTING
A. V. MURTHY (Old Dominion University, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 25, Nov. 1987, p. 1522-1524. refs
(Contract NAS1-334)

The simplified form of the similarity rule for sidewall boundary layer effects presented envisions the generation of changes in both airfoil thickness and freestream Mach number by the sidewall boundary layer. Within the small-disturbance approximation, this approach encompasses the methods of both Barnwell (1980) and Sewall (1982), and can accordingly be applied at speeds ranging from the lowest to transonic Mach numbers. O.C.

A88-19261* Lockheed Missiles and Space Co., Sunnyvale, Calif.
FLUID DYNAMICS OF UNSTEADY SEPARATED FLOW. II - LIFTING SURFACES
L. E. ERICSSON and J. P. REDING (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 24, no. 4, 1987, p. 249-356. refs
(Contract NAS1-7999; NAS1-9987; NAS9-11495; NAS8-28130; NAS8-30652)

An analytic method is described which uses static experimental data to predict the separated flow effect on rigid and elastic vehicle

dynamics. Key parameters in the analytic relationship between steady and nonsteady aerodynamics are: the time lag occurring before a change of flow conditions can affect the separation-induced aerodynamic loads; the accelerated flow effect (i.e., the pressure gradient lag relative to the static aerodynamic characteristics); and the moving wall effect (i.e., the effect of the nonsteady boundary condition at the vehicle surface). Using the existing experimental data base, an analytic theory is formulated that can predict the separation-induced unsteady aerodynamics if the static characteristics are known from theory or experiment. Reference is made to increased-maneuverability advanced aircraft and to Space Shuttle Orbiter aerodynamics. B.J.

A88-19348
NONSTATIONARY TRANSONIC AND VISCOUS FLOWS IN TURBOMACHINES [NESTATSIONARNYE TRANSZVUKOVYE I VIAZKIE TECHENIIA V TURBOMASHINAKH]
GEORGII ALEKSANDROVI SOKOLOVSKII and VITALII ISAEVICH GNESIN Kiev, Izdatel'stvo Naukova Dumka, 1986, 264 p. In Russian. refs

Mathematical models are developed for two- and three-dimensional nonstationary flows in turbine stages. The nonstationary aerodynamic and power characteristics of moving plane cascades and blading of actual turbine stages are analyzed numerically for nominal and partial regimes. An analysis is also made of the effect of nonaxisymmetric parameter distribution behind the rotor on the characteristics of the preceding stage. A mathematical model of plane viscous transonic separated gas flows is constructed, and the resulting solutions are analyzed. V.L.

A88-19665*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFICIENT SELF-CONSISTENT VISCOUS-INVISCID SOLUTIONS FOR UNSTEADY TRANSONIC FLOW
JAMES T. HOWLETT (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Nov. 1987, p. 737-744. Previously cited in issue 07, p. 847, Accession no. A85-19779. refs

A88-19670*# Wichita State Univ., Kans.
VORTEX SHEET MODELING WITH CURVED HIGHER-ORDER PANELS
M. G. NAGATI (Wichita State University, Kansas), J. D. IVERSEN, and J. M. VOGEL (Iowa State University of Science and Technology, Ames) Journal of Aircraft (ISSN 0021-8669), vol. 24, Nov. 1987, p. 776-782. Research supported by the Wichita State University and NASA. Previously cited in issue 17, p. 2463, Accession no. A86-37833. refs

A88-19671#
EXPERIMENTAL FLOWFIELD STUDY ON A SUPERCRITICAL AIRFOIL
KARL A. BUETEFISCH and EGON STANEWSKY (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 911-922) Journal of Aircraft (ISSN 0021-8669), vol. 24, Nov. 1987, p. 783-788. Previously cited in issue 24, p. 3532, Accession no. A86-49074. refs

A88-19703
2-D/3-D FINITE-ELEMENT SOLUTION OF THE STEADY EULER EQUATIONS FOR TRANSONIC LIFTING FLOW BY STREAM VECTOR CORRECTION
FADI EL DABAGHI (Institut National de Recherche en Informatique et en Automatique, Le Chesnay, France), OLIVIER PIRONNEAU (Paris VI, Universite, France), JACQUES PERIAUX, and GERARD POIRIER (Avions Marcel Dassault-Breguet Aviation, Saint Cloud, France) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 7, Nov. 1987, p. 1191-1209. Sponsorship: Service Technique des Programmes Aeronautiques. refs
(Contract STPA-84,9500312)

The validation of the new formulation (potential-stream vector) of the steady Euler equations in two-dimensional/three-dimensional transonic lifting regime flow is studied. This approach, which is based on the Helmholtz decomposition of a velocity vector field, is designed to extend the potential approximation of Euler equations for severe situations such as high transonic or rotational subsonic flows. Different results computed by a fixed-point algorithm on the stream vector correction are shown and discussed by comparing them with those obtained by the full potential approach. Author

A88-19704* Texas Univ., Austin.
ADAPTIVE FINITE ELEMENT METHODS FOR HIGH-SPEED COMPRESSIBLE FLOWS
J. T. ODEN, T. STROUBOULIS, and PH. DEVLOO (Texas, University, Austin) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 7, Nov. 1987, p. 1211-1228. refs
(Contract N00014-84-K-0409; NAS1-17894)

An adaptive finite element algorithm for solving the unsteady Euler equations is described. The finite element algorithm is based on a Taylor/Galerkin formulation and uses a very fast and efficient data structure to refine and unrefine the grid in order to optimize the approximation. A general version of the method which can be applied to moving grids with sliding interfaces is given, and results for a transient supersonic calculation of rotor-stator interaction are presented. Author

A88-19706* Tennessee Univ., Knoxville.
ON A FINITE ELEMENT CFD ALGORITHM FOR COMPRESSIBLE, VISCOUS AND TURBULENT AERODYNAMIC FLOWS
A. J. BAKER, J. W. KIM (Tennessee, University, Knoxville), J. D. FREELS (Technology for Energy Corp., Knoxville, TN), and J. A. *ORZECHOWSKI (Computational Mechanics Corp., Knoxville, TN)* International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 7, Nov. 1987, p. 1235-1259. Research supported by the Computational Fluid Dynamics Laboratory. refs
(Contract NAG1-319; NAS2-12347; N62669-84-C-0264)

This paper develops and analyses individual construction aspects of an efficient and accurate finite element algorithm for prediction of viscous and turbulent flow fields of impact in aerodynamics. The theoretical construction employs a Taylor weak statement (TWS) for coincident embedding of stability mechanisms within a classic Galerkin finite element formulation of semidiscrete approximation error orthogonalization. A wide variety of the stabilizing mechanisms of independently derived CFD algorithms are contained within the TWS theory. An implicit construction that meets the requirement of efficient convergence to steady state is developed. The theoretical asymptotic error estimates of the TWS finite element algorithm for supersonic and viscous boundary layer flows are verified. Application to a three-dimensional turbulent flow is cited. Author

A88-19737
MEASUREMENTS AND CALCULATIONS OF STEADY AND OSCILLATORY PRESSURES ON A LOW ASPECT RATIO MODEL AT SUBSONIC AND TRANSONIC SPEEDS
D. G. MABEY and B. L. WELSH (Royal Aircraft Establishment, Aerodynamics Dept., Bedford, England) Journal of Fluids and Structures (ISSN 0889-9746), vol. 1, Oct. 1987, p. 445-468. refs

Steady and time-dependent pressures have been measured for oscillatory pitching motion at frequencies of 0, 12, 33 and 70 Hz on a model of the AGARD SMP tailplane at Mach numbers from 0.65 to 1.20. Some wall interference effects at transonic speeds were observed. For attached flows at transonic speeds the time-dependent pressures are in good agreement with predictions according to Garner's semiempirical theory, as long as the local Mach number upstream of the shock is less than 1.1. For separated flows the semiempirical theory gives poor predictions, particularly for the imaginary component of the pressure. Flow separation causes large low frequency effects beyond the scope of the predictions. Author

A88-19776
INVISCID THEORY OF TWO-DIMENSIONAL AEROFOIL/SPOILER CONFIGURATIONS AT LOW SPEED. I - SOME EXPERIENCES ON SIMPLE PANEL METHODS APPLIED TO ATTACHED AND SEPARATED FLOWS. II - STEADY AEROFOIL-SPOILER CHARACTERISTICS
H. B. TOU and G. J. HANCOCK (Queen Mary College, London, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, Oct. 1987, p. 350-366. Research supported by the Ministry of Defence of England. refs

In the first part of this work, attached flows and separated flows past an airfoil/spoiler configuration are treated by simple, first-order surface singularity methods based, in the first instance, on Smith and Hess (1966) uniform source panels in conjunction with a uniform vorticity around the airfoil profile; and in the second, on piecewise linear vorticity around the airfoil profile with different assumptions for the Kutta condition. In the second part, the surface singularity method formulated for the prediction of two-dimensional spoiler characteristics at low speeds yields theoretical results for a variety of airfoil/spoiler configurations that compare reasonably well with experimental results. O.C.

A88-19803#
AIRCRAFT BUFFET ONSET MEASUREMENTS AT TRANSONIC MACH NUMBERS
P. R. VISWANATH (National Aeronautical Laboratory, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 39, Feb. 1987, p. 21-28. refs

Buffet onset measurements have been performed on a low aspect ratio, moderately swept, aircraft model at three transonic Mach numbers in the 1.2 m tunnel. Instrumentation included wing root strain gauges, a wing tip accelerometer, wing trailing edge pressure taps and standard six component internal strain gauge balance. Results of buffet onset determined from both static as well as dynamic techniques are compared. A discussion of the buffet onset results, as it relates to the main features of the flow on the wing upper surface, is also included. Author

A88-19861#
VALIDATION OF TURBULENCE MODELS APPLIED TO TRANSONIC SHOCK-WAVE/BOUNDARY-LAYER INTERACTION
R. BENAY, M. C. COET, and J. DELERY (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1987, p. 1-16. Translation. Previously cited in issue 16, p. 2500, Accession no. A87-38050. refs

A88-19862#
EFFECT OF COMPUTATION PARAMETERS ON THE RESULTS OF 3-D POTENTIAL METHODS
D. DESTARAC (ONERA, Chatillon-sous-Bagneux, France) (ONERA, TP no. 1986-169, 1986) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1987, p. 17-29. Translation. Previously cited in issue 07, p. 857, Accession no. A87-21069. refs
(ONERA, TP NO. 1986-169)

A88-19970
NUMERICAL COMPUTATION OF THREE-DIMENSIONAL TURBULENT BOUNDARY LAYERS FOR THE INFINITE SWEPT WING
R. TOUZANI (Lausanne, Ecole Polytechnique Federale, Switzerland) Zeitschrift fuer angewandte Mathematik und Physik (ISSN 0044-2275), vol. 38, Sept. 1987, p. 741-757. refs
(Contract SNSF-2,855,0,85)

The turbulent three-dimensional boundary-layer flow of an incompressible viscous fluid on an infinite swept wing is investigated analytically. Governing equations based on Cartesian coordinates are introduced; the choice of an anisotropic eddy-viscosity turbulence model (Nakkasyan et al., 1987) is discussed in detail; a numerical scheme is developed to discretize the problem; and numerical results are presented in extensive graphs and compared with published values. Good agreement is obtained both with experimental data and with the predictions of a streamline-coordinate method. T.K.

A88-20464* New York Univ., New York.
REDESIGN OF A SUPERCRITICAL WING IN THE PRESENCE OF AN ENGINE NACELLE
DAVID S. ROSS (New York University, NY) Journal of Computational Physics (ISSN 0021-9991), vol. 73, Dec. 1987, p. 233-243. refs
(Contract DE-AC02-76ER-03077; NSF DMS-83-20430; NAG2-345)

If an obstacle, such as an engine nacelle, is placed in the flow near a virtually shockless wing, shocks of substantial magnitude may appear on the wing. A source distribution method is presently employed in the modeling of an engine nacelle in compressible flow, through incorporation into a free-boundary supercritical wing design code. Code calculation results are presented which show the transonic shock to appear, on average, 10 percent forward of its position on the clean wing. Attention is also given to an associated method for the calculation of wave drag. O.C.

A88-20472
SOLUTION OF THE EULER EQUATIONS FOR TRANSONIC FLOW OVER A LIFTING AEROFOIL - THE BERNOULLI FORMULATION (ROE/LYTTON METHOD)
C. C. LYTTON (Ministry of Defence Procurement Executive, Farnborough, England) Journal of Computational Physics (ISSN 0021-9991), vol. 73, Dec. 1987, p. 395-431. refs

The Euler equations for the steady inviscid supercritical flow past an airfoil are presently solved by incorporating the 'Superbee' form of Roe's (1981) algorithm into an explicit, flux-difference-splitting, nontime-split sequence of one-dimensional spatial operators in local-sidestep mode. The consistency of the method is tested through its application to a problem involving an RAE 2822 airfoil at Mach 0.75. A 180 x 24 grid extending to 16 chords out from the airfoil will yield satisfactory results for most purposes. O.C.

N88-13218*# Coe Engineering, Inc., Los Altos, Calif.
PREDICTIONS OF F-111 TACT AIRCRAFT BUFFET RESPONSE AND CORRELATIONS OF FLUCTUATING PRESSURES MEASURED ON ALUMINUM AND STEEL MODELS AND THE AIRCRAFT
CHARLES F. COE and ATLEE M. CUNNINGHAM, JR. (General Dynamics Corp., Fort Worth, Tex.) 1987 152 p
(Contract NAS2-11420)
(NASA-CR-4069; NAS 1.26:4069) Avail: NTIS HC A08/MF A01 CSCL 01A

Results of buffet research that was conducted as part of the joint USAF/NASA F-111 TACT Research Program are presented. The correlation of wind tunnel and flight measurements of buffet excitation showed that there generally was good agreement between measurements of pressure fluctuations on the models and aircraft in regions of separated flow. At shock-wave boundaries of the separated flow, correlations of pressure fluctuations were not so good, due to Reynolds number and static elastic effects. The buffet prediction method, which applies a forcing function that is obtained by real-time integration of pressure time histories with the natural modes, is described. The generalized forces, including the effects of wing and tail, correlations of predicted and measured damping, and correlations of predicted and measured buffet response are presented. All presented data are for a Mach number of 0.8 with wing-sweep angles of 26 and 35 deg for a range of angles-of-attack that include buffet onset to high intensity buffeting. Generally, the buffet predictions were considered to be quite good particularly in light of past buffet-prediction experience. Author

N88-13219# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
AERODYNAMICS OF HYPERSONIC LIFTING VEHICLES
Nov. 1987 560 p In ENGLISH and FRENCH Symposium held in Bristol, United Kingdom, 6-9 Apr. 1987
(AGARD-CP-428; ISBN-92-835-0435-6) Avail: NTIS HC A24/MF A01

The Symposium was conducted at the outset of a new era in hypersonic aerodynamics. The Proceedings therefore present a valuable stock taking of the status of the field after a comparative lull in the last decade. A particular gap exists in the field of experimental facilities. At the same time, developments in computational fluid dynamics and experimental techniques provide possibilities that did not exist 10 years before. The papers presented were grouped in the fields: experimental facilities; experimental techniques and results; computational techniques; design methods; and projects. The most significant results of the symposium was a perspective of the need for special effort in the near future.

N88-13226*# Texas Univ., Austin. Dept. of Aerospace Engineering.
DRIVING MECHANISM OF UNSTEADY SEPARATION SHOCK MOTION IN HYPERSONIC INTERACTIVE FLOW
D. S. DOLLING and J. C. NARLO, II *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 12 p Nov. 1987 Sponsored in part by NASA, Washington, D.C. and ONR, Washington, D.C.
(Contract AF-AFOSR-0112-86)
Avail: NTIS HC A24/MF A01 CSCL 01A

Wall pressure fluctuations were measured under the steady separation shock waves in Mach 5 turbulent interactions induced by unswept circular cylinders on a flat plate. The wall temperature was adiabatic. A conditional sampling algorithm was developed to examine the statistics of the shock wave motion. The same algorithm was used to examine data taken in earlier studies in the Princeton University Mach 3 blowdown tunnel. In these earlier studies, hemicylindrically blunted fins of different leading-edge diameters were tested in boundary layers which developed on the tunnel floor and on a flat plate. A description of the algorithm, the reasons why it was developed and the sensitivity of the results to the threshold settings, are discussed. The results from the algorithm, together with cross correlations and power spectral density estimates suggests that the shock motion is driven by the low-frequency unsteadiness of the downstream separated, vortical flow. Author

N88-13233*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NUMERICAL ANALYSIS OF FLOW THROUGH SCRAMJET ENGINE INLETS
AJAY KUMAR *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 11 p Nov. 1987
Avail: NTIS HC A24/MF A01 CSCL 01A

A set of computer programs was developed to analyze flow through supersonic combustion ramjet (scramjet) inlets. These programs solve either the two or three dimensional Euler/Navier-Stokes equations in full conservation form by MacCormack's explicit or explicit-implicit method. An algebraic two-layer eddy viscosity model is used for turbulent flow calculations. The programs are operational in Control Data CYBER-200 series vector-processing computer system and were optimized to take maximum advantage of the vector processing capability of the system. Since their development, the programs were extensively verified and used to analyze a number of very complex inlet configurations. Results are presented from two-dimensional, quasi-three-dimensional, and three-dimensional analyses of the inlet flow field to illustrate the use of the program. Author

N88-13234*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL SIMULATION OF THE HYPERSONIC FLOW AROUND LIFTING VEHICLES
YEHIA RIZK (Sterling Federal Systems, Inc., Palo Alto, Calif.), DENNY CHAUSSEE, and JOSEPH STEGER *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 11 p Nov. 1987
Previously announced as N87-22116
Avail: NTIS HC A24/MF A01 CSCL 01A

A method of solving the viscous hypersonic flow field around realistic configurations is presented. The numerical procedure for generating the required finite difference grid and the two-factored implicit flow solver are described. Results are presented for the shuttle orbiter and a generic wing-body configuration at hypersonic Mach numbers. Author

N88-13238# Glasgow Univ. (Scotland). Dept. of Aeronautics and Fluid Mechanics.
NUMERICAL EXPERIMENTS WITH HYPERSONIC FLOWS BENEATH A CONE-DELTA-WING COMBINATION
N. QIN and B. E. RICHARDS *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 14 p Nov. 1987
Avail: NTIS HC A24/MF A01

Numerical experiments of hypersonic flows beneath a cone-delta-wing combination were carried out by solving the compressible Navier-Stokes equations using an assumption of local conicity. An implicit method is combined with a multigrid scheme in the solution procedure to achieve fast convergence to the steady state. Detailed flow field results provide further insight into the complex flow structures due to interaction between the cone shock and the wing shock and the interaction of the resulting flow with the wing or cone boundary layer. Flow field pictures reveal phenomena of value in the design of hypersonic lifting vehicles, such as the interference surface pressure and the high local wall heating. Comparisons with experimental data and conical Euler solution are also made. Author

N88-13241# Imperial Coll. of Science and Technology, London (England). Dept. of Aeronautics.
COMPUTATION OF FLOW PAST CONICAL HYPERSONIC WINGS USING A SECOND ORDER GODUNOV METHOD
R. HILLIER *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 15 p Nov. 1987
Avail: NTIS HC A24/MF A01

Computations of inviscid hypersonic flow past flat plate delta wings during a second order Godunov-type scheme are presented. The governing equations are written in an unsteady conical form

and then time marched to a final conical steady state. The core of the calculation is a generalized Riemann problem which is used to determine the flux transfers at the interfaces between computational cells. Results are presented for wings with shock waves both attached at and detached from the leading edges. The leeward surface flows support embedded shock waves and separated vortex flows and the likely influence of real viscous effects on these is discussed. Author

N88-13243# Messerschmitt-Boelkow-Blohm G.m.b.H., Hamburg (West Germany). Unternehmensbereich Transport- und Verkehrsflugzeuge.
VORTEX FORMATION OVER DELTA, DOUBLE-DELTA AND WAVE RIDER CONFIGURATIONS AT SUPERSONIC SPEEDS
UWE GANZER and JOACHIM SZODRUCH *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 32 p Nov. 1987
Avail: NTIS HC A24/MF A01

The flow field of the thick delta wing at high subsonic and supersonic speeds was the subject of quite a variety of investigations at the Technical University of Berlin. The research work started as early as in the late 60's and is still going on today. It was triggered off by the initiatives of the late Dietrich Kuchemann-aiming at a hypersonic transport and it was taken as a contribution to the Eurohyp activities. The wing configurations investigated were of simple shape: delta wings with straight leading edges and triangular cross sections of different thicknesses. The interest was focussed on the development of the leeside flow with changes in angle of incidence and main stream Mach number. In addition to that similar delta wings with curved leading edges and also with a jump in leading edge sweep were investigated, as well as two types of wave riders. Besides some theoretical work mainly wind tunnel tests were made applying available test techniques: surface pressure measurements, Pitot measurements in the flow field, flow visualization by Schlieren, vapor and oilfilm techniques, skin friction determination using oilfilm interferrogramm and, finally, laser velocimetry. The experimental investigations were particularly challenging, because of the small models of generally not more than 6 cm span. This limitation arose from the small size of the transonic and supersonic wind tunnel. Author

N88-13246# *Southampton Univ. (England). Dept. of Aeronautics* and Astronautics.
HYPERSONIC STATIC AND DYNAMIC STABILITY OF AXISYMMETRIC SHAPES: A COMPARISON OF PREDICTION METHODS AND EXPERIMENT
R. A. EAST and G. R. HUTT *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 15 p Nov. 1987 Sponsored in part by Ministry of Defence, United Kingdom
Avail: NTIS HC A24/MF A01

The stability of oscillatory motions of vehicles flying at hypersonic Mach numbers is of considerable relevance to their initial design. Methods are needed for quick and accurate predictions of stability and control which are applicable over a wide range of body shapes, angles of attack, and flow conditions, without the need to resort to computationally time consuming numerical flow field calculation methods. Experimental data, obtained over a range of angles of attack, concerning the static and dynamic pitching stability of a wide range of both pointed and blunted axisymmetric shapes including cones and blunted cylinder flares are presented. Although Newtonian theory gives inadequate accuracy of prediction, inviscid embedded Newtonian theory, which accounts for the reduced dynamic pressure and lower flow velocity in the embedded flow downstream of the strong bow shock, is shown to provide surprisingly good agreement with the experimental data over a wide range of conditions. Comparisons with experimental results show that the broad flow features and their effect on static and dynamic stability are well described in regimes not containing flow structural change. However, in some cases discrepancies exist between the predictions and experimental observations and these were attributed to a variety of viscous flow phenomena involving boundary layer transition and flow separation, including complex lee-surface vortical flows. Author

N88-13249# British Aerospace Public Ltd. Co., Bristol (England). Aerodynamics Research Dept.
EXPERIENCES USING THE MARK IV SUPERSONIC HYPERSONIC ARBITRARY BODY PROGRAM
CARREN M. E. FISHER *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 18 p Nov. 1987
Avail: NTIS HC A24/MF A01

Work done during the last two years in an attempt to gain an understanding of, and to establish a capability for the use of, the Douglas Supersonic/Hypersonic Arbitrary Body Program (S/HABP) is described. This program has a complex structure and offers a large variety of aerodynamic prediction methods to solve many different types of problems. Most of the features of the program were used with success. Aspects of the flowfield routines and viscous options, which could not be utilized correctly, are either under investigation, or updates to the programming are awaited. Some accurate predictions were made using the inviscid pressure methods, which were evaluated for a wide range of configurations, for Mach numbers from 1.7 to 25.0 and from an incidence of -8 to 40 deg. The code was seen to be highly flexible, but the accuracy of the results is user dependent. Relative to computational fluid dynamics codes, S/HABP geometries are easy to prepare and the code is cheap to run. Author

N88-13253# National Aerospace Lab., Tokyo (Japan).
PROCEEDINGS OF THE 4TH NAL SYMPOSIUM ON AIRCRAFT COMPUTATIONAL AERODYNAMICS
Dec. 1986 308 p In ENGLISH and JAPANESE Symposium held in Tokyo, Japan, 19-20 Jun. 1986
(NAL-SP-7; ISSN-0452-2982) Avail: NTIS HC A14/MF A01

Thirty-six papers on computational fluid dynamics with aeronautical applications are presented.

N88-13254# National Aerospace Lab., Tokyo (Japan).
AN ANALYSIS OF THE COMPRESSIBLE-VISCOUS FLOW FIELD AROUND A 3D-OSCILLATING WING
JIRO NAKAMICHI and KOJI ISOGAI *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 1-11 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A 3D Navier-Stokes program based upon a Beam-Warming diagonalization scheme has been combined with a moving grid system so that it can be applied to the solution around an oscillating wing. The wing is in a pitching motion with an amplitude of 1 deg and a reduced frequency of 0.428 (based upon the root semichord). The free stream Mach number is 0.9 and the mean angle of attack of the wing is 4 deg. To the extent that results have been compared with experimental data, the unsteady flow is successfully simulated and the leading edge separations are observed, which is one of the most significant aspects of the experiment. It is demonstrated that the present code is feasible and applicable to the computation of the unsteady viscous compressible flow field around an oscillating wing. Author

N88-13255# Tokyo Univ. (Japan).
COMPUTATION OF DYNAMIC STALL OF NACA0012 AIRFOIL BY BLOCK PENTADIAGONAL MATRIX SCHEME
YOSHIFUMI SHIDA and KUNIO KAWAHARA *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 13-23 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

The flow field around an oscillating NACA0012 airfoil in pitch at 0.25 chord is analyzed by solving the two-dimensional compressible Navier-Stokes equations. A block pentadiagonal matrix scheme based on the approximate factorization method is adopted. Two meshes, 161 by 40 and 213 by 80, are used. With the coarse mesh, lift stall is captured. With the fine mesh, not only lift stall but also the restoration process of the lift coefficient in the downstroke is captured. Author

N88-13256# National Aerospace Lab., Tokyo (Japan).
NUMERICA CALCULATION IN THE LAPLACE DOMAIN FOR SUBSONIC UNSTEADY AERODYNAMIC FORCES ACTING ON A FINITE WING
TETSUHIKO UEDA *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 25-32 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A method of obtaining subsonic unsteady aerodynamic forces in the Laplace domain is presented. The kernel function of singular integral equations based on the lifting surface theory is numerically computed in the exact way for the entire s-plane. In an example calculation of the generalized forces, a singularity appears in the left half of the p-plane at a high Mach number of eight-tenths. It is shown that the singularity is a pole of the order one and that it can be modeled by a simple rational function which is relevant to the aeroelastic analysis. The theory of functions is utilized for obtaining the singularity model for the generalized forces. Author

N88-13257# Mitsubishi Heavy-Industries Ltd., Tokyo (Japan).
PRACTICAL APPLICATION OF TWO-DIMENSIONAL VISCOUS FLOW COMPUTATION
TAKESHI KAIDEN, JUNICHI MIYAKAWA, NAOKI HIROSE, and NOBUHIRO KAWAI (National Aerospace Lab., Tokyo, Japan) *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 33-38 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A validative discussion of the NSFOIL code (a high Reynolds number transonic airfoil analysis code) is presented in the region of low speed and high attack angle. The computational results are comapred with results of wind tunnel tests and the vortex method, which is a separated flow analysis method, to investigate the validity of the code and to further the development of future improvements. NSFOIL is found to be able to predict non-linear characteristics, in which conventional numerical methods are powerless. There is still some room for improvement to be able to calculate an exact stall angle. Author

N88-13258# Kawasaki Heavy Industries Ltd., Kagamihara (Japan).
A NUMERICAL INVESTIGATION ON WING/NACELLE INTERFERENCES
KEISUKE SAWADA and SUSUMU TAKANASHI (National Aerospace Lab., Tokyo, Japan) *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 39-44 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A numerical investigation of wing/nacelle interferences of upper surface blown (USB) configuration was carried out. A grid system about the realistic configuration of wing/nacelle combination was generated by the multi-block grid generation technique. The Euler equations were solved by the second order accurate upwind scheme. Results were obtained for M sub infinity = 0.7, alpha = 2.0. The existence of channel flows accompanied by strong shock between two engine nacelles was confirmed. Power effects of two engines were examined by modeling both the plane of intake and that of jet exhaust appropriately. Author

N88-13259# Kawasaki Heavy Industries Ltd., Kagamihara (Japan).
THE ROLE OF COMPUTATION FLUID DYNAMICS IN AERONAUTICAL ENGINEERING (4). THE DEVELOPMENT AND APPLICATIONS OF IMPLICIT TVD FINITE VOLUME CODE
EIJI SHIMA and TADAMASA JOUNOUCHI *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 45-51 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

An implicit total variation diminishing (TVD) finite volume code was developed. This code applies to van Leer's flux splitting, the Diagonalized Lower/Upper block diagonal Alternating Direction Implicit (LU-ADI) factored algorithm, TVD formulation using characteristic variables and the smooth limiter. The code is more robust and gives sharper shock profile than the conventional central difference scheme, while it takes nearly as much CPU time/step as the Beam-Warming scheme. The computed results are shown for: (1) transonic viscous flow about a NACA0012 airfoil; (2) supersonic inviscid flow about a two-dimensional air intake; and (3) supersonic inviscid flow about an axisymmetric blunt body. Author

N88-13261# Kyoto Univ. (Japan).
NUMERICAL CALCULATIONS OF THE FLOWFIELD AROUND PROPELLERS
MAKOTO KOBAYAKAWA, HIROYUKI ONUMA, and YASUHIRO SHIOTA (Toyota Motor Co., Tokyo, Japan) *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 61-69 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

In order to examine the flow field around ATP by numerical calculations, the finite difference method is applied. First, the partial differential equation for the disturbance velocity potential is solved by the line relaxation technique. In order to do the calculations, boundary fitted meshes are generated. The transformations between physical and computational space are performed by chain rule. The SR-3 is used for numerical calculations. In the second part of the paper, the Euler equations are solved by non-iterative Alternating Direction Implicit (ADI) schemes in AF algorithm. Boundary fitted meshes are also used for this case. The results show qualitative agreement with the results obtained by Bober et al. Finally, the aerodynamic performances, such as power coefficients and efficiencies, are obtained. Potential calculations show that these quantities are relatively larger than the experimental values obtained by NASA; however, Euler solutions show that the values come closer to the experimental values. Author

N88-13262# National Aerospace Lab., Tokyo (Japan).
NUMERICAL ANALYSIS OF CASCADE FLOW SOLVING NAVIER-STOKES EQUATIONS
OSAMU NOZAKI, NAOKI HIROSE, NOBUHIRO KAWAI, and ATSUHIRO TAMURA *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 71-75 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

Numerical analysis based on Navier-Stokes equations was carried out for high Reynolds number flow through two-dimensional cascades using the initial approach fix (IAF) scheme. An algebraic eddy viscosity model of the turbulent boundary layer was used. To make fine orthogonal grids on inner and outer boundaries, C-type grids are generated around a cascade by solving Poisson's equations which have inhomogeneous terms. Several results have been obtained for a compressor and FJR turbine. These results show good agreement with experimental data. Author

N88-13266# Mitsubisi Electric Corp., Tokyo (Japan).
NUMERICAL ANALYSIS OF SUPERSONIC FLOWS USING PANEL METHOD
YUICHI MARUYAMA, SADAO AKISHITA, and AKIHITO NAKAMURA (Mitsubishi Space Software Corp., Japan) *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 99-106 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

Steady supersonic linearized potential flows about two types of wings and a wing-body configuration were simulated using the panel method program MARCAP. Linearly varying doublet distribution is adopted to ensure the continuity of the strength on panel edges, while constant distribution on each panel is used for source. Morino's scheme is employed for most cases. The velocity boundary condition scheme is also applied to some cases. The results show good agreement with analytical solutions and wind tunnel testings. The computation time is within a reasonable limit,

and the program size is comparable to those of panel methods for incompressible or subsonic flows. Author

N88-13267# Fuji Heavy Industries Ltd., Utsunomiya (Japan).
COMPUTATION OF NACELLE INTERFERENCE USING BOUNDARY ELEMENT METHOD
MASAAKI NAKADATE, HIDEFUMI NAGASHIMA, and MITSUNORI YANAGIZAWA (National Aerospace Lab., Tokyo, Japan) *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 107-120 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

The aerodynamic interference problem of jet transport aircraft due to the close coupling between nacelle and wing is one of the major concerns of aerdynamic engineers. At the research level, the Navier-Stokes code is beginning to be applied to such a problem. At the engineering level the application of the panel method is more practical. This paper presents the results of applying the Boundary Element Method code to the analysis of nacelle interference of a practical jet transport configuration. Correlation between calculated and tested results is also presented. Author

N88-13268# National Aerospace Lab., Tokyo (Japan).
APPLICATION OF DISCRETE VORTEX METHOD TO ANALYSIS OF SEPARATED FLOW AROUND AEROFOILS
MASASHI SHIGEMI *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 121-128 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

The discrete vortex method was applied to the calculation of the separated flow around aerofoils. A new approach was formulated, in which the strength of the vortex, which is shed off at the separation point, was included in the unknown variables. In order to save computational cost, simplifications were introduced in the formulation, e.g., clusters of the drifting vortices were treated as concentrated single vortices. Because the total pressure in the separated region is less than that in the other region, the pressure distribution around the aerofoil, which is obtained from the velocity distribution through the Bernoulli formula, has to be evaluated individually for the non-separated and separated regions. To define the relativity between the two pressure distributions, a method of estimating the amount of the total pressure loss in the separated region was introduced. The Blasius formula, which is generally used to derive the forces acting on an obstacle, was modified to include the influence of the total pressure loss upon the lift and the drag forces. Author

N88-13273# National Aerospace Lab., Tokyo (Japan).
RAREFIED GAS NUMERICAL WIND TUNNEL. 2: TWO-DIMENSIONAL AND AXIALLY SYMMETRIC BODIES
KATSUHISA KOURA *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 159-164 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A rarefied-gas numerical wind tunnel is being developed in order to simulate the rarefied gas flows around space vehicles such as the AOTV and the space plane. The null-collision (NC) technique, which Koura recently introduced into the direct-simulation Monte Carlo method, is used. The NC technique overcomes the principal fault in the time-counter (TC) technique and the difficulties in the collision-frequency (CF) technique and, moreover, the computation time required for the NC technique is comparable to that for the TC technique. The elastic collisions between molecules are taken to be the energy-dependent hard sphere model. The gas-surface interactions are taken to be the Maxwell reflection model. It is confirmed that the numerical wind tunnel works well for two-dimensional and axially symmetric bodies. Author

N88-13279*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A PERSPECTIVE OF COMPUTATIONAL FLUID DYNAMICS
PAUL KUTLER *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 203-213 Dec. 1986 Previously announced as N86-28057
Avail: NTIS HC A14/MF A01 CSCL 01A

Computational fluid dynamics (CFD) is maturing, and is at a stage in its technological life cycle where it is now routinely applied to complex problems. It is starting to create an impact on the design cycle of aerospace flight vehicles and their components. CFD is also being used to better understand the fluid physics of flows heretofore not understood, such as three-dimensional separation. CFD is also being used to complement and is complemented by experiments. In this paper, the primary and secondary pacing items that have governed CFD in the past are reviewed and updated. The future prospects of CFD are explored, which will offer people working in the discipline challenges that should extend the technological life cycle to further increase the capabilities of a proven and demonstrated technology. Author

N88-13286# National Aerospace Lab., Tokyo (Japan).
NAVIER-STOKES ANALYSIS OF LAMINAR FLOW CONTROL OF A TWO-DIMENSIONAL AIRFOIL
NOBUHIRO KAWAI, NAOKI HIROSE, and YOJI ISHIDA *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 277-280 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A numerical analysis method for laminar flow control (LFC) based on the Navier-Stokes equations is presented. Suction over the airfoil surfaces is formulated as the velocity boundary condition of the Navier-Stokes solver which uses the implicit approximate factorization scheme. As examples, the present method for LFC was applied to the NACA0012 airfoil at Mach numbers of 0.2 and 0.75. Computational results show that appropriate suction distribution brings about a large amount of recession of the boundary-layer transition point and a great deal of drag reduction. Author

N88-13288# National Aerospace Lab., Tokyo (Japan).
NAVIER-STOKES SIMULATION OF TRANSONIC TRANSPORTATION AIRCRAFT CONFIGURATIONS. 1: FLOW-FIELD SIMULATION OVER WING-FUSELAGE COMBINATIONS
KOZO FUJII, SUSUMU TAKANASHI, and SHIGERU OBAYASHI (Tokyo Univ., Japan) *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 289-298 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

Viscous transonic flow-field simulations over wing-fuselage combinations were carried out using three-dimensional Reynolds averaged Navier-Stokes equations. the Lower/Upper block diagonal Alternating Direction Implicit (LU-ADI) factorization scheme was used with an implementation of new nonlinear smoothing terms. The computations were done for a practical wing-fuselage combination called W-18 which was designed for the transonic transportation aircraft. The computed results reveal the effect of the existence of the fuselage near the junction of wing and fuselage. Each computation currently requires several hours of computer time, which is, however, quite reasonable when considering the number of grid points to be used for this study. The results indicate that the application of the present Navier-Stokes solution code to the complete aircraft geometries is quite promising. Author

N88-13289# Mitsubishi Heavy-Industries Ltd., Tokyo (Japan).
NUMERICAL SIMULATION OF TRANSONIC AIRCRAFT IN COMPARISON TO WIND TUNNEL TEST
JUNICHI MIYAKAWA, SUSUMU TAKANASHI, KOZO FUJII, and KANICHI AMANO (Japan Aircraft Development Corp., Tokyo.) *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 299-315 Dec. 1986
In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

Computational aerodynamics has evolved to the point where it has become a practical design tool comparable to wind tunnel testing and has played an important role in actual aircraft design stages. The Navier-Stokes code, however, is still restricted to two-dimensional applications, which have been repeatedly validated. The three-dimensional application, which is a real challenge for the Navier-Stokes code, is discussed. If this three-dimensional application could be perfected, it would be a big step toward the final target of complete aircraft analysis by numerical simulation. Author

N88-13290*# *National Aeronautics and Space Administration.* Ames Research Center, Moffett Field, Calif.
TIP AERODYNAMICS FROM WIND TUNNEL TEST OF SEMI-SPAN WING
JOHANNES M. VANAKEN (Kansas Univ. Center for Research, Inc., Lawrence.) and ROBERT H. STROUB Sep. 1986 19 p
(NASA-TM-88253; A-86247; NAS 1.15:88253) Avail: NTIS HC A03/MF A01 CSCL 01A

Presented are the results of a low-speed wind tunnel test on a 5.33-aspect-ratio, semi-span wing with 30- and 35 deg swept tapered tips. The test results include aerodynamic data for the tip itself and for the entire wing including the tip. The metric tip extended inboard 1.58 wing chord lengths. The aerodynamic drag data show the strong influence of tip incidence angle on tip drag for various lift levels. Pitching-moment characteristics show the effect of a moment center at 0.13 c and 0.25 c. Author

N88-13291*# Scientific Research Associates, Inc., Glastonbury, Conn.
CALCULATION OF HELICOPTER ROTOR BLADE/VORTEX INTERACTION BY NAVIER-STOKES PROCEDURES Final Report
Y.-N. KIM, S. J. SHAMROTH, and R. C. BUGGELN Apr. 1987 38 p
(Contract NAS2-12363)
(NASA-CR-177441; NAS 1.26:177441) Avail: NTIS HC A03/MF A01 CSCL 01A

Interactions of a modern rotor blade with concentrated tip vortices from the previous blades can have a significant influence on the airloads and the aeroacoustics of a helicopter. A better understanding of the blade/vortex interaction process and a method of analyzing its flow field would provide valuable help in the design of helicopters. The work discussed herein represents an initial effort in applying a 3-D, time-dependent Navier-Stokes simulation to the blade vortex interaction problem. The numerical approach is the Linearized Block Implicit (LBI) technique. In this initial effort, consideration is given to the interaction of a wing of idealized geometry and a vortex whose axis is aligned at an arbitrary angle to the wing. The calculations are made for laminar, subsonic flow, and show the time dependent pressure distribution and flow fields resulting from the interaction. Author

N88-13292*# Vigyan Research Associates, Inc., Hampton, Va.
A SWEPT WING PANEL IN A LOW SPEED FLEXIBLE WALLED TEST SECTION Interim Report
M. J. GOODYER Dec. 1987 20 p
(Contract NAS1-17919)
(NASA-CR-4106; NAS 1.26:4106) Avail: NTIS HC A03/MF A01 CSCL 01A

The testing of two-dimensional airfoil sections in adaptive wall tunnels is relatively widespread and has become routine at all speeds up to transonic. In contrast, the experience with the three-dimensional testing of swept panels in adaptive wall test sections is very limited, except for some activity in the 1940's at NPL, London. The current interest in testing swept wing panels led to the work covered by this report, which describes the design of an adaptive-wall swept-wing test section for a low speed wind tunnel and gives test results for a wing panel swept at 40 deg. The test section has rigid flat sidewalls supporting the panel, and features flexible top and bottom wall with ribs swept at the same angle as the wing. When streamlined, the walls form waves swept at the same angle as the wing. The C sub L (-) curve for the swept wing, determined from its pressure distributions taken with the walls streamlined, compare well with reference data which was taken on the same model, unswept, in a test section deep enough to avoid wall interference. Author

N88-13293# Naval Postgraduate School, Monterey, Calif.
THE DEVELOPMENT OF A COMPUTER CODE (U2DIIF) FOR THE NUMERICAL SOLUTION OF UNSTEADY, INVISCID AND INCOMPRESSIBLE FLOW OVER AN AIRFOIL M.S. Thesis
NGAI-HUAT TENG Jun. 1987 236 p
(AD-A185033) Avail: NTIS HC A11/MF A01 CSCL 20D

A numerical technique is formulated, in a computer program U2DIIF, for the solution of flow over an airfoil executing an arbitrary unsteady motion in an inviscid and incompressible medium. The technique extends the well known Panel Methods for steady flow into solving a non-linear unsteady flow problem arising from the continuous vortex shedding into the trailing wake due to the unsteady motion of the airfoil. Numerous case-runs are presented to verify U2DIIF computer code against other theoretical and/or numerical methods as well as in cases where limited experimental data are obtainable in literatures. These case-runs include airfoils undergoing a step change or a modified ramp change of angle-of-attack, airfoils executing harmonic oscillation in pitching and plunging motions and airfoils penetrating a sharp edge gust.
Author (GRA)

N88-13296# Centre d'Etudes Aerodynamiques et Thermiques, Poitiers (France).
STUDY OF THE EFFECT OF MASS TRANSFER ON A TRANSONIC BOUNDARY LAYER. APPLICATION TO FLOW RELAMINARIZATION Final Report [ETUDE DE L'EFFET DU TRANSFERT DE MASSE SUR UNE COUCHE LIMITE TRANSONIQUE. APPLICATION A LA RELAMINARISATION]
R. LEBLANC, A. STASSINOPOULOS, and A. ELOUATOUATI May 1987 45 p In FRENCH
(Contract DRET-85-1414)
(ETN-88-91169) Avail: NTIS HC A03/MF A01

The relaminarization of delta wings in transonic flow is discussed. The transition over a flat plate was studied in a wind tunnel, including analysis of the effects of aspiration on separated flow. The results allows computation with good accuracy a laminar transonic boundary layer. The effects of slots are discussed.
ESA

N88-13298# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Aerodynamique.
DELTA WING IN INCOMPRESSIBLE FLOW. EXPERIMENTAL STUDY IN F2 [AILE DELTA EN ECOULEMENT INCOMPRESSIBLE. ETUDE EXPERIMENTALE A F2]
P. MOLTON Dec. 1986 62 p In FRENCH
(ONERA-RT-36/1147-AN-249-G; ETN-88-91180) Avail: NTIS HC A04/MF A01

Wind tunnel tests were performed using 22 mm thick steel delta wing models. The measuring system includes 252 air intakes distributed over both wing surfaces and two-component laser velocimeters. Velocities from 10 to 70 m/sec and incident angles from 5 to 30 deg were used. The position of the laminar to turbulent transition is characterized. At large incidences (20 deg) the secondary vortices are strong enough to induce a third separation of the boundary layer. The vortices after separation are studied, showing that the main vortex presents a conical distribution which is not affected by the nature of the boundary layers, while the secondary vortex is larger and continues to evolve after transition. ESA

N88-13299# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
VALIDATION ELEMENTS OF THE COMPUTATION METHODS AND MEASUREMENT TECHNIQUES FOR HIGH LIFT AERODYNAMIC SYSTEMS [ELEMENTS DE VALIDATION DES TECHNIQUES DE MESURE ET DES METHODES DE CALCUL EN AERODYNAMIQUE DES SYSTEMES HYPERSUSTENTES]
P. CAPBERN 1987 31 p In FRENCH; ENGLISH summary
(SNIAS-872-111-101; ETN-88-91184) Avail: NTIS HC A03/MF A01

Problems raised by the prediction of the lift and drag coefficients in a high lift system are discussed. The analysis is restricted to two dimensional flow and incompressible subsonic conditions. Cases of single slotted and double slotted flap systems are studied. Wake-drag measurements were carried out in wind tunnel tests. The results validate the ONERA two dimensional strong interaction method for multielement configurations, but improvements are deemed necessary. ESA

N88-13300# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
COMPUTATION OF TRANSONIC FLOWS WITH NACELLE SIMULATION
Y. VIGNERON, T. LEJAL, and R. COLLERCANDY 1987 34 p
(SNIAS-872-111-117; ETN-88-91198) Avail: NTIS HC A03/MF A01

A method to solve the potential flow equations on an unstructured grid was developed, and tested on a civil aircraft configuration. The basic configuration represents a twin engine aircraft: fuselage + wings + struts + nacelles. The mass flow through the fan is imposed and the exhaust plume is frozen. The grid has 24,558 nodes, of which 1680 are on the surface. The code requires 1 Mwords of central memory, 1050 sec CPU time to reduce the average nonlinear residual by 6 orders of magnitude. Engineering accuracy is obtained in half this time. Configurations of wings + struts + nacelles, wing + nacelles, wing alone are also treated. Surface grids and Mach number contours, focusing on the strut and the nacelle; and pressure distribution on the wing at two stations immediately in board and out board of the strut location are shown. The number of grid points used is not sufficient for a detailed resolution of the flow fields. However the basic trends are predicted correctly, notably the influence of the fuselage and the strut. ESA

N88-13301# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
COMPUTATION OF RIME ICE ACCRETION ON AIRFOILS
STAFFAN MEIJER May 1987 15 p Sponsored by National Swedish Board for Technical Development
(FFA-TN-1987-08; ETN-88-91392) Avail: NTIS HC A03/MF A01

A method to calculate rime ice accretion on airfoils is described. The flow field is calculated using incompressible potential theory. In the trajectory equation only the drag and gravity forces acting on the water droplets are retained. The ice accretion is calculated assuming that all droplets freeze at their points of impact and that the ice grows in a direction normal to the surface. Results from two calculations for single airfoils are compared with previous results. Rime ice accretion is also calculated for a two-dimensional high lift wing consisting of a basic wing profile, based on NACA 65-215, a leading edge slat, a trailing edge vane, and a trailing edge flap. Accuracy of the calculated droplet impact points decreases for trajectories that are very close to the airfoil surface for a long time. ESA

N88-13302# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
LOW SPEED WIND TUNNEL INVESTIGATION OF PROPELLER SLIPSTREAM AERODYNAMIC EFFECTS ON DIFFERENT NACELLE/WING COMBINATIONS. PART 1: TOTAL FORCES AND MOMENTS AND PRESSURE DISTRIBUTIONS ON NACELLE/WING AT DIFFERENT ANGLES OF ATTACK AND YAW AND AT DIFFERENT THRUST COEFFICIENTS
INGEMAR SAMUELSSON 18 Jun. 1987 74 p Sponsored by Swedish Board for Technical Devolopment
(FFA-TN-1987-22; ETN-88-91393) Avail: NTIS HC A04/MF A01

A wind tunnel investigation of propeller slipstream/nacelle/wing aerodynamic interference effects was carried out for 4 nacelle/wing combinations, with different angles of attack and yaw, freestream speeds (33 to 61 m/sec) and thrust coefficients (CF: 0.05 to 0.57). Results show significant propeller slipstream induced lateral nacelle loads (side force, yawing moment, and rolling moment). For an axisymmetrical nacelle (wing/off) set at incidence at zero yaw, the cyclic thrust variation on the propeller blades creates an asymmetrical pressure field in the slipstream. When this asymmetrical slipstream washes the nacelle surfaces there are lateral loads acting on the nacelle. For an nonaxisymmetrical (high) nacelle lateral nacelle loads develop even at zero incidence and zero yaw, due to asymmetrical interference between the propeller swirl, slipstream, and pressure field and the nacelle surfaces. There are also significant effects of CF on the development of the lateral nacelle loads. ESA

N88-13303# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
COMPRESSIBLE EULER SOLUTION ON A MULTIBLOCK GRID AROUND A WING-FUSELAGE CONFIGURATION
TORSTEN BERGLIND 27 Jul. 1987 29 p
(Contract FMK-F-K-82260-84-254-73-001)
(FFA-TN-1987-46; ETN-88-91394) Avail: NTIS HC A03/MF A01

A patched multiblock grid around a wing-fuselage configuration was constructed by transfinite interpolation. The wing is enveloped by an 0-0 type of grid with parabolic singularities at the wing tip, and the fuselage is enveloped by an 0-0 type of grid with polar singularities at the nose and the tail, with a slit for the wing grid. This grid is divided into eight computational blocks, so that each coordinate side of a block has one type of boundary condition. A finite volume Euler solver using explicit Runge-Kutta time stepping was coded to handle general multi-block structures. The flow over the 65 deg round leading edge delta wing with a fuselage, at 10 deg angle of attack, and at a free stream Mach number of 0.85 was computed. Results show the capability of the method and the simplicity of the topology input description. ESA

N88-13304*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AUTOMATED DESIGN OF CONTROLLED DIFFUSION BLADES
JOSE M. SANZ 1987 15 p Prepared for presentation at the 33rd International Gas Turbine and Aero-Engine Congress and Exposition, Amsterdam, The Netherlands, 5-9 Jun. 1988
(NASA-TM-100251; E-3877; NAS 1.15:100251) Avail: NTIS HC A03/MF A01 CSCL 01A

A numerical automation procedure has been developed to be used in conjunction with an inverse hodograph method for the design of controlled diffusion blades. With this procedure a cascade of airfoils with a prescribed solidity, inlet Mach number, inlet air flow angle, and air flow turning can be produced automatically. The trailing edge thickness of the airfoil, an important quantity in inverse methods, is also prescribed. The automation procedure consists of a multidimensional Newton iteration in which the objective design conditions are achieved by acting on the hodograph input parameters of the underlying inverse code. The method, although more general in scope, is applied in this paper to the design of axial flow compressor blade sections, and a wide range of examples is presented. Author

N88-13305*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN EXPERIMENTAL INVESTIGATION OF THE AERODYNAMICS OF A NACA 64A010 AIRFOIL-FLAP COMBINATION WITH AND WITHOUT FLAP OSCILLATIONS. PART 1: STEADY-STATE CHARACTERISTICS
DONALD A. BUELL and GERALD N. MALCOLM Jul. 1986 68 p
(NASA-TM-88217; A-86140; NAS 1.15:88217) Avail: NTIS HC A04/MF A01 CSCL 01A

A NACA 64A010 airfoil with a sealed-gap 1/4-chord flap was tested between splitter plates in the NASA Ames 11- by 11-Foot Transonic Wind Tunnel at Mach numbers from 0.50 to 0.85, and Reynolds numbers based on chord from 3 to 13 million. Although the main purpose of the test was to obtain unsteady pressure data with the flap oscillating, no unsteady data are presented in this paper. The steady-state data are presented and compared with other test data to provide a basis for evaluating the results. Pressure data at two span stations are used to deduce early boundary-layer transitions at the midspan at higher Mach numbers, angles of attack, and flap angles. The effects of flap angle on pressures, normal force, pitching moment, and hinge moment are also presented in the report. Mach number errors caused by the splitter-plate configuration and the angle of attack are evaluated using pressure measurements near the floor and ceiling of the wind tunnel. Author

N88-14068*# Northrop Corp., Hawthorne, Calif. Aircraft Div.
INTEGRATION OF A SUPERSONIC UNSTEADY AERODYNAMIC CODE INTO THE NASA FASTEX SYSTEM Final Report
KARI APPA and MICHAEL J. C. SMITH Dec. 1987 42 p
(Contract NAS2-12597)
(NASA-CR-182329; NAS 1.26:182329) Avail: NTIS HC A03/MF A01 CSCL 01A

A supersonic unsteady aerodynamic loads prediction method based on the constant pressure method was integrated into the NASA FASTEX system. The updated FASTEX code can be employed for aeroelastic analyses in subsonic and supersonic flow regimes. A brief description of the supersonic constant pressure panel method, as applied to lifting surfaces and body configurations, is followed by a documentation of updates required to incorporate this method in the FASTEX code. Test cases showing correlations of predicted pressure distributions, flutter solutions, and stability derivatives with available data are reported. Author

N88-14069# Sandia National Labs., Albuquerque, N. Mex.
DUCTED PROPELLER DESIGN AND ANALYSIS
R. J. WEIR Oct. 1987 60 p
(Contract DE-AC04-76DP-00789)
(DE88-001925; SAND-87-2118) Avail: NTIS HC A04/MF A01

The theory and implementation of the design of a ducted propeller blade are presented and discussed. Straightener (anti-torque) vane design is also discussed. Comparisons are made to an existing propeller design and the results and performance of two example propeller blades are given. The inflow velocity at the propeller plane is given special attention and two dimensionless parameters independent of RPM are discussed. Errors in off-design performance are also investigated. DOE

N88-14070*# Texas Univ., Austin. Dept. of Mechanical Engineering.
POTENTIAL FLOW AROUND TWO-DIMENSIONAL AIRFOILS USING A SINGULAR INTEGRAL METHOD Final Report
YVES NGUYEN and DENNIS WILSON Dec. 1987 129 p
(Contract NAG1-556)
(NASA-CR-182345; NAS 1.26:182345; REPT-87-104) Avail: NTIS HC A07/MF A01 CSCL 01A

The problem of potential flow around two-dimensional airfoils is solved by using a new singular integral method. The potential flow equations for incompressible potential flow are written in a singular integral equation. The equation is solved at N collocation points on the airfoil surface. A unique feature of this method is that the airfoil geometry is specified as an independent variable in the exact integral equation. Compared to other numerical methods, the present calculation procedure is much simpler and gives remarkable accuracy for many body shapes. An advantage of the present method is that it allows the inverse design calculation and the results are extremely accurate. Author

N88-14073 Stanford Univ., Calif.
TRANSONIC NAVIER-STOKES COMPUTATIONS OF STRAKE-GENERATED VORTEX INTERACTIONS FOR A FIGHTER-LIKE CONFIGURATION Ph.D. Thesis
STEVEN GERARD RESNICK 1987 174 p
Avail: Univ. Microfilms Order No. DA8720426

Transonic Euler/Navier-Stokes computations are accomplished for wing-body flow fields using a computer program called Transonic Navier-Stokes (TNS). The wing-body grids are generated using a program called ZONER, which subdivides a coarse grid about a fighter-like aircraft configuration into smaller zones, which are tailored to local grid requirements. These zones can be either finely clustered for capture of viscous effects, or coarsely clustered for inviscid portions of the flow field. Different equation sets may be solved in the different zone types. This modular approach also affords the opportunity to modify a local region of the grid without recomputing the global grid. This capability speeds up the design optimization process when quick modifications to the geometry definition are desired. The solution algorithm embodied in TNS is implicit, and is capable of capturing pressure gradients associated with shocks. The algebraic turbulence model employed has proven adequate for viscous interactions with moderate separation. Boundary conditions are treated explicitly with some necessary restrictions on the solution domain. Proof of concept was demonstrated with solutions for a General Dynamics F-16A-like configuration. The results confirm that the TNS program can successfully be used to simulate transonic viscous flows about complicated three-dimensional geometries. Dissert. Abstr.

N88-14074 Old Dominion Univ., Norfolk, Va.
INVESTIGATION OF VISCOUS/INVISCID INTERACTION IN TRANSONIC FLOW OVER AIRFOILS WITH SUCTION Ph.D. Thesis
CHANDRA SEKHAR VEMURU 1986 126 p
Avail: Univ. Microfilms Order No. DA8719143

The viscous/inviscid interaction over transonic airfoils with and without suction is studied. The streamline angle at the edge of the boundary layer is used to couple the viscous and inviscid flow field. In the shock region the Euler equations are solved using the method of integral relations. For this the potential flow solution is used as the initial and boundary conditions. An integral method is used to solve the laminar boundary layer equations. Since both methods are integral methods, a continuous interaction is allowed between the outer inviscid flow region and the inner viscous flow region. The results are found to be in good agreement with experimental data and with the results of other computational methods. Dissert. Abstr.

N88-14075*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
DEVELOPMENT OF AN UNSTEADY WAKE THEORY APPROPRIATE FOR AEROELASTIC ANALYSES OF ROTORS IN HOVER AND FORWARD FLIGHT Semiannual Status Report No. 1, 1 Jul. - 31 Dec. 1987
DAVID A. PETERS 4 Jan. 1988 32 p
(Contract NAG2-462)
(NASA-CR-182357; NAS 1.26:182357) Avail: NTIS HC A03/MF A01 CSCL 01A

The purpose of this research is the development of an unsteady aerodynamic model for rotors such that it can be used in conventional aeroelastic analysis (e.g., eigenvalue determination and control system design). For this to happen, the model must be in a state-space formulation such that the states of the flow can be defined, calculated and identified as part of the analysis. The fluid mechanics of the problem is given by a closed-form inversion of an acceleration potential. The result is a set of first-order differential equations in time for the unknown flow

coefficients. These equations are hierarchical in the sense that they may be truncated at any number of radial or azimuthal terms. Author

N88-14078*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND TUNNEL RESULTS FOR A HIGH-SPEED, NATURAL LAMINAR-FLOW AIRFOIL DESIGNED FOR GENERAL AVIATION AIRCRAFT
WILLIAM G. SEWALL, ROBERT J. MCGHEE, JEFFERY K. VIKEN, EDGAR G. WAGGONER, BETTY S. WALKER, and BETTY F. MILLARD Nov. 1985 73 p
(NASA-TM-87602; NAS 1.15:87602) Avail: NTIS HC A04/MF A01 CSCL 01A

Two dimensional wind tunnel tests were conducted on a high speed natural laminar flow airfoil in both the Langley 6 x 28 inch Transonic Tunnel and the Langley Low Turbulence Pressure Tunnel. The test conditions consisted of Mach numbers ranging from 0.10 to 0.77 and Reynolds numbers ranging from 3 x 1 million to 11 x 1 million. The airfoil was designed for a lift coefficient of 0.20 at a Mach number of 0.70 and Reynolds number of 11 x 1 million. At these conditions, laminar flow would extend back to 50 percent chord of the upper surface and 70 percent chord of the lower surface. Low speed results were also obtained with a 0.20 chord trailing edge split flap deflected 60 deg. Author

N88-14079*# Rockwell International Corp., Los Angeles, Calif. North American Aircraft Operations.
NONLINEAR AERODYNAMIC WING DESIGN Final Report
ELLWOOD BONNER Washington NASA Dec. 1985 78 p
(Contract NAS1-15820)
(NASA-CR-3950; NAS 1.26:3950) Avail: NTIS HC A05/MF A01 CSCL 01A

The applicability of new nonlinear theoretical techniques is demonstrated for supersonic wing design. The new technology was utilized to define outboard panels for an existing advanced tactical fighter model. Mach 1.6 maneuver point design and multi-operating point compromise surfaces were developed and tested. High aerodynamic efficiency was achieved at the design conditions. A corollary result was that only modest supersonic penalties were incurred to meet multiple aerodynamic requirements. The nonlinear potential analysis of a practical configuration arrangement correlated well with experimental data. Author

N88-14081# Virginia Polytechnic Inst. and State Univ., Blacksburg. Center for Turbomachinery and Propulsion Research.
POST STALL BEHAVIOR IN AXIAL-FLOW COMPRESSORS Final Report, Mar. 1983 - Jan. 1987
WALTER F. OBRIEN 20 Aug. 1987 67 p
(Contract F49620-83-K-0024)
(AD-A185712; WFOB/87-0801; AFOSR-87-1195TR) Avail: NTIS HC A04/MF A01 CSCL 20D

A multi-element research program was conducted to improve understanding of the role of cascade losses in compressor post-stall behavior. Experiments in a special wind tunnel designed for high-angle-of-attack investigations included surface and smoke flow visualizations and hot film anemometer velocity measurements. Results showed the details of the stall development in a cascade, and the effect of stagger on measured flow losses. Predictions of a Navier-Stokes model for separated cascade flows were compared with experimental results. An improved compressor stage model predicts post-stall characteristics, and illustrates the application of the results to compression system analysis. GRA

N88-14139# Joint Publications Research Service, Arlington, Va.
DEVELOPMENT OF TRANSONIC SPEED CASCADE DESIGN METHOD USING EULER CODE AND INVERSE SOLUTION
NAOKI YOKOSE *In its* JPRS Report: Science and Technology. Japan p 65-71 6 Oct. 1987 Transl. into ENGLISH from Kogiken Nyusu (Tokyo, Japan), May 1987 p 12-14
Avail: NTIS HC A06/MF A01

In the past, computed aerodynamics have been made useful for aerospace technology. Recently, with numerical simulators in full scale operation, practical and useful improvements in analysis and design codes as aerodynamic tools are becoming more rapid. A great advantage has been gained by using computed aerodynamics technology which was developed for transonic blade design and analysis. A NSCAS code, improving and expanding the high Reynolds number transonic Navier-Stokes analysis code NSFOIL, was created and an analysis of the transonic buffet of compressor blades was realized. It is estimated that the WINDES, which realizes a designated pressure distribution as desired, can be applied to cascades, and a design was attempted combining it with a transonic cascade analysis code created by a quick adjustment to the transonic obtuse physical object EULER analysis code. Afterwards, upon completing the structure of a rigid design theory for cascades, a grid mesh creation code capable of easily handling actual turboprop blades, compressors, and turbine blades, was developed. Development of a full scale cascade design method was conducted and good results were obtained. Author

N88-14371# Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec).
AERODYNAMIC TESTING OF SMALL TURBINES
U. OKAPUU *In* Von Karman Inst. for Fluid Dynamics, Small High Pressure Ratio Turbines 20 p 1987
Avail: NTIS HC A17/MF A01

A cold flow turbine rig test section was designed to simulate prototype engine inlet and outlet gas paths. A turbulence generator is incorporated at gas inlet. Second stage turbines can be tested with first stage turbines in front of them to establish the appropriate inlet conditions. Experience indicates that major differences in absolute values of measured efficiency are caused by leakages and unfavorable steps in the gas paths in the engine, and differences in tip clearance. ESA

03

AIR TRANSPORTATION AND SAFETY

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

A88-18298
AALPS - A KNOWLEDGE-BASED SYSTEM FOR AIRCRAFT LOADING
DEBRA ANDERSON and CHARLES ORTIZ (SRI International, Menlo Park, CA) IEEE Expert (ISSN 0885-9000), vol. 2, Winter 1987, p. 71-79. DARPA-supported research. refs
(Contract MDA903-84-C-0261)

The complex set of constraints driving the automated air load planning system (AALPS) planning function is described. The system's development is traced and a review is given of the problem representation and reasoning methods used. By automatically generating valid cargo loads, AALPS assists transportation officers in their day-to-day planning for mission contingencies as well as for real-time load planning at the airfield. K.K.

A88-19339
AIRCRAFT FLIGHT SAFETY: THEORY AND ANALYSIS [BEZOPASNOST' POLETOV LETATEL'NYKH APPARATOV: TEORIIA I ANALIZ]
VASILII IVANOVICH ZHULEV and VLADIMIR SERGEEVICH IVANOV Moscow, Izdatel'stvo Transport, 1986, 224 p. In Russian. refs

Methods for the scientific investigation of flight-safety problems are examined. Particular consideration is given to flight-safety indices, models for pilot actions in special situations, analytical and statistical methods for the investigation of flight-safety level, the evaluation of the influence of adverse factors on flight safety, and the statistical evaluation of flight-safety level on the basis of actual flight data. B.J.

A88-19932* National Aeronautics and Space Administration. Wallops Flight Center, Wallops Island, Va.
STATUS OF THE NASA CONTINUING INVESTIGATION OF CATASTROPHIC BALLOON FAILURES
H. C. NEEDLEMAN (NASA, Wallops Flight Center, Wallops Island, VA) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 5-9.

The findings and status of the continuing NASA investigation of catastrophic balloon failures, conducted following the adoption in 1984 of a new material specification, are reported on. Current efforts include a microstructual analysis, balloon stress studies, and seal investigations. Attention is given to the Recovery Plan, a program to demonstrate the use of the existing film and to develop an improved film is discussed. No specific cause for the increased occurrence of catastrophic failures has been identified. R.R.

A88-19946* Harvard Univ., Cambridge, Mass.
LONG EXTENSION REELING IN THE STRATOSPHERE - A PROGRESS REPORT
N. HAZEN, E. THOMPSON, W. BRUNE, and J. G. ANDERSON (Harvard University, Cambridge, MA) (COSPAR, Plenary Meeting, *26th, Symposium on Scientific Ballooning - V, 10th, Toulouse*, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 97-100. Research supported by the Chemical Manufacturers Association. refs
(Contract NASW-3960)

Results of the second flight of the Harvard Reel Down balloon-born winching system, in which a more complex photochemical detection package was twice lowered from a float altitude of 39 km and reeled back to the winch, are reported. Modifications over the original package design include improvements to the winch platform and reconstruction of the suspended detection package for specific ClO measurement and for tight weight control. Controlled velocities of 4-7 m/sec were implemented for both of the scans, and the package was brought to a brief stop during the first scan to evaluate dynamic effects. The results demonstrate the operational effectiveness of the system. R.R.

N88-13308# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
AIRLINE SAFETY: A COMPARATIVE ANALYSIS M.S. Thesis
MARY K. HIGGINS 1987 88 p
(AD-A185358; AFIT/CI/NR-87-68T) Avail: NTIS HC A05/MF A01 CSCL 01C

In this study of airline safety, the focus will be on fatal accidents, considering the records of U.S. domestic airlines and international air carriers over the past ten years. A passenger's probability of being killed on a given flight is estimated using data from each of 157 airlines (35 U.S. domestics and 122 internationals). The calculations suggest substantial divergence of risk across groups of airlines with U.S. domestic trunk lines and large international flag carriers significantly outperforming the small international airlines and children of U.S. airline deregulation. At the same time, the general trend has been toward major reductions over time in air travel risk. GRA

N88-13309# *Ministry of Transport and Waterways, The Hague* (Netherlands).
CIVIL AERONAUTICS Annual Report, 1985 [RIJKSLUCHTVAARTDIENST]
1986 67 p In DUTCH
(ETN-88-90616) Avail: NTIS HC A04/MF A01

Activities in aeronautics inspection, airport development, air transportation policy, and aerospace safety are described. The status and activities of the Civil Aeronautics School, the National Aerospace Museum Aviodome, the National Aerospace Laboratory, and the National Aerospace Medical Center are outlined. ESA

N88-13310*# Wichita State Univ., Kans.
THEORETICAL ANALYSIS OF THE ELECTRICAL ASPECTS OF THE BASIC ELECTRO-IMPULSE PROBLEM IN AIRCRAFT DE-ICING APPLICATIONS Final Report
ROBERT A. HENDERSON and ROBERT L. SCHRAG Nov. 1987 80 p
(Contract NAG3-284)
(NASA-CR-180845; NAS 1.26:180845) Avail: NTIS HC A05/MF A01 CSCL 01C

A method of modelling a system consisting of a cylindrical coil with its axis perpendicular to a metal plate of finite thickness, and a simple electrical circuit for producing a transient current in the coil, is discussed in the context of using such a system for de-icing aircraft surfaces. A transmission line model of the coil and metal plate is developed as the heart of the system model. It is shown that this transmission model is central to calculation of the coil impedance, the coil current, the magnetic fields established on the surfaces of the metal plate, and the resultant total force between the coil and the plate. FORTRAN algorithms were developed for numerical calculation of each of these quantities, and the algorithms were applied to an experimental prototype system in which these quantities had been measured. Good agreement is seen to exist between the predicted and measured results. Author

N88-14083* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LIGHTNING DISCHARGE PROTECTION ROD Patent
CHARLES F. BRYAN, JR., inventor (to NASA) 6 Oct. 1987 7 p Filed 24 Apr. 1986 Supersedes N86-26296 (24 - 17, p 2686)
(NASA-CASE-LAR-13470-1; US-PATENT-4,698,723; US-PATENT-APPL-SN-855983; US-PATENT-CLASS-361-218; US-PATENT-CLASS-361-222) Avail: US Patent and Trademark Office CSCL 01C

A system for protecting an in-air vehicle from damage due to a lighning strike is disclosed. It is an extremely simple device consisting of a sacrificial graphite composite rod, approximately the diameter of a pencil with a length of about five inches. The sacrificial rod is constructed with the graphite fibers running axially within the rod in a manner that best provides a path of conduction axially from the trailing edge of an aircraft to the trailing end of the rod. The sacrificial rod is inserted into an attachment hole machined into trailing edges of aircraft flight surfaces, such as a vertical fin cap and attached with adhesive in a manner not prohibiting the conduction path between the rod and the aircraft. The trailing end of the rod may be tapered for aerodynamic and esthetic requirements. This rod is sacrificial but has the capability to sustain several lightning strikes and still provide protection.
Official Gazette of the U.S. Patent and Trademark Office

N88-14084# Centre d'Essais Aeronautique Toulouse (France). Lab. de Chimie Inflammabilite.
FLAMMABILITY TEST ON AIRCRAFT SEATS EQUIPPED WITH FIRE BARRIER FABRICS FOR THE PORCHER COMPANY Test Report [ESSAIS D'INFLAMMABILITE SUR SIEGES D'AVION AVEC TISSUS BARRIER FEU POUR LA SOCIETE PORCHER]
10 Jun. 1985 8 p In FRENCH
(CEAT-M5-525200; ETN-88-91167) Avail: NTIS HC A02/MF A01

A Kevlar fabric used to protect aircraft seats was tested for flammability. The results are satisfactory. ESA

N88-14085# Centre d'Essais Aeronautique Toulouse (France). Lab. de Chimie Inflammabilite.
FLAMMABILITY, SMOKE AND TOXICITY TEST ON FIRE BARRIER FABRIC FROM THE PORCHER COMPANY Test Report [ESSAI D'INFLAMMABILITE FUMEE-TOXICITE SUR TISSU BARRIER FEU DE LA SOCIETE PORCHER]
30 Jun. 1985 5 p In FRENCH
(ETN-88-91168; M5-515108) Avail: NTIS HC A02/MF A01

The results of safety tests on Kevlar fabric for the inside of passenger aircraft are presented. ESA

N88-14086# National Transportation Safety Board, Washington, D. C.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 4 OF 1986 ACCIDENTS
30 Jun. 1987 392 p
(PB87-916906; NTSB/AAB-87/06) Avail: NTIS HC A17/MF A01 CSCL 01C

Selected aircraft accident reports in brief format occurring in U.S. civil and foreign aviation operations during 1986 are given. Approximately 200 general aviation and air carrier accidents represent a random selection. The facts, conditions, circumstances and probable causes are given. Author

N88-14087# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: GRAND CANYON AIRLINES, INC., AND HELITECH, INC., MIDAIR COLLISION OVER GRAND CANYON NATIONAL PARK, JUNE 18, 1986
24 Jul. 1987 68 p
(PB87-910403; NTSB/AAR-87/03) Avail: NTIS HC A04/MF A01 CSCL 01C

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the flightcrews of both aircraft to see and avoid each other for undetermined reasons. Contributing to the accident was the failure of the Federal Aviation Administration to exercise its oversight responsibility over flight operations in the Grand Canyon airspace and the actions of the National Park Service to influence the selection of routes by the Canyon scenic tour operators. Also contributing to the accident was the modification and configuration of the routes of the rotary wing operators resulting in their intersecting with the routes of Grand Canyon Airlines near Crystal Rapids. Author

N88-14088*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PROPULSION-INDUCED EFFECTS CAUSED BY OUT-OF-GROUND EFFECTS
RICHARD MARGASON Nov. 1987 30 p
(NASA-TM-100032; A-87359; NAS 1.15:100032) Avail: NTIS HC A03/MF A01 CSCL 01C

Propulsion induced effects encountered by moderate- to high-disk loading STOVL or VSTOL aircraft out-of-ground effect during hover and transition between hover and wing-borne flight are discussed. Descriptions of the fluid flow phenomena are presented along with an indication of the trends obtained from experimental investigations. In particular, three problem areas are reviewed: (1) the performance losses sustained by a VSTOL aircraft hovering out-of-ground effect, (2) the induced aerodynamic effects encountered as a VSTOL aircraft flies on the combination of powered and aerodynamic lifts between hover and cruise out-of-ground effect, and (3) the aerodynamic characteristics caused by deflected thrust during maneuvering flight over a wide range of both angle of attack and Mach number. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A88-17326
INSTITUTE OF NAVIGATION, NATIONAL TECHNICAL MEETING, ANAHEIM, CA, JAN. 20-23, 1987, PROCEEDINGS
Meeting sponsored by the Institute of Navigation, Canadian Marconi Co., Raytheon Co., et al. Washington, DC, Institute of Navigation, 1987, 210 p. For individual items see A88-17327 to A88-17345.

Topics addressed include the status of the GPS, all-digital GPS receiver mechanization, the integration of GPS and strapdown inertial subsystems into a single unit, and the integration of GPS/INS for maximum velocity accuracy. Consideration is also given to flight data evaluation of a technique for payload inertial reference alignment transfer from the Shuttle navigation system, an empirical method for verifying GPS oscillator requirements, field test results on the use of translated GPS for Trident I, accuracy enhancement techniques applied to MARLIN, and a calibration experiment concerning GPS satellite-to-user range accuracies. B.J.

A88-17327#
ALL-DIGITAL GPS RECEIVER MECHANIZATION - SIX YEARS LATER
J. S. GRAHAM, P. C. OULD, and R. J. VAN WECHEL (Interstate Electronics Corp., Anaheim, CA) IN: Institute of Navigation, National Technical Meeting, Anaheim, CA, Jan. 20-23, 1987, Proceedings . Washington, DC, Institute of Navigation, 1987, p. 25-31. refs

Progress in all-digital baseband correlation processing of GPS signals at IEC in the past six years is described. The technology was initially developed with discrete digital MSI devices; since then, progress has been made in semicustom gate array technology and, more recently, in application-specific ICs, allowing a high degree of development of miniature low-power digital GPS receivers. Consideration is given to the implementation of the 12-tap parallel digital correlator, which is used for both fast acquisition and tracking in the latest receiver development, as well as the numerically controlled oscillator and code generator gate arrays. B.J.

A88-17328#
PROPER TREATMENT OF THE DELTA-RANGE MEASUREMENT IN AN INTEGRATED GPS/INERTIAL SYSTEM
GROVER R. BROWN and PAUL W. MCBURNEY (Iowa State University, Ames) IN: Institute of Navigation, National Technical Meeting, Anaheim, CA, Jan. 20-23, 1987, Proceedings Washington, DC, Institute of Navigation, 1987, p. 32-39. refs

An error covariance analysis is performed which indicates that the system analyst/designer should be wary of treating the delta-range measurement as an instantaneous velocity measurement when the Delta t interval is 1 sec or larger. The error variances as indicated by the P matrix in the approximate model are overly optimistic, especially with regard to velocity. Thus, it is possible to have a false hope of fine system performance when it is, in fact, not achievable even with optimal implementation. In addition, the degree of suboptimality that results from implementing the approximate model can be significant. B.J.

A88-17329#
INTEGRATION OF GPS AND STRAPDOWN INERTIAL SUBSYSTEMS INTO A SINGLE UNIT
DAVID BUECHLER and MICHAEL FOSS (Northrop Corp., Precision Products Div., Norwood, MA) IN: Institute of Navigation, National Technical Meeting, Anaheim, CA, Jan. 20-23, 1987, Proceedings . Washington, DC, Institute of Navigation, 1987, p. 40-48. refs

It has been proposed that the direct design at the outset of a tightly integrated GPS and strapdown INS permits optimization of both for performance and cost. Using this approach, a properly designed slow-sequencing single-channel receiver, married to a low-cost strapdown inertial unit, provides satellite tracking during 10-g acceleration, very high jamming suppression, improved strapdown inertial outputs, and improved GPS navigation accuracy. The packaging of this GPS/I in a single unit reduces software and hardware redundancies and results in a very low-cost design. The GPS/I unit has been packaged into the Navy's Standard Attitude Heading Reference System enclosure. B.J.

A88-17330#
INTEGRATION OF GPS/INS FOR MAXIMUM VELOCITY ACCURACY
JOHN W. DIESEL (Diesel Computing Systems, Inc., Woodland Hills, CA) IN: Institute of Navigation, National Technical Meeting, Anaheim, CA, Jan. 20-23, 1987, Proceedings . Washington, DC, Institute of Navigation, 1987, p. 58-65. refs

It is shown that weapon accuracy can be maintained even though GPS is jammed several minutes before reaching the target, provided that the GPS and INS are integrated for maximum velocity accuracy. It is assumed that the weapon is either a cruise missile or a short-range weapon delivered by a high performance aircraft. In addition, in order to avoid jamming as long as possible, the GPS carrier loop can be rate-aided, provided proper attention is paid to the effect of aircraft attitude motion and the effects of even 1-millisecond lags in the INS data. B.J.

A88-17335#
AN EMPIRICAL METHOD FOR VERIFYING GPS OSCILLATOR REQUIREMENTS
JOHN M. TAMMONE, JR. and CHARLES CRAIG (Interstate Electronic Corp., Anaheim, CA) IN: Institute of Navigation, National Technical Meeting, Anaheim, CA, Jan. 20-23, 1987, Proceedings . Washington, DC, Institute of Navigation, 1987, p. 111-114.

Analytical methods of determining oscillator performance requirements have progressed over the years. However, when it comes time to write that all important procurement specification for this critical system element, some empirical data to back up that analysis is of great value. This paper describes a method used to create controlled degradation of a VCXO, which was used in place of the system reference oscillator to test system performance of a high performance P-code GPS receiver. The phase noise spectrum created was then correlated with various receiver performance parameters. Since the resulting phase noise spectrum is controllable in both level and shape, the resulting test data is useful in estimating receiver performance under conditions, which are not easily attained, e.g., random vibration. Testing of this type gives the ability to establish realistic oscillator specifications since it gives some insight into the importance of various oscillator parameters such as phase noise and g-sensitivity. Author

A88-17336*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
RANGE FILTERING FOR SEQUENTIAL GPS RECEIVERS
RUSSELL PAIELLI (NASA, Ames Research Center, Moffett Field, CA) IN: Institute of Navigation, National Technical Meeting, Anaheim, CA, Jan. 20-23, 1987, Proceedings . Washington, DC, Institute of Navigation, 1987, p. 115-122. refs

The filtering of the satellite range and range-rate measurements from single channel sequential Global Positioning System receivers is usually done with an extended Kalman filter which has state variables defined in terms of an orthogonal navigation reference frame. An attractive suboptimal alternative is range-domain filtering, in which the individual satellite measurements are filtered separately before they are combined for the navigation solution. The main advantages of range-domain filtering are decreased processing and storage requirements and simplified tuning. Several range filter mechanization alternatives are presented, along with an innovative approach for combining the filtered range-domain quantities to determine the navigation state estimate. In addition, a method is outlined for incorporating measurements from auxiliary sensors such as altimeters into the navigation state estimation scheme similarly to the satellite measurements. A method is also described for incorporating inertial measurements into the navigation state estimator as a process driver. Author

A88-17340#
GPS INTEGRITY MONITORING USING AN AHRS AS REFERENCE
SANJAI KOHLI (Litton Aero Products, Moorpark, CA) IN: Institute of Navigation, National Technical Meeting, Anaheim, CA, Jan. 20-23, 1987, Proceedings . Washington, DC, Institute of Navigation, 1987, p. 155-158. refs

GPS satellite signals may degrade between uploads, causing erroneous position outputs. Attention is given to the use of an AHRS (attitude heading reference system) to detect such failures when redundant satellites are not present. Integrity tests for GPS signals using an AHRS are obtained on the basis of delta range measurements. Numerical results are obtained in terms of probabilities of detection for various false alarm and failure rates. B.J.

A88-17341#
IMPROVED GPS ACCURACY FOR TSPI OBTAINED THROUGH POST-FLIGHT ANALYSIS
CARL E. HOEFENER and GERALD S. DANKNER (Interstate Electronics Corp., Anaheim, CA) IN: Institute of Navigation, National Technical Meeting, Anaheim, CA, Jan. 20-23, 1987, Proceedings . Washington, DC, Institute of Navigation, 1987, p. 159, 160.

It is shown that significant accuracy improvement can be obtained by using a GPS translator in the test vehicle in preference to an on-board receiver. Using this approach, the broadband signals from the GPS satellites are transformed from L-band to S-band and retransmitted from the test vehicle to a ground station for recording or processing. When performing postflight analysis, satellite selection can be optimized to select the best GDOP or process data from all satellites in view that will provide maximum accuracy. B.J.

A88-18329#
ON THE FEASIBILITY STUDY OF A DME-BASED NAVIGATION SYSTEM IN JAPAN
SUMIO MOTOYAMA and MORIYUKI MIZUMACHI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 404, 1987, p. 439-446. In Japanese, with abstract in English. refs

A study is performed on the feasibility of a DME-based RNAV system in Japan, where the usage of such an airborne equipment is not authorized. Here a navigation method is proposed that utilizes three DME stations (responders) and the airborne altimeter to obtain the positional information of an aircraft. Computations show how effective the navigation system could be with the current Japanese DME facilities (counting a little more than a hundred). The HDOP is used as the evaluation parameter. Results show that the DME-based navigation would exhibit adequate characteristics on the enroute area all over Japan and vicinity; except Okinawa region where geographical conditions rule out a favorable configuration of DME stations. Author

A88-18843
SIMULATION PERFORMED OF MLS PROCEDURES IN AN ATC TERMINAL AREA
JAMES H. DARGUE ICAO Bulletin, vol. 42, Sept. 1987, p. 15-17.

The challenges posed by the incorporation of a microwave landing system (MLS) into air traffic control systems are examined. A simulation of MLS air traffic control procedures at New York's John F. Kennedy International (KJFK) airport, La Guardia, and Newark International Airport was conducted at NASA Ames. Preliminary analysis of the simulation indicates that when all aircraft can fly curved-path procedures, reduced communications between pilot and controller are evident and control is greatly simplified. It was also found that, at La Guardia and KJFK where maneuvering airspace is limited, it was much more difficult to integrate the MLS aircraft than at Newark, where there are fewer airspace restrictions. K.K.

A88-18844
MLS SUCCESSFULLY MEETS A CLASSIC LANDING-AID CHALLENGE
JOHN R. WHARTON (Wilcox Electric, Inc., Kansas City, MO) ICAO Bulletin, vol. 42, Sept. 1987, p. 18-22.

The challenges posed by the microwave landing system (MLS) site at Friedman Memorial Airport (Hailey, Idaho) are described. Because of the limited space at the Friedman Memorial Airport, the elevation antenna of the MLS had to be installed directly in the middle of an aircraft parking ramp. The azimuth site chosen was 79 m west of the runway center line and 463 m north of the stop end. Unlike the ILS, the MLS hardware can be integrated and tested in the factory and then shipped to the site and placed on the foundations built by local civil contractors. A disadvantage in the installation of MLS is that it must have a very stable foundation. K.K.

A88-18845
NEW PERIPHERALS ENHANCE NAVAIDS SAFETY
HEATHER MALONE (Standard Elektrik Lorenz AG, Stuttgart, Federal Republic of Germany) ICAO Bulletin, vol. 42, Sept. 1987, p. 33-37.

COMCO (a computerized operation and maintenance concept) comprises the peripheral subsystems that complement System 4000, a fully digital navaids and landing system for ILS, VOR, and DVOR. COMCO is designed to upgrade existing ILS/MLS by reducing operation and maintenance costs. Issues discussed in the present paper are precise site determination, the provision of an economical data link, the the Navtest 4200 instrumentation, the provision of permanent recording, and the simplification of repair work. B.J.

A88-19333
AUTOMATED AIR TRAFFIC CONTROL SYSTEMS [AVTOMATIZIROVANNYE SISTEMY UPRAVLENIIA VOZDUSHNYM DVIZHENIEM]
VLADIMIR IL'ICH SAVITSKII, VLADIMIR ANDREEVICH VASILENKO, IURII ALEKSANDROVICH VLADIMIROV, and VIKTOR VASIL'EVICH TOCHILOV Moscow, Izdatel'stvo Transport, 1986, 192 p. In Russian. refs

General information on the structure of automated air traffic control systems (AATCSs) is presented, and relevant standards and recommendations are considered. Various facilities employed in AATCSs are described, including radar systems, communications and data-transmission equipment, computer complexes, and data display systems. The operational efficiency of AATCSs is evaluated. B.J.

A88-19364
NAVIGATION INSTRUMENTS AND SYSTEMS [NAVIGATSIONNYE PRIBORY I SISTEMY]
BORIS BORISOVICH SAMOTOKIN, VLADISLAV VALENTINOV MELESHKO, and IURII VLADIMIROVICH STEPANKOVSKII Kiev, Izdatel'stvo Vishcha Shkola, 1986, 344 p. In Russian. refs

The physical principles and theory of ship navigation instruments and systems are presented with emphasis on inertial navigation systems. Topics discussed include physical fields of the earth and near-earth space; coordinate, line, and surface position navigation systems; instruments and systems implementing the position navigation methods; and the physical principles of inertial navigation and characteristics of the principal types of inertial navigation systems. The discussion also covers instrumental errors of inertial navigation systems, navigation complexes, and reliability of navigation systems. V.L.

A88-19943
REMOTE DATA COMMUNICATIONS AND COMMAND SYSTEM
JESSE PHILLIPS (National Scientific Balloon Facility, Palestine, TX) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 85-88.

Scientific ballooning missions in the continental United States have traditionally been limited in flight time due to the loss of local telemetry capability as the payload drifts beyond the horizon. A Remote Data Communications and Command System has been developed by the NSBF which allows both the recovery and display of limited real-time data and complete command control of a balloon payload that is within the telemetry horizon of a remote station. The general capabilities of this system are discussed here from the standpoint of two virtual systems which can be used independently or together as a single system. Author

A88-19944
REMOTE CONTROL FOR LONG-DISTANCE BALLOONS [TELECOMMANDE POUR BALLONS LONGUE DISTANCE]
M. DURAND, M. DADOU, and P. MALATERRE (CNES, Division Ballons, Toulouse, France) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 89-93. In French.

A remote control command system called TEBALDI has been developed for long-duration balloon flights. The transmission system is the same as that used by the CHACAL down-range telemetry system, with the HF-band carrier frequency being modulated by a two-phase signal. The structure and generation of messages is described. The system employs two receivers which have sensitivities of -125 dBm and which maintain good performance down to temperatures of 155 C. Results have been obtained using the TIBALDI system aboard a 10-day flight of an IR hot-air balloon, and the successful transmission of two commands at a distance of 7000 km has been demonstrated. R.R.

A88-19945
USE OF A TELEPHONE DATA LINK IN STRATOSPHERIC BALLOON FLIGHTS
C. BANNELIER and A. SOUBRIER (CNES, Division Ballons, Toulouse, France) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 95, 96.

The performance and experimental results of a down-range telephone data and command link for long-duration stratospheric balloons are discussed. In the present system, the mother station is linked to the down-range station through a pair of dedicated telephone lines with a capability of 9600 bits/sec each. The same relay is used to enable the mother station to receive telemetry signals from the balloon (relayed by the down-range station) and to send commands to the balloon. A High-level Data Link Control synchronous bit oriented protocol is used for the transmission. Two data reduction methods are considered. R.R.

N88-14090# Federal Aviation Administration, Atlantic City, N.J.
BOEING 727 MLS (MICROWAVE LANDING SYSTEM) TERMINAL INSTRUMENT PROCEDURES (TERPS) APPROACH DATA COLLECTION AND PROCESSING, DATA REPORT Technical Note, Feb. 1986 - Jan. 1987
EDWARD J. PUGACZ May 1987 14 p
(AD-A185523; DOT/FAA/CT-TN87/9) Avail: NTIS HC A03/MF A01 CSCL 17G

This is one part of the Fixed Wing Microwave Landing System (MLS) terminal instrument procedures (TERPS) data collection and processing program being performed at the Federal Aviation Administration (FAA) Technical Center. The program was undertaken to collect flight test data in various aircraft to establish a data base for development of MLS TERPS criteria. Data were collected during both missed approaches and landings using glides

lopes of 3 deg, CAT II, 3.5 deg, and 4 deg with all flights being tracked by ground based tracking systems. Statistical processing was performed on both the airborne and tracker data, and various graphical plots were produced. The processed data were delivered to AVN-210 for inclusion in the MLS TERPS criterita development data base. GRA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A88-17279* Georgia Inst. of Tech., Atlanta.
THE IMPORTANCE OF AERODYNAMICS ON DYNAMICS
DAVID A. PETERS (Georgia Institute of Technology, Atlanta) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 11 p. Army-supported research. refs
(Contract NAG1-710)

The effects of aerodynamic phenomena on helicopter structural dynamics are examined, reviewing the results of recent theoretical and experimental investigations. A schematic diagram of a dynamic analysis is presented and discussed, noting the numerous aerodynamic inputs, and numerical data are presented in graphs. Consideration is given to forcing functions, aerodynamic damping, aeroelastic coupling, negative damping, apparent coriolis coupling, periodic coefficients, inverse damping, additional degrees of freedom, flap-lag stability, and dynamic inflow. The need for theoretical models which account for the dynamic loop between blade lift and induced flow (permitting blade motion to dynamically alter the flowfield during transients) is indicated. T.K.

A88-17287
HELICOPTER DESIGN OPTIMISM - PROMISE VS PRODUCT
EDMUND H. SMITH (U.S. Navy, Naval Air Systems Command, Washington, DC) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 7 p.

The objective of this paper is to show how optimism in the various technical areas causes a large difference between predicted and actual aircraft capability. The major technical areas, drag, rotor performance, weight, and engine performance are examined. Historical data are presented to compare proposal estimates with the actual results, and average values of the performance shortfalls are established. Performance parameters are developed for a notional 20,000-lb-class transport helicopter. Its performance is shown with a baseline aerodynamic and weight data base. The impact of the four performance shortfalls is large, with a 35-percent reduction in payload, and a 6.9-percent decrease in range for a typical sea-level 90 F mission. Author

A88-17466
THE AQUILA REMOTELY PILOTED SYSTEM
CARL V. CAWOOD (Lockheed Missiles and Space Co., Inc., Austin, TX) Lockheed Horizons (ISSN 0459-6773), Sept. 1987, p. 2-17.

The Aquila RPV system encompasses six major elements: a ground control station, an air vehicle and its payload, a datalink, a launcher, a recovery unit, and a maintenance shelter. All these elements are mobile. The ground control station, which is the operational center of a given RPV field unit, is mounted on a 5-ton truck and is involved in the receipt of orders from higher echelons, as well as the control of the RPV and the communication of the targeting intelligence derived from its sensors to artillery units. The entire system is highly automated for the sake of easy operation by U.S. Army personnel. O.C.

A88-17469
CIRCULATION CONTROL TECHNOLOGY FOR POWERED-LIFT STOL AIRCRAFT
ROBERT J. ENGLAR (Lockheed-Georgia Co., Marietta) Lockheed Horizons (ISSN 0459-6773), Sept. 1987, p. 44-55.

Circulation control wing technology avoids the problems posed by mechanical and blown flaps by replacing the sharp trailing edge with a fixed, nondeflecting rounded surface to which the tangentially-blowing lamina of engine bypass air remains attached. This effect initially acts as a BLC technique; the air lamina is then deflected downward, resulting in a supercirculation lift. Attention is presently given to the application of these principles to A-6 and Quiet Short-Haul Research Aircraft. O.C.

A88-17997
AIRSHIPS [DIRIZHABLI]
MIKHAIL IAKOVLEVICH ARIE Kiev, Izdatel'stvo Naukova Dumka, 1986, 264 p. In Russian. refs

The history and evolution of airships, recent advances and current trends in airship design, and future prospects in this area are reviewed. The discussion covers the flight principles and structural types of airships, including flexible, semirigid, rigid, and mixed designs; characteristics and applications of first-generation airships; airship accidents and their causes; and characteristics of a new generation of airships. Attention is also given to problems associated with the development of aerostatic aircraft and the economic efficiency of airships. V.L.

A88-18229* Rensselaer Polytechnic Inst., Troy, N.Y.
THE RP-2 SAILPLANE
STEVEN WINCKLER (Rensselaer Polytechnic Institute, Troy, NY) IN: Advanced composites: The latest developments; Proceedings of the Second Conference, Dearborn, MI, Nov. 18-20, 1986 . Metals Park, OH, ASM International, 1986, p. 29-32. NASA-USAF-sponsored research.

The all-composite design and fabrication methodology employed by Rensselaer Polytechnic Intitute's 'CAPGLIDE' program in producing such sailplanes as the RP-2 is discussed. The RP-2's production methods, which furnish hands-on experience for the students enrolled in the program, encompass wet lay-up and vacuum bag procedures, as well as autoclave curing of prepreg parts employing graphite, kevlar, and glass fiber reinforcements. Epoxy resins are the primary matrix materials, and are used in conjunction with polymer foams for the sandwich panel elements of the sailplane structure. O.C.

A88-18492#
NUMERICAL ANALYSIS OF THE SYMMETRICAL FREE VIBRATIONS OF AN AIRCRAFT, TAKING INTO ACCOUNT THE DEFORMABILITY OF THE STRUCTURE [ANALIZA NUMERYCZNA SYMETRYCZNYCH DRGAN WLASNYCH SAMOLOTU Z UWZGLEDNIENIEM ODKSZTALCALNOSCI STRUKTURY]
JAN BLASZCZYK (Wojskowa Akademia Techniczna, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 42, July 1987, p. 4-10. In Polish. refs

A numerical analysis of the symmetrical free vibrations of an elastic aircraft is carried out on the basis of a structure model consisting of beams and concentrated masses. An appropriate algorithm has been developed along with an ALGOL program implemented on the ODRA-1305 computer. Calculations of vibration spectra are presented for hypothetical and actual structures. Calculation results are compared with resonance measurements. B.J.

A88-18499#
BLIMPS ARE BACK ON BOARD
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 25, Nov. 1987, p. 34-37.

An evaluation is made of the novel technologies and design features that are to be incorporated in the USN's next-generation radar surveillance airships, typified by the Sentinel 5000 whose initial flight trials are scheduled for 1990. Sentinel will cruise at 40

kt for 2.5 days at 5000 ft altitude, and could be replenished from ships for longer patrols. The radar antenna will be mounted atop the gondola, inside the gas envelope. Pressurization of the crew compartment will allow the airship to reach a maximum altitude of 14,000 ft. At 10,000 ft, the radar horizon is 125 n.mi. Attention is given to envelope construction considerations. O.C.

A88-19266
MD-87 - THE PEDIGREE SHOWS
HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 132, Oct. 31, 1987, p. 20-24.

The MD-87 is the smallest variant of the MD-80 family of airliners, carrying as few as 114 seats in mixed class, and is designed to fly medium-range sectors from relatively small airfields as well as longer sectors from standard runways. An account is presently given of the flight handling qualities of the aircraft, as exhibited during a recent demonstration flight from Yuma, Arizona. Attention is given to the characteristics of the novel electronic display flight instruments used and to the comparative performance of the MD-87 and the nearest competitors within its class, the B737-200 and -300 variants. O.C.

A88-19271
THE GRIPEN - AN AMBITIOUS 'JACK OF ALL TRADES'
Air International (ISSN 0306-5634), vol. 33, Nov. 1987, p. 224-230.

An account is given of the airframe and propulsion system design features of the Gripen multirole fighter aircraft, which is required to operate from airstrips no more than 800 m long. Great efforts have been made to arrive at the smallest and lightest airframe consistent with the substantial air/ground weapons-load requirements envisioned; the powerplant chosen is a single 'RM 12' variant of the F404 engine generating over 18,000 lbs of thrust on full afterburner. The multirole pulse-Doppler radar used can be reprogrammed by the pilot to suit specific mission requirements. Six external hardpoints are used for stores that include a mix of Sidewinder and Sky Flash missiles. O.C.

A88-19356
FUNDAMENTALS OF THE DESIGN AND MAINTENANCE OF SINGLE-ROTOR HELICOPTERS [OSNOVY KONSTRUKTSII I TEKHNICHESKOI EKSPLUATATSII ODNOVINTOVYKH VERTOLETOV]
ALEKSANDR MIKHAILOVI VOLODKO and AL'BERT LEONT'EVICH LITVINOV Moscow, Voennoe Izdatel'stvo, 1986, 200 p. In Russian. refs

The general design and principle of operation of the main components of single-rotor helicopters are reviewed in relation to the task of helicopter maintenance. The components discussed include the rotor, the tail rotor, the airframe, the chassis, the control system, and the powerplant. It is shown how the principal advantages and disadvantages of the single-rotor design affect the length of the service life of helicopters, their reliability, and the ease of maintenance. V.L.

A88-19673#
AEROELASTIC STABILITY CHARACTERISTICS OF A COMPOSITE SWEPT WING WITH TIP WEIGHTS FOR AN UNRESTRAINED VEHICLE
I. LOTTATI (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 24, Nov. 1987, p. 793-802. refs

An analytical investigation to determine aeroelastic flutter and divergence behavior of a composite, forward-swept rectangular wing was conducted. It is assumed that the wing is carrying a fuselage at its semispan, a pylon at the wing tip, and that the aircraft is in a free-flight condition (unrestrained vehicle). The influence, due to the variation in the bending-torsion stiffness coupling of the tailored wing on the flutter and divergence critical dynamic pressure, is analyzed. The paper discusses the influence of the warping effect on the system's flutter and divergence velocities. The aeroelastic stability behavior of the system is obtained by applying an optimization procedure that solves exactly the coupled bending-torsion equations of motion for the unrestrained swept-wing aircraft. The results of the present study indicate that the warping effect significantly infuences the system's aeroelastic characteristics.

A88-19675*#
AEROELASTIC TAILORING OF AFT-SWEPT HIGH-ASPECT-RATIO COMPOSITE WINGS
JOHN A. GREEN (Stanford University, CA) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 1151-1161) Journal of Aircraft (ISSN 0021-8669), vol. 24, Nov. 1987, p. 812-819. Previously cited in issue 24, p. 3542, Accession no. A86-49097. refs
(Contract NGL-05-020-243)

A88-19708
SUPER-SONIC V/STOL - WILL IT HAPPEN?
DAN HOLT Aerospace Engineering (ISSN 0736-2536), vol. 7, Nov. 1987, p. 8-13.

An evaluation is made of novel propulsion system configurations that are under consideration as bases for supersonic dash speed-capable V/STOL military aircraft able to supercede the current, subsonic Harrier design. One of the greatest obstacles to the development of such an aircraft is fuel consumption, as well as the enhanced IR emissions generated by the use of afterburners in low level hovering flight. Attention is given to advanced thrust-vectoring, augmenting ejector, tandem fan, and remote augmented lift schemes held capable of circumventing these difficulties. O.C.

A88-19802#
AN AUTOMATED PROCEDURE FOR PRACTICAL AND EFFICIENT DESIGN OF WING STRUCTURE
C. D. D. KANWA, N. S. DWARAKINATH, and T. G. A. SIMHA (Hindustan Aeronautics, Ltd., Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 39, Feb. 1987, p. 11-19. refs

An automated procedure for the structural design of aircraft wing, based on the classical optimization for stiffened panels and balanced design concepts, is presented. The principles of layout design for individual structural components are described. Examples of designs include the wing of a combat aircraft and the wing for an ultralight weight trainer. Multiple diagrams are included. I.S.

A88-19934* National Aeronautics and Space Administration. Wallops Flight Center, Wallops Island, Va.
A STRESS INDEX MODEL FOR BALLOON DESIGN
I. S. SMITH (NASA, Wallops Flight Center, Wallops Island, VA) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 19-24. refs

A NASA stress index model, SINDEX, is discussed which establishes the relative stress magnitudes along a balloon gore as a function of altitude. Application of the model to a data base of over 550 ballon flights demonstrates the effectiveness of the method. The results show a strong correlation between stress levels, failure rates, and the point of maximum stress coinciding with the observed failure locations. It is suggested that the model may be used during the balloon design process to lower the levels of stress in the balloon. R.R.

A88-19937
A LONG-DURATION BALLOON SYSTEM FOR MIDDLE-ATMOSPHERE MEASUREMENTS
JUSTIN H. SMALLEY and NEIL E. CARLSON (National Center for Atmospheric Research, Boulder, CO) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 41-51. refs

Characteristics of the electrodynamics of the middle atmosphere (EMA) vehicle being developed as a platform for long-duration measurements at stratospheric altitudes are discussed.

Measurements made in the southern hemisphere at 26 km for periods ranging from 15 to 60 days have validated the performance of the system. A heat pipe was found to be effective in transferring heat into the gondola. An intermittently-powered stepping motor has helped fulfill the requirement of continuous gondola rotation. Multiple identification codes have increased the ARGOS data rate. Other EMA vehicle technologies described include the solar power supplies, a CMOS data control system, and a balloon launching technique. R.R.

A88-19938
AN IMPROVED SHAPE FOR ZERO-PRESSURE BALLOONS
YUHANG LI, XULIANG HUANG, and YIDONG GU (Chinese Academy of Sciences, Institute of High Energy Physics, Beijing, People's Republic of China) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 53-58. refs

Since the 1950s, efforts have been made to optimize the design of zero-pressure balloons. A possible method for improving on the classical natural-shape is discussed in this paper. It is shown by surface element analysis, that the meridional stress in the balloon film can be adjusted by changing the circumferential stress. It is probable that the stress concentration at the top of a natural-shape balloon can be reduced. A mixed-shape balloon, which has positive circumferential stress above the maximum diameter, has been derived and the results are presented in a form similar to Smalley's 'sigma' table. The stress distribution for balloons having different shapes, with or without load tapes, are also described. Author

A88-19941
DEVELOPMENT OF BALLOON TECHNOLOGY IN CHINA
YIDONG GU and KEWEI YUAN (Chinese Academy of Sciences, Institute of High Energy Physics, People's Republic of China) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 71-76.

Aspects of the development of balloon technology in China are considered, including balloon materials, balloon design and manufacturing procedures, and launch and recovery techniques. LLDPE materials offer the advantages of excellant tensile strength, puncture resistance, and thermal sealing qualities. Goals for the second generation balloons include increasing the balloon volume up to 400,000 cu m and the payload capacity up to 1000-1500 kg. Long duration flights from Beijing to the Gobi region in northwest China, and a new telemetry and command system, are also planned. R.R.

A88-19947
SOME SPECIAL SUB-SYSTEMS FOR STRATOSPHERIC BALLOON FLIGHTS IN INDIA
S. V. DAMLE, G. S. GOKHALE, and R. U. KUNDAPURKAR (Tata Institute of Fundamental Research, Bombay, India) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 101-104.

During the last few years several new subsystems for balloons were developed and are being regularly used in the balloon flights. Some of these subsystems are: (1) positive monitor for magnetic ballast release using an opto-electronic device; (2) one-way pressure switch to terminate flight for a runaway balloon; and (3) in-flight payload reel down system for atmospheric science experiments. The design, usage and performance of these and other subsystems will be presented. Author

A88-19948
POWER CONSIDERATIONS FOR LONG DURATION BALLOON FLIGHTS
G. M. FRYE, JR., A. OWENS (Case Western Reserve University, Cleveland, OH), R. KOGA (The Aerospace Corp., El Segundo, CA), B. V. DENEHY, O. MACE (Royal Australian Air Force, Parkville, Australia) et al. (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 105-108. Research supported by the Australian Research Grants Committee, Royal Australian Air Force, and Aerospace Corp. refs
(Contract NSF ATM-82-06044)

A power supply system consisting of a solar panel and silicad batteries was developed to provide 100 W of power for a balloon-borne solar neutron experiment. The system was successfully tested during a 22-day circumglobal RACOON flight launched from Australia in 1983. The Extended Observation of Solar and Cosmic Radiation detector is described in detail. Tests have shown the solar power array to be capable of withstanding a 7 G load without deformation. R.R.

A88-19951
A 3-AXIS STABILISED BALLOON PLATFORM FOR USE DURING DAY- AND NIGHT-TIME FLIGHTS
M. E. FARMAN and A. L. HARDIE (SERC, Rutherford Appleton Laboratory, Didcot, England) (COSPAR, Plenary Meeting, 26th, Symposium on Scientific Ballooning - V, 10th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 7, 1987, p. 121-127.

The Balloon Platform developed at the Rutherford Appleton Laboratory (R.A.L.) is being adapted to carry the ZEBRA telescope which requires an arcminute day- and night-pointing capability. The basic features of the platform and the modifications necessary for the ZEBRA application are briefly described. The new inertial stabilization system uses 3-axis rate integrating gyros. Problems relating to gyro drifts and the methods of drift compensation to achieve the required pointing accuracy are discussed. The paper concludes by outlining the proposed strategy for setting up the control system in flight. Author

A88-19999
INTEGRATION OF A HELICOPTER SIZING CODE WITH A COMPUTER-AIDED DESIGN SYSTEM
LIANG-JU LU, ARVID MYKLEBUST (Virginia Polytechnic Institute and State University, Blacksburg), and STEVEN WAR (IBM Corp., Federal Systems Div., Owego, NY) (CUE, International Conference, Paris, France, May 1986) American Helicopter Society, Journal (ISSN 0002-8711), vol. 32, Oct. 1987, p. 16-27. IBM-supported research. refs

HESCOMP is a preliminary helicopter design tool for sizing and performance computations developed at Boeing Vertol under NASA and U.S. Navy contracts. All output from HESCOMP was numerical in form. An interface has been developed which writes helicopter geometric models directly into a computer-aided design system data-base. Three orthographic views and a 3-D wireframe are produced for both single rotor and tandem rotor helicopters, with or without wings or auxiliary propulsion, and with or without fenestron tails. This interface produces geometric models automatically, using data taken directly from HESCOMP. These models allow rapid evaluation of HESCOMP results and, with the aid of the CAD/CAM system, enable assessment of mission equipment packages (such as avionics) on the geometry, weight, and performance of the helicopter. Author

A88-20000* Sikorsky Aircraft, Stratford, Conn.
PREDICTION OF AEROELASTIC RESPONSE OF A MODEL X-WING ROTOR
ROBERT SOPHER and JAMES E. DUH (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) (NASA, Circulation Control Workshop, Moffett Field, CA, Feb. 19-21, 1986) American Helicopter Society, Journal (ISSN 0002-8711), vol. 32, Oct. 1987, p. 54-62. NASA-supported research. refs

The Rotorcraft Dynamics Analysis was used to predict the aeroelastic responses of a representative X-Wing model with a 10-ft diameter rotor. The aeroelastic methodology used and the tests and assumptions involved are reviewed. Results are reported on the findings concerning control power and higher harmonic control in hover, transition flight, vibratory loads at forward speed, and responses in conversion. It is concluded that the analysis can give satisfactory predictions of X-Wing behavior. C.D.

A88-20008
STOL EAGLE
MIKE GAINES Flight International (ISSN 0015-3710), vol. 132, Nov. 7, 1987, p. 32-34.

An account is given of the design features and performance capabilities anticipated for a substantially modified version of the F-15 fighter, incorporating canards and two-dimensional vectoring nozzles, that has been conceived as capable of operating from the 50 ft-wide and 1500 ft-long landing strips able to survive the bombing of NATO airfields. The two-dimensional exhaust nozzles will be capable of 20-deg pitch up/down, either together or differentially, as well as full reverse-thrust operation. The engines used are based on an F100-PW220 core with changed rear cases for the transition from round to square cross-section for the two-dimensional nozzles. O.C.

A88-20155
LANDING GEAR DESIGN FOR LIGHT AIRCRAFT. VOLUME 1
LADISLAO PAZMANY San Diego, CA, Pazmany Aircraft Corp., 1986, 249 p. refs

A comprehensive treatment is presented of performance criteria and established practices for the design of light aircraft landing gears of both fixed and retractable types. Separate discussions are undertaken for landing gear arrangements and their essential relations to aircraft masses and centers, as well as for ground-loop accidents, tires, wheels, brake designs and performance capabilities, integrated brake systems, landing gear loads and deflections, and the distinctive requirements of main, nose and tail landing gear elements. O.C.

A88-20179*# Cambridge Acoustical Associates, Inc., Mass.
ALL-THEORETICAL PREDICTION OF CABIN NOISE DUE TO IMPINGEMENT OF PROPELLER VORTICES ON A WING STRUCTURE
R. MARTINEZ, J. E. COLE, III, K. MARTINI, and A. WESTAGARD (Cambridge Acoustical Associates, Inc., MA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p. refs
(Contract NAS1-18020)
(AIAA PAPER 87-2681)

Reported calculations of structure-borne cabin noise for a small twin engine aircraft powered by tractor propellers rely on the following three-stage methodological breakup of the problem: (1) the unsteady-aerodynamic prediction of wing lift harmonics caused by the whipping action of the vortex system trailed from each propeller; (2) the associated wing/fuselage structural response; (3) the cabin noise field for the computed wall vibration. The first part--the estimate of airloads--skirts a full-fledged aeroelastic situation by assuming the wing to be fixed in space while cancelling the downwash field of the cutting vortices. The model is based on an approximate high-frequency lifting-surface theory justified by the blade rate and flight Mach number of application. Its results drive a finite-element representation of the wing accounting for upper and lower skin surfaces, spars, ribs, and the presence of fuel. The fuselage, modeled as a frame-stiffened cylindrical shell, is bolted to the wing. Author

A88-20185#
HOW TO SATISFY THE TAKEOFF NOISE REQUIREMENTS FOR A SUPERSONIC TRANSPORT
ULF MICHEL (DFVLR, Abteilung Turbulenzforschung, Berlin, Federal Republic of Germany) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 11 p. refs
(AIAA PAPER 87-2726)

The noise during takeoff of a supersonic transport is calculated for the flyover and the lateral reference noise measurement points defined by ICAO Annex 16. Only the contribution of jet mixing noise is considered. The influences of the following parameters are studied: jet speed, aircraft weight, aircraft wing loading, aircraft lift-to-drag ratio, and the amount of power cutback after takeoff. The influence of the takeoff procedure is also studied. It is shown that jet speed has the largest influence of all parameters and that values of about 400 m/s or less are required to satisfy the noise limits that are currently valid for subsonic jet aircraft. Such low jet speeds can be achieved by choosing large engine bypass ratios or by employing ejector mixers with large nozzle exit diameters. The first solution may be very difficult to realize technically for a supersonic transport, the second solution requires that the mixer can be fully retracted which may be impossible because of its size. Author

A88-20566
MEETING AH-64A ATTACK HELICOPTER DESIGN OBJECTIVES WITH A SYSTEMS APPROACH TO INTERCONNECTION
ROLAND B. LAWRENCE (Deutsch Co., Deutsch Engineered Connecting Devices, Banning, CA) Vertiflite (ISSN 0042-4455), vol. 33, Nov.-Dec. 1987, p. 34-39.

The role of common termination systems (CTSs) in increasing the reliability, availability, and maintainability of the U.S. Army AH-64A helicopter is described in detail and illustrated with extensive photographs. Particular attention is given to the pilot matrix wiring assembly (the principal point of cross-ship interconnection) and the power center. The use of CTSs is shown to reduce the weight and installed volume of the electrical systems, to permit mounting in-line junctions in environmentally hostile locations in the aircraft, and to increase flexibility in the design and/or later addition of electronics modules. T.K.

A88-20569
THE EH-101 - CAPABILITIES AND OPERATIONAL ASPECTS FROM A LAUNCH CUSTOMER'S VIEWPOINT
GRAHAM PAY (British Embassy, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 33, Nov.-Dec. 1987, p. 50-56.

The design and development history of the Anglo-Italian EH-101 advanced-technology multipurpose military/civilian helicopter are discussed, with a focus on the influence of the design and performance specifications imposed by the UK and Italian navies. Consideration is given to the needs for (1) both large cabin size and foldability into a small maintenance and storage 'box', (2) 150-kt cruise speed and 4-h endurance, (3) safe flyaway with only one engine, (4) small-flight-deck operability, and (5) flight in icing conditions. Also examined are crew size (three); reliability, availability, and maintainability; and the performance improvements offered by the British Experimental Rotor Program phase III high-speed low-vibration rotor system. Diagrams and drawings are provided. T.K.

N88-13244# Lockheed-California Co., Burbank.
THE OFF-DESIGN PERFORMANCE OF HYPERSONIC WAVERIDERS
LYLE N. LONG *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 14 p Nov. 1987
Avail: NTIS HC A24/MF A01

Waveriders are being considered more and more as potential aerospace vehicles. However there are several questions regarding these configurations that must be answered before they can be considered viable designs. The most significant problems are related to aerothermal heating, propulsion integration, and off-design performance. Off-design performance predictions for two generic waveriders are presented. The results are from a numerical

method based upon the nonlinear, inviscid Euler equations. Comparisons to experimental data are also shown. Author

N88-13245*# Maryland Univ., College Park. Dept. of Aerospace Engineering.
NUMERICAL OPTIMIZATION OF CONICAL FLOW WAVERIDERS INCLUDING DETAILED VISCOUS EFFECTS
KEVIN G. BOWCUTT, JOHN D. ANDERSON, JR., and DIEGO CAPRIOTTI *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 23 p Nov. 1987 Sponsored in part by NASA Langley Research Office, Hampton, Va. and Army Research Office, Washington, D.C.
Avail: NTIS HC A24/MF A01 CSCL 01A

A family of optimized hypersonic waveriders is generated and studied wherein detailed viscous effects are included within the optimization process itself. This is in contrast to previous optimized waverider work, wherein purely inviscid flow is used to obtain the waverider shapes. For the present waveriders, the undersurface is a streamsurface of an inviscid conical flowfield, the upper surface is a streamsurface of the inviscid flow over a tapered cylinder (calculated by the axisymmetric method of characteristics), and the viscous effects are treated by integral solutions of the boundary layer equations. Transition from laminar to turbulent flow is included within the viscous calculations. The optimization is carried out using a nonlinear simplex method. The resulting family of viscous hypersonic waveriders yields predicted high values of lift/drag, high enough to break the L/D barrier based on experience with other hypersonic configurations. Moreover, the numerical optimization process for the viscous waveriders results in distinctly different shapes compared to previous work with inviscid-designed waveriders. Also, the fine details of the viscous solution, such as how the shear stress is distributed over the surface, and the location of transition, are crucial to the details of the resulting waverider geometry. Finally, the moment coefficient variations and heat transfer distributions associated with the viscous optimized waveriders are studied. Author

N88-13248# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Aeromechanics Div.
LIFTING BODIES: AN ATTRACTIVE AERODYNAMIC CONFIGURATION CHOICE FOR HYPERVELOCITY VEHICLES
ALFRED C. DRAPER and MELVIN L. BUCK *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 44 p Nov. 1987
Avail: NTIS HC A24/MF A01

A brief chronology is given of the lifting body configurations investigated by the Flight Dynamics Laboratory, along with their aeroperformance capabilities including ASSET, PRIME, the X-24A, and the X-24B. Also included is a brief discussion of lifting body applications at supercircular velocities such as the SORTIE. The impact of basic geometric and component effects on aerodynamic performance parameters is addressed. These results were then translated into an aerodynamic configuration which eliminates the aft vertical fins without degrading the hypersonic lift-to-drag ratio while maintaining directional stability. Additionally, the benefits and applicability are examined. Specifically, the more significant methods such as the Hypersonic Arbitrary Body Program (HABP), PANAIR, Euler, Parabolized Navier-Stokes (PNS), and Navier-Stokes (NS) codes are discussed. Experimental capabilities and needs are discussed and finally, long term goals for future lifting body configurations are assessed. Author

N88-13315# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
SPECIAL COURSE ON FUNDAMENTALS OF FIGHTER AIRCRAFT DESIGN
Oct. 1987 290 p Course held in Rhode-St-Genese, Belgium, 17-21 Feb. 1986, in Athens, Greece, 24-25 Feb. 1986, and in Ankara, Turkey, 27-28 Feb. 1986
(AGARD-R-740; ISBN-92-835-1560-9) Avail: NTIS HC A13/MF A01

The Special Course on the Fundamentals of Fighter Aircraft was sponsored by the AGARD Fluid Dynamics Panel and the von Karman Institute and presented at the latter in Rhode-Saint-Genese, Belgium, 17 to 21 February 1986, at the Greek Air Force Academy, Athens, Greece, 24 to 25 February 1986, and at the ARGE, Ankara, Turkey, 27 to 28 February 1986. The Course presented a comprehensive review of fundamental procedures used during a fighter pre-development phase concentrating on the following: basic mission requirements and aircraft sizing; aerodynamic design including performance, stability and control; materials, structural optimization and aeroelasticity; aircraft dynamics; engine intake and nozzle integration; and airframe store-compatibility. Experimental and theoretical work has been demonstrated to play complementary roles and, in conclusion, recommendations are given for future development of engineering tools.

N88-13316# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter and Military Aircraft Div.
FUNDAMENTALS OF FIGHTER AIRCRAFT DESIGN
P. W. SACHER *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 5 p Oct. 1987
Avail: NTIS HC A13/MF A01

Following the technical program of the AGARD Fluid Dynamics Panel (FDP) for the past few years, the aeronautical engineer has found many subjects related to a special technical discipline and directed to industrial applications. But in nearly all cases the analysis of given geometry by experimental or theoretical techniques has overruled the more important engineering task, i.e., the design of a new shape which has desired properties. But in all cases concerning successful flying aircraft the result of engineering work has ben a design compromise achieved by the fruitful cooperation of all technically relevant disciplines. Therefore, one of the most important intentions of this course has been to attract people from different aeronautical disciplines, working in industry and research institutes, and to look for links within the different branches of aerodynamics such as Wind Tunnel Test Techniques, Computational Fluid Dynamics, Vortex Dynamics, Unsteady Aerodynamics, Viscous Flow Drag Prediction, and their impact on designing aircraft components. Author

N88-13317# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Design Branch.
MISSION REQUIREMENTS AND AIRCRAFT SIZING
JAMES L. PARKER *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 46 p Oct. 1987 Previously announced in IAA as A87-17881
Avail: NTIS HC A13/MF A01

The development of requirements for new fighter aircraft involves defining threats, targets, and air combat scenarios for the future. Current fighter requirements emphasize the need for close-in combat and beyond-visual-range combat capability to achieve superiority in the air-to-air role. High sortie rates and the ability to perform air-to-surface missions are also primary requirements. Conceptual design and aircraft sizing are used to help define requirements. With conceptual design tools, different fighter designs can be sized for different missions. These configurations allow life cycle cost and effectiveness analysis to be performed, which provide the basis for the definition of the requirement to be constrained to a technologically feasible and economically affordable solution. Author

N88-13318# Boeing Military Airplane Development, Seattle, Wash.
DESIGN OF WINGS AND WING/BODY CONFIGURATIONS FOR TRANSONIC AND SUPERSONIC SPEEDS
H. YOSHIHARA *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 19 p Oct. 1987
Avail: NTIS HC A13/MF A01

Procedures to design wing/fuselage configurations at transonic and supersonic conditions are described. This is preceded by an introductory section sketching the significant flow features as the shock wave and separation patterns for typical fighter wings which affect the performance, followed by a description of the interference effects due to the fuselage. Author

N88-13320# National Research Council of Canada, Ottawa (Ontario). Unsteady Aerodynamics Lab.
AIRCRAFT DYNAMICS: AERODYNAMIC ASPECTS AND WIND TUNNEL TECHNIQUES
K. J. ORLIK-RUECKEMANN *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 30 p Oct. 1987
Avail: NTIS HC A13/MF A01

The dynamic behavior of modern fighter aircraft depends more and more on unsteady aerodynamics. Until recently, the designer concentrated on classical problems such as aeroelasticity and flutter. Dynamic stability parameters were most often determined by low angle-of-attack calculation methods, without much recourse to experiment. The results obtained from the few dynamic experiments performed were used to confirm the absence of problems rather than as design parameters. New requirements for fighter aircraft performance include the ability to fly at high angles of attack in the presence of extensive regions of separated or vortical flows, relaxed static stability, greatly increased agility, and an interest in unorthodox geometries such as closely-coupled-canard or tail-first configurations. The time lags and unsteady phenomena associated with flow fields resulting from rapid maneuvers and large amplitude motions significantly affect the dynamic behavior of modern fighter aircraft and become as important for aircraft design as the classical static performance criteria. A review is made of the various aerodynamic aspects affecting aircraft dynamic behavior, followed by a survey of the most pertinent experimental techniques.

N88-13321# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France). Div. des Etudes Avancees.
TECHNIQUES FOR PERFORMANCE OPTIMISATION IN CRUISE AND MANOEUVERABILITY
PIERRE PERRIER *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 12 p Oct. 1987
Avail: NTIS HC A13/MF A01

The design of a combat aircraft cannot be left to trial and error design when a definite performance target is precisely defined. It is obvious that there is a large variation in the possible aerodynamic aircraft shapes having the internal volume required for fuel, engine, equipment and weapon system accommodation. Among all possible shapes, the best aircraft will have definite advantages over a poor design in terms of performance for a given cost or in terms of cost for given performance. The best aerodynamic definition need no longer be left to the designers in the design office when efficient theoretical-experimental processes of optimization are available in the aircraft industry. Presented is the state of the art of the reflection and application of optimization, i.e., the latter's targets and tools, and some results and perspectives in combat aircraft design are reviewed. Author

N88-13322# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
FUNDAMENTALS OF FIGHTER AIRCRAFT DESIGN: ENGINE INTAKE AND AFTERBODY
J. LEYNAERT *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 39 p Oct. 1987 Previously announced in IAA as A87-21014
Avail: NTIS HC A13/MF A01

Basic conditions, study parameters, and various solutions of fighter intake and afterbody (except VTOL) are reviewed. Airframe integration and intake adaptation to the flight Mach number are discussed. The following topics of intake flow are analyzed: buzz phenomena, internal bleed flow, high incidence, low speed, mean flow, distortion index, and unsteady distortion. The afterbody discussion covers variable geometry, thrust vectoring, and reverse. Wind tunnel test techniques are also described. Author

N88-13323# British Aerospace Public Ltd. Co., Kingston-upon-Thames (England).
AIRFRAME/STORE COMPATIBILITY
C. L. BORE *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 27 p Oct. 1987
Avail: NTIS HC A13/MF A01

By considering the various parameters dominating the value of a fighter air force, those terms can be isolated which respond to influences of store release features. It is shown that stores affect the transport capacity of the air force through the lift/drag ratio, the availability factor through the agility term, and the target-killing factor through the delivery accuracy term. The physical effects of store installation are then examined, and ways identified to minimize undesirable effects. Thus, drag prediction and drag reduction are considered in some depth. The effects of drag on the agility of the aircraft are examined and stability and flutter effects are reviewed. Store release conditions are reviewed. Finally, some recent approaches to store/airframe integration are considered. Author

N88-13324# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter and Military Aircraft Group.
AEROELASTICITY AND OPTIMIZATION IN FIGHTER AIRCRAFT DESIGN
H. GOEDEL and H. HOERNLEIN *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 15 p Oct. 1987
Avail: NTIS HC A13/MF A01

Constraint functions and their differentiations are given for the most interesting physical disciplines of structural optimization and well-known optimization techniques are mentioned. Because of the growing significances of iterative methods a large space has been conceded to the iterative solution of linear equation systems and its use in various algorithms. It is shown that big computer time saving effects would be achieved if the special characteristics of the physical formulation could be exploited mathematically. Author

N88-13325# British Aerospace Public Ltd. Co., Preston (England).
MATERIALS FOR FIGHTER AIRCRAFT
R. J. SELLARS *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 17 p Oct. 1987 Sponsored in part by Ministry of Defence, United Kingdom
Avail: NTIS HC A13/MF A01

Of the many important decisions to be made during the initial conception and design of advanced fighter aircraft, one of the most critical is that made by the materials engineer. Together with the designer, he will recommend the type of material to be incorporated into the aircraft's structure. Such recommendations, while respecting the criteria of minimum mass and minimum cost, must also ensure that the structure will possess a long life and be simple to service and maintain. Discussed are some of the new materials and production processes available for use on advanced fighter aircraft. Comparisons are made between the advanced light alloys now becoming available (i.e., aluminum-lithium), and the latest intermediate modulus fibers for use in carbon fiber components. Author

N88-13326# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter and Military Aircraft Div.
THE ROLE OF EXPERIMENTAL INVESTIGATION AND COMPUTATIONAL FLUID DYNAMICS DURING FIGHTER AIRCRAFT DESIGN
P. W. SACHER *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 26 p Oct. 1987
Avail: NTIS HC A13/MF A01

In a discussion of the role of experimental investigation and computational fluid dynamics in fighter aircraft design the following topics are reviewed: (1) two ways to simulate compressible flowfields, advantages versus disadvantages of numerical and experimental investigations; (2) general trends in time/speed and costs in experiment and computation; (3) state of the art in numerical aerodynamics; (4) model for numerical simulation; and

(5) applications and typical results. In a discussion of wind tunnel technology, the following topics are examined: (1) results from wind tunnel/critical review; (2) effect of Reynolds number; (3) wind tunnel effects; (4) the role of CFD during wind tunnel testing; and (5) the role of wind tunnels during configuration development. In conclusion, it is felt that the computer is not about to replace the wind tunnel, the role of computers is a complementary one to save time and costs and to improve the quality of the final product. F.M.R.

N88-13327# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Aerodynamic Dept.
REQUIREMENTS AND RECOMMENDATIONS FOR THE DEVELOPMENT OF THEORETICAL CODES AND EXPERIMENTAL FACILITIES IN THE NEAR FUTURE
B. COSTES *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 15 p Oct. 1987
Avail: NTIS HC A13/MF A01

In order to properly use all available tools, the aircraft designer has to be acquainted with both their good qualities and shortcomings. This guides the improvement studies in a context characterized by the following: the general development of the potential of methods and calculation means, wind tunnels and relevant instrumentation; the new reuirements for aircraft performance and the ever-growing industrial risks. The incoming developments for various levels of calculation codes, used for an industrial design or for fundamental research are examined. Also, the improvements needed for wind tunnels and testing methods are examined, depending on the character of the studies to be carried out. Examples permit a definition of the present state of the art and an examination of the improvements under study which may be exploitable in the not too distant future. Author

N88-13328# Materials Research Labs., Ascot Vale (Australia).
AN EXAMINATION OF COATING FAILURE ON WING PIVOT FITTINGS OF F111 AIRCRAFT
L. V. WAKE May 1987 34 p
(AD-A185028; MRL-R-1060) Avail: NTIS HC A03/MF A01 CSCL 11C

Failure of replacement coatings on the wing pivot fittings in integral wing fuel tanks of F111 aircraft has resulted in serious corrosion and pitting on critical sections of the fittings. Failed paint flakes from the fittings were characterized by adhesive detachment of the epoxy polyamide priming coat. Examination of fuel and moisture resistance of a range of possible coatings has been undertaken against those currently in use. The results suggest that coatings based on epoxy polymide resins are sensitive to glycol ether compounds employed as fuel system icing inhibitors in aviation turbine fuels. A more resistant epoxy polyurethane paint coating has therefore been proposed for use on the inspection areas of the fittings. It is also recommended that respraying over existing coatings inside the wing fuel tanks and on the fittings away from the inspection areas, a practice that has led to a series of intercoat adhesion failures following overhaul, be discontinued. Author (GRA)

N88-13329# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
AEROELASTIC ANALYSIS OF MODERN TRANSPORT AIRCRAFT [ANALYSE AEROELASTIQUE DES AVIONS MODERNES DE TRANSPORT]
J. ROUSTAN and M. CURBILLON 1987 15 p In FRENCH; ENGLISH summary
(SNIAS-872-111-102; ETN-88-91185) Avail: NTIS HC A02/MF A01

The method used by an aircraft manufacturer to take into consideration static aeroelastic phenomena and to estimate the quantitative effects is described. ESA

N88-13330# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
DAMAGE CONSIDERATIONS IN SIZING AIRCRAFT CELLS. LIFE PREDICTIONS [PRISE EN COMPTE DE L'ENDOMMAGEMENT DANS LE DIMENSIONNEMENT DES CELLULES D'AVIONS. PREDICTIONS DES DUREES DE VIE]
J. M. THOMAS and B. HECIAK 1986 18 p In FRENCH Presented at Conference Endommagement Mecanique des Materiaux et des Structures GAMI, Paris, France, 25-26 Nov. 1986
(SNIAS-872-111-116; ETN-88-91197) Avail: NTIS HC A03/MF A01

Fatigue computation and modeling procedures adopted by an aircraft manufacturer are presented, and a damage tolerance application to A-300 and A-310 aircraft is described. Design and control procedures are listed. ESA

N88-14091# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
DAMAGE TOLERANCE OF STIFFENED-SKIN STRUCTURES: PREDICTION AND EXPERIMENTAL VERIFICATION
H. VLIEGER 2 Jun. 1986 87 p Presented at the 19th National Symposium on Fracture Mechanics, San Antonio, Tex., 30 Jun. - 2 Jul. 1986
(Contract NIVR-1904; NIVR-1823)
(NLR-MP-86041-U; B8707397; ETN-88-91328) Avail: NTIS HC A05/MF A01

Consequences of application of damage tolerance airworthiness requirements for transport aircraft in designing stiffened-skin structures to be safe under all operational load conditions are discussed. Computer programs to provide analytical tools to demonstrate that design meets the required residual strength and crack propagation properties were developed. The principles underlying the calculation procedures used to predict the residual strength of stiffened panels with a skin of ductile material (like 2024) are included. Applications of the programs to practical stiffened skin structures are presented together with analysis test correlations. ESA

N88-14092*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AERODYNAMIC AND PROPELLER PERFORMANCE CHARACTERISTICS OF A PROPFAN-POWERED, SEMISPAN MODEL
ALAN D. LEVIN, RONALD C. SMITH, and RICHARD D. WOOD Dec. 1985 149 p
(NASA-TM-86705; A-85175; NAS 1.15:86705) Avail: NTIS HC A07/MF A01 CSCL 01C

A semispan wing/body model with a powered propeller was tested to provide data on a total powerplant installation drag penalty of advanced propfan-powered aircraft. The test objectives were to determine the total power plant installation drag penalty on a representative propfan aircraft; to study the effect of configuration modifications on the installed powerplant drag; and to determine performance characteristics of an advanced design propeller which was mounted on a representative nacelle in the presence of a wing. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A88-16913#
INTEGRATING AVIONICS INTO THE CONCEPTUAL DESIGN PHASE OF AERONAUTICAL SYSTEMS
GORDON F. QUINN and MICHAEL J. BREZA (USAF, Directorate of Design Analysis, Wright-Patterson AFB, OH) IN: Avionics in conceptual system planning; Proceedings of the Eighth Annual IEEE Symposium, Dayton, OH, Dec. 3, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 15-18.

The role of avionics in the aircraft design process is examined, and it is shown why avionics system parameters should be subjected to iteration with airframe, propulsion, and armament parameters in the early conceptual design tradeoff process. It is noted that current aircraft design synthesis and analysis procedures can be modified or expanded to incorporate an avionics suite synthesis and analysis procedure that is integral to the overall aeronautical system design methodology. It is emphasized that the incorporation of avionics considerations into the aeronautical system design process with quantifiable measures of merit will significantly improve the performance-to-cost ratio of new aeronautical weapon systems. V.L.

A88-16915#
INTEGRATED AVIONICS - WATERSHED IN AERONAUTICAL SYSTEMS DEVELOPMENT
JOHN M. BORKY (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Avionics in conceptual system planning; Proceedings of the Eighth Annual IEEE Symposium, Dayton, OH, Dec. 3, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 29-34.

Trends in avionics technology and systems for aeronautical weapon systems are reviewed, with attention given to functional integration, R&M, digital electronics, and modularity. Design ground rules which must be imposed to realize the full potential of avionics systems are considered; emphasis is placed on architecture, R&M design, standardization, and life cycle upgrading. Finally, implications for system planning are discussed. B.J.

A88-17142#
ON MICROCOMPUTER INTELLIGENT MONITOR OF AIRCRAFT SIMULATION SYSTEM
KANGBAO LI and WEIQIN WANG Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 5, Oct. 1987, p. 427-436. In Chinese, with abstract in English. refs

The Intelligent Monitor System (IMS), a microcomputer-based system integrating the mechanism, electrical devices, and instruments of an aircraft simulation system, is described. The microcomputer operates as the front-end of a minicomputer and performs pretest, pretreatment, and various simulation monitoring functions. The system architecture, principal functions, and software support are described in detail. V.L.

A88-17342#
GPS GROUND PROXIMITY WARNING SYSTEM
MARK A. STURZA (Litton Aero Products, Moorpark, CA) IN: Institute of Navigation, National Technical Meeting, Anaheim, CA, Jan. 20-23, 1987, Proceedings . Washington, DC, Institute of Navigation, 1987, p. 161-163.

The paper describes a ground proximity warning system (GPWS) using GPS altitude and a stored table of highest points in each area. The GPS-GPWS can operate in conjunction with conventional GPWSs to reduce the incidence of aircraft-ground collisions. User acceptance of the GPS-GPWS is contingent on the achievement of an acceptably low false alarm rate at a reasonable cost. A secondary application of the GPS-GPWS is as a restricted airspace avoidance system. B.J.

A88-18203
TRUE AIRSPEED MEASUREMENT WITH A COHERENT LASER RADAR
B. MORBIEU and J. MANDLE (Crouzet, S.A., Valence, France) IN: International Conference on Advanced Infrared Detectors and Systems, 3rd, London, England, June 3-5, 1986, Proceedings . London, Institution of Electrical Engineers, 1986, p. 154-157. DRET-sponsored research.

The present functional breadboard for a coherent laser radar anemometer, which is based on a CO2 Doppler lidar technique, has been flight tested aboard a Puma helicopter and a Caravelle aircraft. The source is a DC-excited CO2 waveguide laser; the detector is a cadmium mercury telluride photodiode cooled to 77 K by a Joule-Thomson device. The focusing optics involve an off-axis Dall-Kirkham telescope with 75-mm effective aperture. It is important that sensor sensitivity be calibrated, in order to know the altitude at which the equipment may be usefully flown. O.C.

N88-13331# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
WORKSHOP ON AVIONICS CORROSION CONTROL
Sep. 1987 80 p Workshop held in Hovik, Norway, 16-17 Apr. 1986 Original contains color illustrations
(AGARD-R-733; ISBN-92-835-0428-3) Avail: NTIS HC A05/MF A01

This document contains the keynote and other presentations made at a Workshop held by the Structures and Materials Panel on Avionics Corrosion. The discussion covered the problem's extent, the state of the corrosion-prevention art, the prospects for innovative corrosion avoidance techniques, including the substitution of nonmetallic for metallic materials and preventive maintenance techniques.

N88-13332# Naval Air Development Center, Warminster, Pa.
AVIONIC CORROSION
IRVING S. SHAFFER *In* AGARD Workshop on Avionics Corrosion Control 10 p Sep. 1987
Avail: NTIS HC A05/MF A01

The paper discusses the major causes of corrosion in the Navy's avionic equipment and provides specific examples of corrosion failures. Maintenance and readiness data summaries are included to denote further the corrosion problem severity. Corrective measures in design, testing, and maintenance are reviewed. Author

N88-13333# Air Force Materials Lab., Wright-Patterson AFB, Ohio. Electronic Failure Analysis Group.
CORROSION OF ELECTRONIC COMPONENTS
BILL DOBBS *In* AGARD Workshop on Avionics Corrosion Control 26 p Sep. 1987 Original document contains color illustrations
Avail: NTIS HC A05/MF A01

The Materials Laboratory Electronic Failure Analysis Group supports US Air Force electronic systems in the areas of materials and manufacturing processes. A large majority of electronic failures is caused my materials and manufacturing process defects. It has been found that corrosion of electronic components is the cause of failure in about 20% of items submitted for testing. Airframe corrosion prevention requirements are well documented. It would be beneficial to the Air Force if corrosion prevention in electronic systems were as well documented. Existing documents, such as T.O. 1-1-689 and NAVAIR 16-1-540, are a step in the right direction. However, compulsory MIL specifications should be applied, since corrosion in Air Force electronic systems contributes significantly to system failure. Failure analysis investigations have been conducted for aircraft circuit breakers, antennas, printed wiring boards, fuses, linear steering position transducers, stepper motors, accelerometers, disk recorder heads, and electrical connectors. The cause of failure is identified and means of preventing future occurrence are presented. Author

N88-13334# Commanders Naval Air Forces US Atlantic and Pacific Fleets, Norfolk, Va. Material Advisor.
US NAVAL AIR FORCE AVIONIC AND ELECTRICAL SYSTEM CORROSION PREVENTION AND CONTROL MAINTENANCE
G. T. BROWNE *In* AGARD Workshop on Avionics Corrosion Control 20 p Sep. 1987
Avail: NTIS HC A05/MF A01

A study of premature failures of installed avionics, electrical equipment, and systems experienced in US Fleet operational aircraft in the 1960s and 1970s has been reported. These failures were caused by corrosion, water intrusion, and other contaminating agents. To reverse this trend the Commanders Naval Air Forces US Atlantic and Pacific Fleets (COMNAVAIRLANT) (COMNAVAIRPAC) requested that Commander Naval Air System Command (COMNAVAIRSYSCOM) develop a corrosion prevention and control program for avionics, electrical and installed systems used in naval aircraft. COMNAVAIRSYSCOM directed the Naval Air Development Center (NAVAIRDEVCEN) to develop the program together with a technical manual.\A conference of interested parties was held in 1976 and action initiated to develop the program and technical manual for use by the fleet technicians. Author

N88-13335# Industrial Marine Products Group Ltd., Dartmouth (Nova Scotia). Aerospace Engineering Div.
CORROSION IN AVIONICS AND ASSOCIATED EQUIPMENT; CAUSE, EFFECT AND PREVENTION
R. G. BARTLETT and E. G. EDGAR *In* AGARD Workshop on Avionics Corrosion Control 9 p Sep. 1987
Avail: NTIS HC A05/MF A01

Addressed, with examples, are the cause, effect, and prevention of corrosion as it relates to Canadian Forces aircraft. It deals particularly with aircraft operated in a marine environment and is based on the experience of the authors during previous service with the Department of National Defence and in their present employment in industry. The Canadian Forces corrosion prevention treatment program is also mentioned and discussed briefly. Author

N88-13336# Societe d'Applications Generales d'Electricite et de Mecanique, Paris (France).
AVIONICS AND CORROSION
ALAIN POINTET and CHRISTOPHE TURPIN-INVERNON *In* AGARD Workshop on Avionics Corrosion Control 6 p Sep. 1987
Avail: NTIS HC A05/MF A01

Avionic manufacturing and environmental conditions are responsible for corrosion and/or make easier the action of corrosion in the various parts of an avionics system. A brief survey is made of environmental conditions affecting avionics, how to reproduce them in accordance with norms and which associated problems might occur. All parts of an avionic system are examined, i.e., housings, printed circuit boards, hybrid and integrated circuits. For each component, examples and solutions are given. Author

07

AIRCRAFT PROPULSION AND POWER

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

A88-17139#
A STUDY OF BLADE VIBRATION INDUCED BY NON-UNIFORM CASCADE AND ITS WAKES IN TURBO-ENGINE
SHAOZE OUYANG, DAKUAN SHEN, and QUN CHEN Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 5, Oct. 1987, p. 401-407. In Chinese, with abstract in English. refs

A method for calculating the wakes and blade vibration response is presented which is based on the equilibrium energy input to and output from the blade. Calculations are carried out for two kinds of nonuniform cascades (one with an unequal pitch and the other with an unequal stagger angle) and a uniform cascade. It is found that large distortions of flow produce many new components of the excitation force, particularly low-order excitation components. The low-order components make it possible for the blade to have low-order resonances in the engine operation range. V.L.

A88-18493#
TORSIONAL-VIBRATION DAMPING OF CRANKSHAFTS IN AIRCRAFT PISTON ENGINES. I [TLUMIENIE DRGAN SKRETNYCH WALOW KORBOWYCH LOTNICZYCH SILNIKOW TLOKOWYCH. I]
MICHAL LAGOSZ and STEFAN SZCZECINSKI (Wojskowa Akademia Techniczna, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 42, July 1987, p. 18-20. In Polish.

Types of torsion dampers for aircraft piston engine crankshaft assemblies are described. Attention is given to the basic design features, the dynamic characteristics, and the applications of the dampers. The possibility of a blade dynamic effect on the torsional vibrations of the crankshaft is indicated. B.J.

A88-18576#
TORSIONAL-VIBRATION DAMPING OF CRANKSHAFTS IN AIRCRAFT PISTON ENGINES. II [TLUMIENIE DRGAN SKRETNYCH WALOW KORBOWYCH LOTNICZYCH SIKNIKOW TLOKOWYCH. II]
MICHAL LAGOSZ and STEFAN SZCZECINSKI (Wojskowa Akademia Techniczna, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 42, Aug. 1987, p. 7-9. In Polish. refs

A88-18577#
SPECIAL OPERATING MODES OF THE CLUTCHES OF HELICOPTER POWER UNIT REDUCTION GEARS [OSOBLIWE STANY PRACY SPRZEGIEL GLOWNYCH REDUKTOROW ZESPOLU NAPEDOWEGO SMIGLOWCOW]
RYSZARD GRUCHALSKI (WSK, Rzeszow, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 42, Aug. 1987, p. 18-20. In Polish.

A88-19267
PW4000 - PRATT & WHITNEY'S BIG FAN BIDS FOR THE FUTURE
JULIAN MOXON Flight International (ISSN 0015-3710), vol. 132, Oct. 31, 1987, p. 30-34.

An account is given of the design features and performance characteristics of the 56,000-60,000 lb thrust range PW4000 high bypass turbofan engine, which has the potential for 65,000 lb of thrust upon incorporation of an improved high pressure turbine. The PW4000 design stresses reliability and reduced maintenance costs over fuel efficiency, with a 25-percent cut in maintenance costs and a 7-percent reduction in fuel burn relative to one of the current engines of this class, the JT9D-7R4. Potential applications

of the engine include the A310, MD-11, and B747-400 airliners. Performance comparisons are made with the CF6-80C2 and RB.211-524 engines that have targeted similar applications. O.C.

A88-19669*# Sverdrup Technology, Inc., Cleveland, Ohio.
ANALYTICAL DETERMINATION OF PROPELLER PERFORMANCE DEGRADATION DUE TO ICE ACCRETION
T. L. MILLER (Sverdrup Technology, Inc., Cleveland, OH), K. D. KORKAN (Texas A & M University, College Station), and R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH) Journal of Aircraft (ISSN 0021-8669), vol. 24, Nov. 1987, p. 768-775. refs

A computer code capable of computing the propeller performance for clean, glaze, or rime ice propeller configurations to determine the performance degradation resulting from a given icing encounter has been developed. The inviscid, incompressible flowfield at each specified propeller radial location is first computed using the Theodorsen method. A droplet trajectory computation then calculates the droplet impingement points and airfoil collection efficiency for each radial location. User-selectable empirical correlations are available for determining the aerodynamic penalties due to ice accretion. Propeller performance is finally computed using strip analysis for either the clean or iced propeller. In the iced mode, the thrust and torque coefficient equations are modified by the drag and lift coefficient increments due to ice to obtain the appropriate iced values. Comparison with available experimental propeller icing data shows generally good agreement. The code's capability of properly predicting the thrust coefficient, power coefficient, and propeller efficiency of an iced propeller is shown to be dependent on the choice of empirical correlation employed as well as on the proper specification of the radial icing extent and propeller blade angle. Author

A88-20192
SCRAMJET - THE NASP PROPULSION GOAL
BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 17, Nov. 1987, p. 1207-1209.

An evaluation is made of the propulsion system options open to the X-30 hypersonic cruise research vehicle whose task is to serve as a technology testbed for the National Aerospace Plane (NASP). It is noted that no scramjet has yet been successfully flown, and that ground testing has proceeded only as far as Mach 8; CFD studies conducted on supercomputers can only be validated by flight testing with the X-30. Attention is given to continuing engineering speculation on the use of high-Mach number turbine cycles in place of the ramjet that would propel the NASP to initial scramjet operation speeds, and which would, like the scramjet, employ hydrogen fuel. O.C.

N88-13231# Johns Hopkins Univ., Laurel, Md. Applied Physics Lab.
HYPERSONIC AIRBREATHING PROPULSION: EVOLUTION AND OPPORTUNITIES
P. J. WALTRUP *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 29 p Nov. 1987
Avail: NTIS HC A24/MF A01

A history of the evolution of airbreathing propulsion, with emphasis on the development of supersonic combustion ramjet (scramjet) engines, is presented. The current status of scramjet engines is discussed and deficiencies in fundamental and applied data and/or knowledge, which comprise opportunities for future work, are noted. Author

N88-13337# Massachusetts Inst. of Tech., Cambridge. Gas Turbine Lab.
VELOCITY SCALED AEROELASTIC TESTING OF AN UNDUCTED FAN
ERIC H. DUCHARME and EDWARD F. CRAWLEY Sep. 1987 251 p Sponsored in part by General Electric Co., Evendale, Ohio
(GTL-191) Avail: NTIS HC A12/MF A01

The aeroelastic behavior of an unducted fan is investigated through a procedure for the sub-velocity scaled testing of anisotropic aeroelastic models. The flutter equations of motion and scaling laws for an anisotropic, rotating model are developed. The scaling laws indicate that by proper choice of model geometry, stiffness, and density, all of the important aeroelastic similarity parameters except for the Mach number can be satisfied in a sub-velocity scaled test. The development of the model building technology to construct reduced stiffness anisotropic models for sub-velocity scaled testing is then described. With the validity of the sub-velocity scaled procedure established, the versatility in the low model stresses was exploited through the construction of models which allowed for the parametric variation of such aeroelastic parameters as: sweep, mass distribution, solidity, blade laminate, and mistuning. The flutter dependence of the models on these parameters was experimentally demonstrated. A flutter model employing the determined blade frequencies and mode shapes for the structural model and a strip theory based on a 2D unsteady cascade theory for the model is presented. Author

N88-13339 Iowa State Univ. of Science and Technology, Ames.
EFFECTS OF FREE STREAM TURBULENCE, REYNOLDS NUMBER AND INCIDENCE ANGLE ON AXIAL TURBINE CASCADE PERFORMANCE Ph.D. Thesis
S. B. VIJAYARAGHAVAN 1987 292 p
Avail: Univ. Microfilms Order No. DA8716834

A large-scale, low-speed, axial turbine cascade was designed using a fast interactive design code and tested over a range of turbulence level and incidence angle for Reynolds numbers typical of gas turbines. Thirty-six tests were done primarily to investigate the profile boundary layer development under different inlet flow conditions. Glue-on hot film gages and surface flow visualizations were used to identify transition and separation over the airfoil surface. In addition to transition measurements, overall cascade performance was determined from static pressure distributions on the airfoil and detailed five-hole pressure probe and hot-wire probe traverses in an exit plane of the cascade. The measured transition start and end points were compared against predictions using existing transition models. Also, the measured losses were compared against predicted losses from boundary layer calculations based on dissipation integral and finite difference analyses.
Dissert. Abstr.

N88-13340# Dayton Univ., Ohio.
CORRELATION OF AIR PRESSURE DROP AND FLAME ARRESTOR CHARACTERISTICS FOR EXPLOSION SUPPRESSION MATERIALS Final Report, 1 Feb. 1985 - 31 Jan. 1986
JOHN E. MINARDI and MAURICE O. LAWSON Nov. 1986 55 p
(Contract F33615-84-C-2411)
(AD-A184960; UDR-TR-86-115; AFWAL-TR-86-2087) Avail: NTIS HC A04/MF A01 CSCL 13L

A theory is presented for predicting the pressure rise versus void fraction in the flame tube located at Wright-Patterson Air Force Base. The effects of initial temperature and pressure are included in the theory. A study of the heat losses in the flame tube is presented and an empirical fit to the cool down phase of the pressure time history data is developed. An equation for correlating the friction factors measured in the pressure drop rig with the hydraulic diameter of the foam is developed. An equation for the critical hydraulic diameter (or quenching diameter) as a function of initial pressure and temperature is also given in the report. The theoretical results are compared to experimental data and are shown to compare favorably. GRA

N88-13341# Naval Postgraduate School, Monterey, Calif.
STUDY OF ELECTROSTATIC MODULATION OF FUEL SPRAYS TO ENHANCE COMBUSTION PERFORMANCE IN AN AVIATION GAS TURBINE M.S. Thesis
WALTER W. MANNING Jun. 1987 104 p
(AD-A184967) Avail: NTIS HC A06/MF A01 CSCL 21E

The influence of electrostatic and electrohydrodynamic charging on hydrocarbon fuel spray patterns and droplet atomization has been investigated. Research was performed in a combustion

environment with an Allison T-56 combustor liner and an unmodified pressure-jet atomizer fuel nozzle. High-voltage probes and a variable-geometry probe insertion device were developed to assess the effectiveness of probe type and location on fuel spray modification and modulation. Exhaust gas temperatures and temperature profiles were measured to determine changes in the combustor's thermal profile and combustion efficiency. JP-4, JET-A and Number-2 Diesel fuels were tested to analyze electrically-assisted atomization effectiveness relative to off-design fuel performance. GRA

N88-13342# Naval Postgraduate School, Monterey, Calif.
AN EXPERIMENTAL INVESTIGATION OF THE IGNITION AND FLAMMABILITY LIMITS OF VARIOUS HYDROCARBON FUELS IN A TWO-DIMENSIONAL SOLID FUEL RAMJET M.S. Thesis
RICHARD C. WOOLDRIDGE Jun. 1987 43 p
(AD-A184968) Avail: NTIS HC A03/MF A01 CSCL 21D

An experimental investigation was conducted to study the effects of inlet step height on ignition and flammability limits and recirculation zone and boundary layer combustion phenomena of various hydrocarbon fuels. A windowed two-dimensional solid fuel ramjet (SFRJ) was utilized. Hydrocarbon fuels were burned under conditions similar to the actual flight were studied using a variable geometry inlet, an automatic data acquisition system, and high speed motion pictures of the interior of the combustion chamber at the recirculation zone and the boundary layer development region. Data was obtained at a mass flux of 0.2 lbm/sq in/sec at a nominal air inlet temperature of 1000 R with pressures ranging from 100 to 150 psia. GRA

N88-13343# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
SIMULATED SERVICE TEST BEHAVIOR OF VARIOUS INTERNAL AND EXTERNAL COATINGS APPLIED ON CF6-50 FIRST STAGE TURBINE BLADES
A. J. A. MOM and J. A. M. BOOGERS 4 Mar. 1986 24 p Presented at the Conference on High Temperature Alloys for Gas Turbines and Other Applications, Liege, Belgium, 6-9 Oct. 1986 Previously announced in IAA as A87-49556
(NLR-MP-86018-U; B8709826; ETN-88-91327) Avail: NTIS HC A03/MF A01

Simulated service testing of protective external overcoating and internal coating on the the CF6-50 first stage turbine blade is described. Service life is limited by the external coating life and corrosion attack in the uncoated cooling passages. Results indicate that external overcoats in most cases improve the corrosion behavior of the CF6-50 blades. The best external protection is an Al/Si slurry type of coating on top of Codep B. The application of internal coatings considerably improves corrosion performance of the CF6-50 blade. Internal corrosion is virtually eliminated by the application of Al/Si or Al gas phase coatings. ESA

N88-13344# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
APPLICATION OF MODIFIED LOSS AND DEVIATION CORRELATIONS TO TRANSONIC AXIAL COMPRESSORS
M. CETIN, A. S. UECER, CH. HIRSCH, and G. K. SEROVY Nov. 1987 74 p
(AGARD-R-745; ISBN-92-835-0346-4) Avail: NTIS HC A04/MF A01

The goal was to analyze the transonic compressor tests available in the open literature and to propose possible improvements in total loss and turning correlations. From the work performed six conclusions could be drawn for the achievement of better loss predictions. A comparison with results of a two-stage compressor showed that the results of the new correlation set were satisfactory. For more accurate predictions a consistent end-wall boundary layer and secondary loss calculation method must be applied; in multi-stage compressors, spanwise loss mixing procedures must be used. Author

N88-13345*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REGRESSED RELATIONS FOR FORCED CONVECTION HEAT TRANSFER IN A DIRECT INJECTION STRATIFIED CHARGE ROTARY ENGINE
CHI M. LEE and HAROLD J. SCHOCK (Michigan State Univ., East Lansing.) 1988 24 p Proposed for presentation at the 1988 International Congress and Exposition, Detroit, Mich., 29 Feb. - 4 Mar. 1988; sponsored by the Society of Automotive Engineers, Inc.
(NASA-TM-100124; E-3689; NAS 1.15:100124) Avail: NTIS HC A03/MF A01 CSCL 20E

Currently, the heat transfer equation used in the rotary combustion engine (RCE) simulation model is taken from piston engine studies. These relations have been empirically developed by the experimental input coming from piston engines whose geometry differs considerably from that of the RCE. The objective of this work was to derive equations to estimate heat transfer coefficients in the combustion chamber of an RCE. This was accomplished by making detailed temperature and pressure measurements in a direct injection stratified charge (DISC) RCE under a range of conditions. For each specific measurement point, the local gas velocity was assumed equal to the local rotor tip speed. Local physical properties of the fluids were then calculated. Two types of correlation equations were derived and are described in this paper. The first correlation expresses the Nusselt number as a function of the Prandtl number, Reynolds number, and characteristic temperature ratio; the second correlation expresses the forced convection heat transfer coefficient as a function of fluid temperature, pressure and velocity. Author

N88-13346*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
UNSTEADY AERODYNAMICS OF AN OSCILLATING CASCADE IN A COMPRESSIBLE FLOW FIELD
DANIEL H. BUFFUM, DONALD R. BOLDMAN, and SANFORD FLEETER (Purdue Univ., West Lafayette, Ind.) 1987 22 p Presented at the 4th Symposium on Unsteady Aerodynamics and Aeroelasticity of Turbomachines and Propellers, Aachen, Fed. Republic of Germany, 6-10 Sep. 1987; sponsored by Aachen Univ.
(NASA-TM-100219; E-3830; NAS 1.15:100219) Avail: NTIS HC A03/MF A01 CSCL 20E

Fundamental experiments were performed in the NASA Lewis Transonic Oscillating Cascade Facility to investigate and quantify the unsteady aerodynamics of a cascade of biconvex airfoils executing torsion-mode oscillations at realistic reduced frequencies. Flush-mounted, high-response miniature pressure transducers were used to measure the unsteady airfoil surface pressures. The pressures were measured for three interblade phase angles at two inlet Mach numbers, 0.65 and 0.80, and two incidence angles, 0 and 7 deg. The time-variant pressures were analyzed by means of discrete Fourier transform techniques, and these unique data were then compared with predictions from a linearized unsteady cascade model. The experimental results indicate that the interblade phase angle had a major effect on the chordwise distributions of the airfoil surface unsteady pressure, and that reduced frequency, incidence angle, and Mach number had a somewhat less significant effect. Author

N88-13347*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A NUMERICAL STUDY OF THE EFFECTS OF CURVATURE AND CONVERGENCE ON DILUTION JET MIXING
J. D. HOLDEMAN, R. REYNOLDS, and C. WHITE (Garrett Turbine Engine Co., Phoenix, Ariz.) 1987 19 p Presented at the 23rd Joint Propulsion Conference, San Diego, Calif., 29 Jun. - 2 Jul. 1987; sponsored by AIAA, SAE, ASME and ASEE
(NASA-TM-89878; E-3548; NAS 1.15:89878) Avail: NTIS HC A03/MF A01 CSCL 21E

An analytical program was conducted to assemble and assess a three-dimensional turbulent viscous flow computer code capable of analyzing the flow field in the transition liners of small gas

turbine engines. This code is of the TEACH type with hybrid numerics, and uses the power law and SIMPLER algorithms, an orthogonal curvilinear coordinate system, and an algebraic Reynolds stress turbulence model. The assessments performed in this study, consistent with results in the literature, showed that in its present form this code is capable of predicting trends and qualitative results. The assembled code was used to perform a numerical experiment to investigate the effects of curvature and convergence in the transition liner on the mixing of single and opposed rows of cool dilution jets injected into a hot mainstream flow. Author

N88-14093*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA SUPERSONIC STOVL PROPULSION TECHNOLOGY PROGRAM
PETER G. BATTERTON and BERNARD J. BLAHA 1987 20 p Presented at the International Powered Lift Conference, Santa Clara, Calif., 7-10 Dec. 1987; sponsored by the Society of Automotive Engineers
(NASA-TM-100227; E-3846; NAS 1.15:100227) Avail: NTIS HC A03/MF A01 CSCL 21E

Supersonic capable STOVL fighter/attack aircraft can provide capabilities for close support and air superiority which will be highly desirable in the future. Previous papers in this session described the historical aspects, trade-offs, and requirements for powered lift propulsion systems, and it is shown that propulsion technology is more key to the success of this type of aircraft then for any previous fighter/attack aircraft. The NASA Lewis Research Center program activities which address required propulsion technology development are discussed. Several elements of this program were initiated which address hot gas ingestion and ejector augmenter performance and some preliminary results are shown. In addition, some additional near-term research activity plans and the new Powered Lift Facility (PLF) research capability are presented. Author

N88-14094*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL STUDY OF CHEMICALLY REACTING FLOWS USING AN LU SCHEME Final Contractor Report
JIAN SHUN SHUEN (Sverdrup Technology, Inc., Cleveland, Ohio.) and SEOKKWAN YOON 1988 23 p Presented at the 26th Aerospace Sciences Meeting, Reno, Nev., 11-14 Jan. 1988; sponsored by AIAA
(Contract NAS3-24105)
(NASA-TM-180882; E-3875; NAS 1.26:180882; AIAA-88-0436) Avail: NTIS HC A03/MF A01 CSCL 21E

A new computational fluid dynamic code has been developed for the study of mixing and chemical reactions in the flow fields of ramjets and scramjets. The code employs an implicit finite volume, lower-upper symmetric successive overrelaxation scheme for solving the complete two-dimensional Navier-Stokes equations and species transport equations in a fully-coupled and very efficient manner. The combustion processes are modeled by an 8-species, 14-step finite rate chemistry model whereas turbulence is simulated by a Baldwin-Lomax algebraic model. The validity of the code is demonstrated by comparing the numerical calculations with both experimental data and previous calculations of a cold flow helium injection into a straight channel and premixed hydrogen-air reacting flows in a ramped duct. The code is then used to calculate the mixing and chemical reactions of a hydrogen jet transversely injected into a supersonic airstream. Results are presented describing the flow field, the recirculation regions in front and behind the injector, and the chemical reactions. Author

N88-14095*# Hamilton Standard, Windsor Locks, Conn.
ANALYSIS AND TEST EVALUATION OF THE DYNAMIC STABILITY OF THREE ADVANCED TURBOPROP MODELS AT ZERO FORWARD SPEED Final Report
ARTHUR F. SMITH Dec. 1985 115 p
(Contract NAS3-22755)
(NASA-CR-175025; NAS 1.26:175025; HSER-11054) Avail: NTIS HC A06/MF A01 CSCL 01A

Results of static stability wind tunnel tests of three 62.2 cm (24.5 in) diameter models of the Prop-Fan are presented. Measurements of blade stresses were made with the Prop-Fans mounted on an isolated nacelle in an open 5.5 m (18 ft) wind tunnel test section with no tunnel flow. The tests were conducted in the United Technology Research Center Large Subsonic Wind Tunnel. Stall flutter was determined by regions of high stress, which were compared with predictions of boundaries of zero total viscous damping. The structural analysis used beam methods for the model with straight blades and finite element methods for the models with swept blades. Increasing blade sweep tends to suppress stall flutter. Comparisons with similar test data acquired at NASA/Lewis are good. Correlations between measured and predicted critical speeds for all the models are good. The trend of increased stability with increased blade sweep is well predicted. Calculated flutter boundaries generaly coincide with tested boundaries. Stall flutter is predicted to occur in the third (torsion) mode. The straight blade test shows third mode response, while the swept blades respond in other modes. Author

N88-14096*# Hamilton Standard, Windsor Locks, Conn.
ANALYSIS AND TEST EVALUATION OF THE DYNAMIC RESPONSE AND STABILITY OF THREE ADVANCED TURBOPROP MODELS AT LOW FORWARD SPEED Final Report
ARTHUR F. SMITH Dec. 1985 110 p
(Contract NAS3-22755)
(NASA-CR-175026; NAS 1.26:175026; HSER-11055) Avail: NTIS HC A06/MF A01 CSCL 01A

Results of wind tunnel tests at low forward speed for blade dynamic response and stability of three 62.2 cm (24.5 in) diameter models of the Prop-Fan, advanced turboprop, are presented. Measurements of dynamic response were made with the rotors mounted on an isolated nacelle, with varying tilt for nonuniform inflow. Low speed stall flutter tests were conducted at Mach numbers from 0.0 to 0.35. Measurements are compared to Eigen-solution flutter boundaries. Calculated 1P stress response agrees favorably with experiment. Predicted stall flutter boundaries correlate well with measured high stress regions. Stall flutter is significantly reduced by increased blade sweep. Susceptibility to stall flutter decreases rapidly with forward speed. Author

N88-14097*# Hamilton Standard, Windsor Locks, Conn.
LARGE-SCALE ADVANCED PROP-FAN (LAP) BLADE DESIGN Contractor Report, Sep. 1983 - Mar. 1984
JOHN A. VIOLETTE, WILLIAM E. SULLIVAN, and JAY E. TURNBERG 1984 181 p
(Contract NAS3-23051)
(NASA-CR-174790; NAS 1.26:174790; HSER-9246) Avail: NTIS HC A09/MF A01 CSCL 01C

This report covers the design analysis of a very thin, highly swept, propeller blade to be used in the Large-Scale Advanced Prop-Fan (LAP) test program. The report includes: design requirements and goals, a description of the blade configuration which meets requirements, a description of the analytical methods utilized/developed to demonstrate compliance with the requirements, and the results of these analyses. The methods described include: finite element modeling, predicted aerodynamic loads and their application to the blade, steady state and vibratory response analyses, blade resonant frequencies and mode shapes, bird impact analysis, and predictions of stalled and unstalled flutter phenomena. Summarized results include deflections, retention loads, stress/strength comparisons, foreign object damage resistance, resonant frequencies and critical speed margins, resonant vibratory mode shapes, calculated boundaries of stalled

and unstalled flutter, and aerodynamic and acoustic performance calculations. Author

N88-14370# Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec).
AERODYNAMIC DESIGN OF FIRST STAGE TURBINES FOR SMALL AERO ENGINES
U. OKAPUU *In* Von Karman Inst. for Fluid Dynamics, Small High Pressure Ratio Turbines 32 p 1987
Avail: NTIS HC A17/MF A01

Minimization of tip leakeage and limit loading are discussed. Results obtained with a 4.5:1 pressure ratio turbine having an aerodynamic loading of 2.11 indicate that very efficient turbines can be designed in loading and pressure ratio regimes of interest in the next generation of small aero engines. ESA

08

AIRCRAFT STABILITY AND CONTROL

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

A88-17143#
DESIGN OF AN ADAPTIVE CONTROL AUGMENTATION STABILITY SYSTEM FOR FIGHTER AIRCRAFT WHOSE FLIGHT ALTITUDE AND MACH NUMBER VARY
LIANGFU LEI and GUANGLUM JIANG Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 5, Oct. 1987, p. 437-446. In Chinese, with abstract in English. refs

An adaptive model is applied to the design of an adaptive control augmentation stability system for fighter aircraft characterized by variable flight altitude and Mach number. A generalized inverse method is used to design the feedforward gain and feedback gain of a conventional feedback loop under given flight conditions, with the conventional feedback loop designed to match the reference model. The design of the adaptive loop is based on Popov's superstability theory and the 'proportional plus integrated' adaptive control law. Digital simulation results are presented. V.L.

A88-17280
IMPORTANCE OF AERODYNAMICS ON HANDLING QUALITIES
R. W. PROUTY (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 15 p. refs

Aerodynamic interactions affecting the handling performance of helicopters are examined, reviewing the results of theoretical and wind-tunnel studies of conventional and advanced configurations. Drawings, diagrams, and graphs of typical data are provided, and particular attention is given to (1) increased pitching moments in low-speed flight (due to the impingement of main-rotor downwash on the horizontal stabilizer), (2) low dynamic pressure and random turbulence at the tail in high-speed flight, (3) tail-rotor instability in left sideward flight, and (4) tail-boom drag in right sideward flight. T.K.

A88-18024
FUNDAMENTALS OF HELICOPTER FLIGHT OPERATIONS: FLIGHT DYNAMICS [OSNOVY LETNOI EKSPLUATATSII VERTOLETOV: DINAMIKA POLETA]
ALEKSANDR MIKHAILOVI VOLODKO Moscow, Izdatel'stvo Transport, 1986, 264 p. In Russian. refs

The fundamentals of the flight dynamics of helicopters are examined with reference to stability, flight automation, characteristics of the rotor, and special flight conditions. The discussion covers maneuverability and controllability of helicopters, the dynamics of the rotor-powerplant system, takeoff and landing, and rotor and control system malfunctions. Particular attention is given to the physical phenomena underlying the principal flight limitations and flight safety. V.L.

A88-18219* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MODELING AERODYNAMIC DISCONTINUITIES AND ONSET OF CHAOS IN FLIGHT DYNAMICAL SYSTEMS
M. TOBAK, G. T. CHAPMAN (NASA, Ames Research Center, Moffett Field, CA), and A. UNAL (Santa Clara, University, CA) Annales des Telecommunications (ISSN 0003-4347), vol. 42, May-June 1987, p. 300-314. Previously announced in STAR as N87-17663. refs

Various representations of the aerodynamic contribution to the aircraft's equation of motion are shown to be compatible within the common assumption of their Frechet differentiability. Three forms of invalidating Frechet differentiability are identified, and the mathematical model is amended to accommodate their occurrence. Some of the ways in which chaotic behavior may emerge are discussed, first at the level of the aerodynamic contribution to the equations of motion, and then at the level of the equations of motion themselves. Author

A88-19476
THE LIAPUNOV FUNCTION METHOD IN MOTION POLYSTABILITY PROBLEMS [METOD FUNKTSII LIAPUNOVA V ZADACHAKH O POLIUSTOICHIVOSTI DVIZHENIIA]
A. B. AMINOV and T. K. SIRAZETDINOV Prikladnaia Matematika i Mekhanika (ISSN 0032-8235), vol. 51, Sept.-Oct. 1987, p. 709-716. In Russian. refs

The polystability of motion is defined as a property whereby various groups of variables describing the motion are characterized by different kinds of stability (e.g., stability in the small, asymptotic stability, and limited stability). Polystability theorems are proved using the Liapunov function method. The theorems are then used to investigate the motion stability of winged flight vehicles with respect to groups of variables. V.L.

A88-19672*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ANGLE-OF-ATTACK ESTIMATION FOR ANALYSIS OF WIND SHEAR ENCOUNTERS
R. E. BACH, JR. (NASA, Ames Research Center, Moffett Field, CA) and E. K. PARKS (Arizona, University, Tucson) (Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-Aug. 2, 1985, Proceedings, p. 6.1-1 to 6.1-4) Journal of Aircraft (ISSN 0021-8669), vol. 24, Nov. 1987, p. 789-792. Previously cited in issue 23, p. 3415, Accession no. A86-47798. refs

A88-19709
BREAKING THE STALL BARRIER
Aerospace Engineering (ISSN 0736-2536), vol. 7, Nov. 1987, p. 27-29.

An account is given of the prospective performance achievements of a joint USA/West German technology development program whose aim is the production of the X-31 Enhanced Fighter Maneuverability aircraft. The X-31 is intended to be able to perform virtually instantaneous three-dimensional maneuvers in the poststall regime, in order to confer upon similarly designed and equipped future aircraft a substantial tactical advantage over more conventional opponents in dogfight engagements. The X-31 will integrate three moment-generators in the pitch-control axis: flaps, canards, and thrust vectoring; poststall maneuverability will depend heavily on engine thrust vectoring. O.C.

N88-13247# Waterloo Univ. (Ontario). Dept. of Applied Mathematics and Mechanical Engineering.
DYNAMIC STABILITY OF HYPERSONIC CONICAL LIFTING VEHICLES ACCORDING TO NEWTON-BUSEMANN THEORY
W. H. HUI and H. J. VANROESSEL (University of Western Ontario, London.) *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 13 p Nov. 1987 Sponsored in part by Natural Science and Engineering Research Council of Canada
Avail: NTIS HC A24/MF A01

A theory is given of the aerodynamic stability of hypersonic conical lifting vehicles performing small amplitude pitching motion about its steady flight by using the Newton-Busemann flow theory, which is the rational limit of gas dynamic theory as the flight Mach number M sub infinity yields infinite and the ratio of specific heat Gamma yields 1. This is done by reformulating the gas dynamic equations using a set of material functions as independent variables which are a generalization of the stream functions of steady flow. In this formulation, calculations of the steady flow field are reduced to finding the geodesics of the body surface. The unsteady flow field is then calculated by perturbation of the steady flow; in particular, for conical shapes it requires only numerical quadrature. The theory is applied to conical wings of parabolic cross-section. The dependence of the stiffness and damping-in-pitch derivative on the angle of attack, the slenderness, concavity and convexity of the wing, and on the pivot axis position is studied systematically. Author

N88-13319*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NONLINEAR LIFT CONTROL AT HIGH SPEED AND HIGH ANGLE OF ATTACK USING VORTEX FLOW TECHNOLOGY
JOHN E. LAMAR *In* AGARD, Special Course on Fundamentals of Fighter Aircraft Design 23 p Oct. 1987 Previously announced in IAA as A86-37050
Avail: NTIS HC A13/MF A01 CSCL 01C

Nonlinear lift control at subsonic, transonic and low supersonic speeds owes its origin to the separated but organized vortical flows interacting with the wing upper surface. Since most of this flow originates near the wing or control-surface leading edge, a variety of devices has been studied experimentally which interact with and/or control this flow in order to gain a beneficial effect. The benefits (effects) originally studied were associated only with lift enhancement. Whereas, now the studied benefits encompass performance increase, attention to changes in trimmed conditions and longitudinal stability, improvements in lateral stability, and the attendant variation with changing Mach number. For those devices that can be theoretically modeled, state-of-the-art computer codes have been used for device design and/or analysis. Comparisons at design and off-design conditions are presented for validation purposes. Author

N88-13348# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
STATIC AEROELASTIC EFFECTS ON HIGH PERFORMANCE AIRCRAFT
Jul. 1987 186 p In ENGLISH and FRENCH Meeting held in Athens, Greece, 28 Sep. - 3 Oct. 1986
(AGARD-CP-403; ISBN-92-835-0424-0) Avail: NTIS HC A09/MF A01

Modern high performance aircraft designs tend to employ very thin airfoils having a degree and a distribution of stiffness far from the ideal; in consequence, there is a loss of control effectiveness and maneuverability. Moreover, the introduction of the highly forward swept wing planform poses a static aeroelastic effect of fundamental importance; these effects are felt at model as well as at full scale. The meeting was organized not only to review instances of these problems but to see how successfully modern tools for structural and aeroelastic analysis can be applied.

N88-13349# British Aerospace Public Ltd. Co., Preston (England). Military Aircraft Div.
EXAMPLES OF STATIC AEROELASTIC EFFECTS ON PRESENT COMBAT AIRCRAFT PROJECTS
W. E. SHARPE and J. B. NEWTON *In* AGARD Static Aeroelastic Effects on High Performance Aircraft 10 p Jul. 1987
Avail: NTIS HC A09/MF A01

The results of static aeroelastic calculations for a recent canard/cranked delta fighter project, in which a complete aircraft aerodynamic and structural model is used to demonstrate fully interacted free aircraft deflection modes and resulting stability effects are described. The significance of these results are illustrated by comparison with corresponding fixed root calculations, thereby indicating a requirement for complete aircraft aeroelastic modeling at the earliest possible stage in project design. Aeroelastic modeling of external stores in the context of store/aircraft integration is also discussed. Finally, the correlation of high speed wind tunnel results for aeroelastic distortion is addressed, indicating those parameters which are likely to be significantly affected. Author

N88-13350# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
TRENDS IN AEROELASTIC ANALYSIS OF COMBAT AIRCRAFT
C. PETIAU and S. BRUN *In* AGARD Static Aeroelastic Effects on High Performance Aircraft 25 p Jul. 1987
Avail: NTIS HC A09/MF A01

After recalling the general principles of aeroelastic coupling with structural finite element analysis, the simplifying assumptions of static aeroelasticity are explained. The technique of load basis used in a general aircraft structural analysis program is discussed. This technique allows one to separate the big expensive computation of finite element resolutions and theoretical aerodynamic analysis from aeroelastic coupling and flight maneuver computation. Author

N88-13351# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter and Airplane Div.
STATIC AEROELASTIC CONSIDERATIONS IN THE DEFINITION OF DESIGN LOADS FOR FIGHTER AIRPLANES
G. SCHMIDINGER and O. SENSBURG *In* AGARD Static Aeroelastic Effects on High Performance Aircraft 20 p Jul. 1987
Avail: NTIS HC A09/MF A01

Some typical effects of static aeroelastic correction factors in context with the definition of structural design loads for major aircraft components are discussed. The influences on response parameters and resulting design loads are shown as well as the aeroelastic optimization of trailing edge flaps with respect to geometry, efficiency, and hingemoments. Author

N88-13352# Aerospatiale Usines de Toulouse (France).
AEROELASTIC ANALYSIS OF MODERN TRANSPORT AIRCRAFT [ANALYSE AEROELASTIQUE DES AVIONS MODERNES DE TRANSPORT]
J. ROUSTAN and M. CURBILLON *In* AGARD Static Aeroelastic Effects on High Performance Aircraft 27 p Jul. 1987 In FRENCH; ENGLISH summary
Avail: NTIS HC A09/MF A01

Static aeroelastic phenomena play a very important role in modern transport aircraft with regard to both handling qualities and loads applied to the structure. Aerospatiale's method for taking these effects into consideration and calculating them is presented. Author

N88-13353*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STATIC AEROELASTIC EFFECTS ON THE FLUTTER OF A SUPERCRITICAL WING
E. CARSON YATES, JR. and LI-CHUAN CHU (PRC Kentron, Inc., Hampton, Va.) *In* AGARD Static Aeroelastic Effects on High Performance Aircraft 14 p Jul. 1987
Avail: NTIS HC A09/MF A01 CSCL 01C

The results of an effort to calculate the effects of angle of attack and the associated aeroelastic deformation on the flutter of a highly swept supercritical wing by use of the modified strip analysis employed in previous studies of this wing are discussed. The spanwise distributions of steady state section lift-curve slope and aerodynamic center required as input for these calculations were obtained from static aeroelastic calculations for the wing by use of the FLO22 transonic code and an assumed dynamic pressure. The process is iterative so that flutter can be obtained at the same dynamic pressure as that used to calculate the statistically deformed shape and loading about which the flutter oscillation occurs (matched conditions). The results of this investigation show that the unconventional backward turn of the transonic dip in the experimental flutter boundary for angles of attack greater than zero is caused by variations in mass ratio and not by static aeroelastic deformation, although inclusion of the latter appears to be required for quantitative accuracy in the calculations. Author

N88-13354# Royal Aircraft Establishment, Farnborough (England).
WING DIVERGENCE OF TRIMMED AIRCRAFT
LL. T. NIBLETT *In* AGARD Static Aeroelastic Effects on High Performance Aircraft 9 p Jul. 1987
Avail: NTIS HC A09/MF A01

By means of a simple theoretical model it is shown that wing divergence of a free aircraft can be defined using the static case of trimmed level flight. The same model also shows that the control angle per g goes to zero at a speed near the fixed root divergence speed and that there is a large change in the spanwise distribution of airload in going from a low speed to speeds above that of fixed root divergence. Author

N88-13355# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Helicopter and Airplane Div.
THE USE OF AEROELASTIC WIND TUNNEL MODELS TO PROVE STRUCTURAL DESIGN
H. HOENLINGER, J. SCHWEIGER, and G. SCHEWE (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, West Germany) *In its* Static Aeroelastic Effects on High Performance Aircraft 15 p Jul. 1987
Avail: NTIS HC A09/MF A01

In a wind tunnel study on an aeroelastic carbon fiber fin/rudder model, it is demonstrated how structural design methods can be checked by experiment beginning in an early stage of the design. Emphasis was put on the static aeroelastic investigations, which became more important in high performance A/C design. Transonic measurements with a rigid balance based on an opto-electronic deformation measurement method were performed. An attempt was made to evaluate rudder efficienies from these aeroelastic measurements. A nonlinear behavior of the rudder based on geometrical coupling with the fin box played an important role in the test evaluation. Author

N88-13356*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PREDICTION OF WING AEROELASTIC EFFECTS ON AIRCRAFT LIFE AND PITCHING MOMENT CHARACTERISTICS
CLINTON V. ECKSTROM *In* AGARD Static Aeroelastic Effects on High Performance Aircraft 17 p Jul. 1987 Previously announced as N87-15975
Avail: NTIS HC A09/MF A01 CSCL 01C

The distribution of flight loads on an aircraft structure determine the lift and pitching moment characteristics of the aircraft. When the load distribution changes due to the aeroelastic response of the structure, the lift and pitching moment characteristics also change. An estimate of the effect of aeroelasticity on stability and control characteristics is often required for the development of aircraft simulation models of evaluation of flight characteristics. This presentation outlines a procedure for incorporating calculated linear aeroelastic effects into measured nonlinear lift and pitching moment data from wind tunnel tests. Results are presented which were obtained from applying this procedure to data for an aircraft with a very flexible transport type research wing. The procedure described is generally applicable to all types of aircraft. Author

N88-13357# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
INFLUENCE OF THE STATIC DEFORMATION ON A WING IN THE UNSTEADY AERODYNAMIC
R. DESTUYNDER *In* AGARD Static Aeroelastic Effects on High Performance Aircraft 8 p Jul. 1987 Previously announced in IAA as A87-21054
Avail: NTIS HC A09/MF A01

Wind tunnel tests and related calculations were carried out to study the influence of static deformation due to steady loads on the flutter phenomenon experienced by modern civil aircraft. Consideration is also given to the nonlinearity of unsteady forces on an engine as a function of global incidence. It is found that the spanwise untwisting effect associated with positive incidences increases the flutter limits for given Mach number and dynamic pressure values. Author

N88-13358# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
MEASUREMENT OF MODEL DEFORMATION IN WIND TUNNELS
M. CHARPIN, C. ARMAND, and R. SELVAGGINI *In* AGARD Static Aeroelastic Effects on High Performance Aircraft 20 p Jul. 1987 In FRENCH; ENGLISH summary Original language document was announced in IAA as A87-36943
Avail: NTIS HC A09/MF A01

Various techniques used at ONERA for the wind tunnel measurement of the deformation of models undergoing aerodynamic and body loading are presented. Photography of reflecting targets is used to measure trailing edge deformation. Global torsion measurement of a wing at its wing tip is performed by the torsiometer measurement of the angle between the incident and reflected laser beam. An example of the determination of airfoil trailing edge deformation by tracking the position of light sources with an optical detector is presented. Finally, a technique for computing the strain from stress measurements is presented and demonstrated with a helicopter rotor blade model. Author

N88-13359*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
INTEGRATED CONTROL AND DISPLAY RESEARCH FOR TRANSITION AND VERTICAL FLIGHT ON THE NASA V/STOL RESEARCH AIRCRAFT (VSRA)
JOHN D. FOSTER, ERNESTO MORALEZ, III, JAMES A. FRANKLIN, and JEFFERY A. SCHROEDER (Army Aviation Research and Development Command, Moffett Field, Calif.) Oct. 1987 35 p
(NASA-TM-100029; A-87350; NAS 1.15:100029) Avail: NTIS HC A03/MF A01 CSCL 01C

Results of a substantial body of ground-based simulation experiments indicate that a high degree of precision of operation for recovery aboard small ships in heavy seas and low visibility with acceptable levels of effort by the pilot can be achieved by integrating the aircraft flight and propulsion controls. The availability of digital fly-by-wire controls makes it feasible to implement an integrated control design to achieve and demonstrate in flight the operational benefits promised by the simulation experience. It remains to validate these systems concepts in flight to establish their value for advanced short takeoff vertical landing (STOVL) aircraft designs. This paper summarizes analytical studies and simulation experiments which provide a basis for the flight research

program that will develop and validate critical technologies for advanced STOVL aircraft through the development and evaluation of advanced, integrated control and display concepts, and lays out the plan for the flight program that will be conducted on NASA's V/STOL Research Aircraft (VSRA). Author

N88-13360# Technische Univ., Brunswick (West Germany). Fakultaet fuer Maschinenbau and Elektrotechnik.
CONTRIBUTION TO THE IMPROVEMENT OF THE GUIDANCE ACCURACY OF AUTOMATIC PILOTS Ph.D. Thesis [BEITRAEGE ZUER VERBESSERUNG DER FUEHRUNGSGENAUIGKEIT VON FLUGREGLERN]
ARTUR REDEKER 1986 153 p In GERMAN
(ETN-88-90607) Avail: NTIS HC A08/MF A01

A multiple-quantity configuration controller for aircraft longitudinal motion was developed for the processing and anticipatory control of perturbation and control quantities. A quasi stationary, nonlinear model of the controlled system was used. The deviations between model and flight test data are of the order of a few percent. A computer program of the configuration controller was implemented and tested onboard a research aircraft. A high degree of decoupling between control and eigenbehavior is observed. The flight test results show that an extensive anticipatory control and perturbation compensation for the longitudinal motion can be realized with practical advantages and substantially higher accuracy than in present passenger aircraft. ESA

N88-13361# Societe Nationale Industrielle Aerospatiale, Paris (France). Div. Avions.
ELECTRICAL FLIGHT COMMANDS IN TRANSPORT AIRCRAFT [LES COMMANDES DE VOL ELECTRIQUES DES AVIONS DE TRANSPORT]
MICHEL DURANDEAU and JACQUES TROYES 1986 25 p In FRENCH Presented at the Cercle des Officiers Mecaniciens et Ingenieurs Navigants de l'Aviation Civile (COMINAC), Roissy-en-France, France, 15 Jan. 1986
(SNIAS-872-111-108; ETN-88-91190) Avail: NTIS HC A03/MF A01

The philosophy and implementation of the electrical flight commands adopted for the A320 aircraft are described. The design is very conservative to provide maximum safety, including the design of two-in-one computers where a maximum of asymmetry is provided (components, programs, languages, design teams). ESA

N88-13362# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
REDUCED ORDER OPTIMAL COMMAND APPLIED TO LONGITUDINAL AUTOMATIC PILOTS [LA COMMANDE OPTIMALE D'ORDRE REDUIT. APPLICATION AU PILOTAGE AUTOMATIQUE LONGITUDINAL]
O. HERAIL 1987 21 p In FRENCH
(SNIAS-872-111-114; ETN-88-91195) Avail: NTIS HC A02/MF A01

A flight control method is outlined. The method implies the fixation of the order and structure of the regulator independently of the complexity of the model. The theory provides the coupled matrix equations which give the optimal regulator. The solution is found using nonlinear programming interpreting one of the coupled equations as the expression of the gradient of the quadratic criteria. The technique minimizes a classical quadratic criterion. Examples of models order 11 to 15 are included. ESA

N88-13363*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FULL-ENVELOPE AERODYNAMIC MODELING OF THE HARRIER AIRCRAFT
B. DAVID MCNALLY Oct. 1986 18 p Presented at the 17th Annual Symposium Flight Testing: The Continuing Challenge, Washington, D.C., 10-13 Aug. 1986
(NASA-TM-88376; A-86380; NAS 1.15:88376) Avail: NTIS HC A03/MF A01 CSCL 01C

A project to identify a full-envelope model of the YAV-8B Harrier using flight-test and parameter identification techniques is described. As part of the research in advanced control and display concepts for V/STOL aircraft, a full-envelope aerodynamic model of the Harrier is identified, using mathematical model structures and parameter identification methods. A global-polynomial model structure is also used as a basis for the identification of the YAV-8B aerodynamic model. State estimation methods are used to ensure flight data consistency prior to parameter identification . Equation-error methods are used to identify model parameters. A fixed-base simulator is used extensively to develop flight test procedures and to validate parameter identification software. Using simple flight maneuvers, a simulated data set was created covering the YAV-8B flight envelope from about 0.3 to 0.7 Mach and about -5 to 15 deg angle of attack. A singular value decomposition implementation of the equation-error approach produced good parameter estimates based on this simulated data set. Author

N88-14099*# Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
A SIMULATION STUDY OF THE FLIGHT DYNAMICS OF ELASTIC AIRCRAFT. VOLUME 1: EXPERIMENT, RESULTS AND ANALYSIS Final Report
MARTIN R. WASZAK, JOHN B. DAVIDSON, and DAVID K. SCHMIDT Washington NASA Dec. 1987 122 p
(Contract NAG1-254)
(NASA-CR-4102; NAS 1.26:4102) Avail: NTIS HC A06/MF A01 CSCL 01C

The simulation experiment described addresses the effects of structural flexibility on the dynamic characteristics of a generic family of aircraft. The simulation was performed using the NASA Langley VMS simulation facility. The vehicle models were obtained as part of this research. The simulation results include complete response data and subjective pilot ratings and comments and so allow a variety of analyses. The subjective ratings and analysis of the time histories indicate that increased flexibility can lead to increased tracking errors, degraded handling qualities, and changes in the frequency content of the pilot inputs. These results, furthermore, are significantly affected by the visual cues available to the pilot. Author

N88-14101*# Boeing Co., Wichita, Kans.
DESIGN VERIFICATION AND FABRICATION OF ACTIVE CONTROL SYSTEMS FOR THE DAST ARW-2 HIGH ASPECT RATIO WING, PART 1
C. R. MCGEHEE Jan. 1986 334 p
(Contract NAS1-16010)
(NASA-CR-177959-PT-1; NAS 1.26:177959-PT-1; BMAC-D500-10897-1) Avail: NTIS HC A15/MF A01 CSCL 01C

A study was conducted under Drones for Aerodynamic and Structural Testing (DAST) program to accomplish the final design and hardware fabrication for four active control systems compatible with and ready for installation in the NASA Aeroelastic Research Wing No. 2 (ARW-2) and Firebee II drone flight test vehicle. The wing structure was designed so that Active Control Systems (ACS) are required in the normal flight envelope by integrating control system design with aerodynamics and structure technologies. The DAST ARW-2 configuration uses flutter suppression, relaxed static stability, and gust and maneuver load alleviation ACS systems, and an automatic flight control system. Performance goals and criteria were applied to individual systems and the systems collectively to assure that vehicle stability margins, flutter margins, flying qualities and load reductions are achieved. Author

N88-14102*# Boeing Co., Wichita, Kans.
DESIGN VERIFICATION AND FABRICATION OF ACTIVE CONTROL SYSTEMS FOR THE DAST ARW-2 HIGH ASPECT RATIO WING. PART 2: APPENDICES
C. R. MCGEHEE Jan. 1986 389 p
(Contract NAS1-16010)
(NASA-CR-177959-PT-2; NAS 1.26:177959-PT-2;
BMAC-D500-10897-1) Avail: NTIS HC A17/MF A01 CSCL 01C

This is Part 2-Appendices of a study conducted under Drones for Aerodynamic and Structural Testing (DAST) Program to accomplish the final design and hardware fabrication for four active control systems compatible with and ready for installation in the NASA Aeroelastic Research Wing No. 2 (ARW-2) and Firebee II drone flight test vehicle. The wing structure was designed so that Active Control Systems (ACS) are required in the normal flight envelope by integrating control system design with aerodynamics and structure technologies. The DAST ARW-2 configuration uses flutter suppression, relaxed static stability, and gust and maneuver load alleviation ACS systems, and an automatic flight control system. Performance goals and criteria were applied to individual systems and the systems collectively to assure that vehicle stability margins, flutter margins, flying qualities, and load reductions were achieved. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A88-17995
AIRFIELD OPERATION (2ND REVISED AND ENLARGED EDITION) [EKSPLUATATSIIA AERODROMOV /2ND REVISED AND ENLARGED EDITION/]
LEONID IGNAT'EVICH GORETSKII Moscow, Izdatel'stvo Transport, 1986, 280 p. In Russian. refs

The fundamentals of airfield operation are discussed with reference to flight operations, air traffic control, airfield marking, and airfield maintenance. In particular, attention is given to the structure of the airfield maintenance system; reliability, performance, and service periods of airfield structures; climatic and environmental factors; and the effect of the condition of the runway pavements on flight safety. The discussion also covers various diagnostic techniques and maintenance technology; methods of airfield maintenance during winter; and safety engineering. V.L.

A88-19269
FATIGUE TESTING OF AN ALL-COMPOSITE WING FOR THE MFI-18 HIGH-LIFT AIRCRAFT
S. THURESSON and R. ABELIN (Malmo Research and Development, Ltd., Sweden) Composites (ISSN 0010-4361), vol. 18, Sept. 1987, p. 334-338. refs

The all-composite wing designed for the MFI-18 high-lift aircraft has demonstrated the survival of 25,000 flying hours in the course of static and fatigue test loading; at the end of the test program, the wing remained unbroken and without evident reduction of wing stiffness. The use of Derakane vinylester as the matrix resin is noted to impart substantial toughness to the wing's laminate structure, together with superior chemical resistance and elongation properties. It is concluded that the critical strength of such wing structures depends on resin properties. O.C.

A88-19865#
FLOW AROUND A SYMMETRICAL PROFILE (HYDRODYNAMIC VISUALIZATIONS)
H. WERLE (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1987, p. 47-72. refs

Studies of the flow around simple profiles have been carried out in the ONERA TH2 water tunnel, using the strobe chronophotographic effect for lighting. Results for various types of leading edges and symmetrical NACA profiles of different thicknesses have been compared, both in the steady regime and during the starting flow which precedes it. The present technique allows the determination of the stagnation point, the extent and structure of the separated zone, and the evolution as a function of parameters such as angle of attack, Reynolds number, leading edge radius, and profile thickness. R.R.

N88-13220# Calspan Corp., Buffalo, N. Y.
A SURVEY OF EXISTING HYPERSONIC GROUND TEST FACILITIES: NORTH AMERICA
C. E. WITTLIFF *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 17 p Nov. 1987
Avail: NTIS HC A24/MF A01

In the past several years there was a significant increase in the number of programs involving hypersonic vehicles, resulting in a resurgance of interest in experimental testing in hypersonic wind tunnels. Unfortunately, there are far fewer such facilities operating now than there were 10 or 15 years ago. The primary purpose is to survey the current status of hypersonic wind tunnels in North America and to describe their performance characteristics. As a part of this survey a comparison is drawn to the number and type of hypersonic wind tunnels that were active in the 1960's and 1970's relative to the current situation. Emphasis is placed on hypersonic aerodynamic and aerothermal testing and related areas. In surveying the hypersonic wind tunnels that are active in North America, all but one are located in the USA. There is a gun tunnel in Canada that will be reactivated this year. Author

N88-13223# Queensland Univ., Brisbane (Australia). Dept. of Mechanical Engineering.
SHOCK TUNNELS FOR REAL GAS HYPERSONICS
R. J. STALKER *In* AGARD, Aerodynamics of Hypersonic Lifting Vehicles 10 p Nov. 1987
Avail: NTIS HC A24/MF A01

The application of free piston shock tunnels to the simulation of real gas effects in hypersonic flight is discussed. It is pointed out that the primary simulation variables for this purpose are the stagnation enthalpy and the binary scaling parameter. The free piston reflected shock tunnel is considered first, and it is shown how test time limitations play a major role in determining the limiting stagnation enthalpy for a given model size. Nevertheless, flight values of the two simulation variables, for vehicles similar to the Space Shuttle Orbiter, can be matched by an existing free piston shock tunnel up to speeds of 1 km/s. Experiments performed in this shock tunnel are used to demonstrate real gas effects in model flow. Radiative energy loss limits the maximum stagnation enthalpy available with reflected shock tunnels. Fortunately, operation in the nonreflected mode circumvents this limitation, and in addition, allows higher values of the binary scaling parameter; although it also leads to greatly reduced test times. The use of the prior steady flow technique to enable high enthalpy nonreflected shock tunnel operation is described, and examples of experiments performed in the facility are used to demonstrate that short test times do not preclude worthwhile experimentation. A variant of the free piston shock tunnel, which is intended for propulsion research at high velocities, also is briefly described. Author

N88-13364# National Aeronautical Lab., Bangalore (India). Aerodynamics Dv.
MODEL HELICOPTER ROTOR RIG AND ASSOCIATED STRAIN GAUGE BALANCE FOR PERFORMANCE STUDIES
S. R. PATIL and M. A. RAMASWAMY (Indian Inst. of Science, Bangalore.) Aug. 1987 37 p
(NAL-TM-AE-8704) Avail: NTIS HC A03/MF A01 CSCL 14B

The details of a teetering rotor model and the associated strain gage balance and calibration fixtures have been presented. Hovering results for a 1.22-m diameter teetering rotor model evaluated experimentally have been compared with the simple blade element momentum theory. Author

N88-13365# National Aeronautical Lab., Bangalore (India). Systems Engineering Div.
NON-LINEAR MAXIMUM LIKELIHOOD ESTIMATION OF STABILITY DERIVATIVES FROM RANGE DATA
V. S. MOHAN RAM and C. V. SRINATH SASTRY Dec. 1986 20 p
(NAL-TM-SE-8608) Avail: NTIS HC A03/MF A01

A parameter identification technique of extracting nondimensional stability derivatives for the AGARD standard ballistic correlation model HB-2 from supersonic free-flight data is investigated. Based on the Maximum Likelihood criterion, the identification technique used is a modified Newton-Raphson quasi-linearization minimization procedure with certain extensions for handling general nonlinear systems without involved program changes. A hybrid type formulation for the 6 degrees of freedom nonlinear equations of motion is employed wherein aerodynamic force and moment representations are in wind-axis and body-axis coordinate systems respectively. Results for both the longitudinal and lateral stability derivatives of the AGARD model demonstrate, as borne out by the excellent fit to the measured motions of a typical flight and accuracy of the parameter estimates, the suitability and power of the maximum likelihood method and functional adequacy of the mathematical model used. Author

N88-13366# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
OVERLOOKED POTENTIAL OF SYSTEMS WITH MARKOVIAN COEFFICIENTS
H. A. P. BLOM 4 Aug. 1986 11 p Presented at the 25th IEEE Conference on Decision and Control, Athens, Greece, 10-12 Dec. 1986
(NLR-MP-86049-U; B8709829; ETN-88-91330) Avail: NTIS HC A03/MF A01

The usual system of linear stochastic difference equations with Markovian coefficients is generalized to cover R sup n valued processes which jump simultaneously with and due to jumps of the coefficients. The additional modeling potential is illustrated for a maneuvering aircraft. To filter partial observations of the generalized system candidate algorithms are reviewed, in particular the generalized pseudo Bayes algorithms and the interacting multiple model (IMM) algorithm. The IMM algorithm for the generalized system is applied to tracking a maneuvering aircraft. The results indicate that the generalized models and the associated IMM algorithm has the potential to yield trackers that perform better than the existing decision-directed trackers. ESA

N88-13367*# *National Aeronautics and Space Administration.* Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF AN INTERFACE FOR AN ULTRARELIABLE FAULT-TOLERANT CONTROL SYSTEM AND AN ELECTRONIC SERVO-CONTROL UNIT
CHARLES SHAVER and MICHAEL WILLIAMSON Sep. 1986 37 p
(NASA-TM-88236; A-86196; NAS 1.15:88236) Avail: NTIS HC A03/MF A01 CSCL 14B

The NASA Ames Research Center sponsors a research program for the investigation of Intelligent Flight Control Actuation systems. The use of artificial intelligence techniques in conjunction with algorithmic techniques for autonomous, decentralized fault management of flight-control actuation systems is explored under this program. The design, development, and operation of the interface for laboratory investigation of this program is documented. The interface, architecturally based on the Intel 8751 microcontroller, is an interrupt-driven system designed to receive a digital message from an ultrareliable fault-tolerant control system (UFTCS). The interface links the UFTCS to an electronic servo-control unit, which controls a set of hydraulic actuators. It was necessary to build a UFTCS emulator (also based on the Intel 8751) to provide signal sources for testing the equipment. Author

N88-14105# Duits-Nederlandse Windtunnel, North East Polder (Netherlands).
DUTCH-GERMAN WIND TUNNEL'S TENTH ANNIVERSARY
1987 25 p Presented in East Polder, Netherlands, 22 Oct. 1986 Original contains color illustrations
(ETN-88-91350) Avail: NTIS HC A03/MF A01

The position of the Netherlands aerospace industry in Dutch society; the role of the Dutch-German wind tunnel (DNW) in aircraft development; and the status and prospects of DNW were discussed. ESA

N88-14106# Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.
A LABORATORY STUDY OF ASPHALT CONCRETE MIX DESIGNS FOR HIGH-CONTACT PRESSURE AIRCRAFT TRAFFIC Final Report, Oct. 1983 - Jun. 1986
GEORGE L. REGAN Jul. 1987 112 p
(Contract MIPR-N-83-05; AF PROJ. 210-4)
(AD-A185753; AFESC/ESL-TR-85-66) Avail: NTIS HC A06/MF A01 CSCL 13C

Effects of high-contact pressure F-4 and F-15 aircraft traffic in the 350-400 psi range on conventionally designed heavy-duty asphalt concretes were studied. Specimens of mix were prepared to current heavy-duty compactive efforts (75 blow per side with an impact hammer) and four other compactive efforts, using a modified gyratory compactor. The gyratory compactor was used to roughly simulate high-contact pressure traffic on some of the mixes. Two aggregate gradations recommended for high-pressure traffic were used to produce crushed limestone aggregate blends. Two grades of asphalt cement, AC 20 and AC 40, and a Chemkrete modified AC 20 asphalt cement were used as binders. Heavy-duty mix selection criteria were used to bracket optimum mixes for supplemental testing and analysis. Testing consisted of indirect tensile tests (dynamic and static), direct shear tests. Accelerated aging tests, and unconfined creep tests. Results indicated that current heavy-duty mix selection criteria can be used, but higher compactive effort is needed to prevent rutting and densification problems. Lower asphalt content mixes were selected when higher compactive efforts were used. Two modified methods of designing high-contact pressure asphalt concrete mixes were presented. The preferred method is based on the use of a gyratory compactor at a higher compactive is not effort. The second method, an approximate method for use when a gyratory compactor is not available, is based on use of the current 75 blow per side impact hammer. Several mixes were recommended for use in a field test at Tyndall AFB, Florida. GRA

N88-14107# Transportation Research Board, Washington, D.C.
MEASURING AIRPORT LANDSIDE CAPACITY
1987 202 p
(PB88-102637; TRB/TRR/SR-215; ISBN-0-309-04457-X; LC-87-22021) Avail: NTIS HC A10/MF A01 CSCL 01E

Congestion at airport terminal buildings, access roads, and parking areas increasingly threatens the capability of airports to serve additional passengers and air cargo. Measuring the capacity of these airport landside facilities and services is becoming as critical to operations of major airports as capacity measurements for the airside taxiways and runways that serve aircraft. Part 1 of the report contains a general description of the airport landside, how landside capacity is defined and measured, a process for landside capacity assessment, and research needs. In Part 2 guidance is presented for applying these definitions and the process

to specific landside functional components likely to represent constraints on the airport's ability to satisfy demand. GRA

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ASTRONAUTICS

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

A88-18895
INDEPENDENT GROUND MONITOR COVERAGE OF GPS SATELLITES
KAREN J. VIETS (Mitre Corp., Civil Systems Div., McLean, VA) (IEEE, Position, Location, and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-23, Sept. 1987, p. 678-685. refs

The Federal Aviation Administration plans to independently monitor signals in space from the Global Positioning System (GPS) for the purpose of providing immediate awareness to civil aviation users of the operational status of GPS when it is used in the National Airspace System. The operational status will be disseminated to Air Traffic Control and will possibly be broadcast from ground monitoring stations to GPS aviation users via a dedicated integrity channel. An algorithm is described that measures the coverage of a configuration of ground monitoring station locations, and is applied to several different configurations of ground monitoring stations to compare the coverage provided. Also included are the resulting ground monitoring station configurations that give the best coverage of GPS signals for several specific geographical areas, the conterminous United States (CONUS), Canada, and Alaska. Author

A88-18985
SOME REMARKS ON MULTIFUNCTION OR 'COMBINED' PROPULSION SYSTEMS [QUELQUES REMARQUES SUR LES SYSTEMES DE PROPULSION MULTIFONCTIONS OU 'COMBINES']
M. BARRERE (ONERA, Chatillon-sous-Bagneux, France) Acta Astronautica (ISSN 0094-5765), vol. 15, Nov. 1987, p. 931-935. In French.

Combined propulsion systems are discussed with respect to their principal functions, their performance, and the factors relating to their choice. Functions considered include the ejection, ramjet or scramjet combustion, mixing, and nozzle augmentation. Performance indices of the combined propulsion systems include the specific impulse and a cost-effectiveness index related to minimization of weight for a given thrust. Factors to be taken into account in the selection of a combined propulsion system are discussed such as the requirements for the booster and sustainer phases, the number of stages, and the horizontal or vertical takeoff and landing specifications. The present work is relevant to the development of systems for powering aircraft to hypervelocities and to the design of orbital aircraft. R.R.

A88-19050
SATELLITES TO FULFILL ATS NEEDS? [DES SATELLITES POUR COUVRIR LES BESOINS ATS?]
D. ALVAREZ Navigation (Paris) (ISSN 0028-1530), vol. 35, Oct. 1987, p. 475-494. In French. refs

The use of the ATS in alleviating the operational and technical problems of air navigation systems is addressed. With respect to navigation, the application of ATS in high density air spaces would require a level of performance which would guarantee a general reduction in separation. In airspaces without heavy traffic, satellites offer the possibility of more efficient surveillance than can be achieved by procedural control. The possible application of Data-link for communications and surveillance in airspaces with heavy traffic is considered. The use of radio determination and data transmission systems to fulfill general aviation needs is also discussed. R.R.

A88-20290* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A HIGH-CAPACITY AERONAUTICAL MOBILE SATELLITE SYSTEM
M. K. SUE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: IEEE, Vehicular Technology Conference, 37th, Tampa, FL, June 1-3, 1987, Proceedings. New York, Institute of Electrical and Electronics Engineers, 1987, p. 170-179. refs

This paper describes a conceptual system design for a satellite-based aeronautical safety communications system capable of serving both general aviation aircraft and commercial aviation aircraft in the contiguous U.S. in the mid-1990s. The space segment is described, including satellite locations and coverage, spacecraft configuration, eclipse capability and stationkeeping, transponder design, and mass and power. The spacecraft mass and power budgets are given. The air mobile terminals, ground segment, and frequency plan and channelization are discussed, and the data rate, modulation/demodulation/coding, and channel spacing are considered. The message format, frequency control, system capacity, and system sensitivity are discussed. C.D.

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CHEMISTRY AND MATERIALS

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

A88-17104
PROPERTIES OF ADHESIVES FOR COMPOSITE AND BONDED METAL REPAIRS
K. B. ARMSTRONG (British Airways, PLC, Hounslow, England) IN: Adhesion 11 . London and New York, Elsevier Applied Science, 1987, p. 118-174. refs

This paper describes the results of testing twelve epoxy, acrylic, and other adhesives (including several cold-setting adhesives and one potting compound) to provide guidance on the choice of adhesives for composite and bonded metal repairs in aircraft industry. It is shown that data on tensile strength, tensile modulus, and elongation to failure of composite and bonded metal structures could be related to the lap-joint performance; up to a limit, lap shear strength rises with adhesive tensile strength. Diffusion and solubility coefficients were also obtained; it is shown that the choice of base resin and curing agent has a marked effect on moisture absorption. I.S.

A88-17868
STRESS-STRAIN STATE OF A FLEXIBLE BRAKING SYSTEM [NAPRIAZHENNO-DEFORMIROVANNOE SOSTOIANIE MIAGKOI TORMOZNOI SISTEMY]
I. V. DNEPROV, A. T. PONOMAREV, A. V. RADCHENKO, and O. V. RYSEV Mekhanika Kompozitnykh Materialov (ISSN 0203-1272), Sept.-Oct. 1987, p. 839-844. In Russian. refs

The stress-strain state of a circular parachute is investigated analytically by successively applying two models. One model is based on the synthesis of nonlinear aerodynamic data on axisymmetric separated flow past the parachute and elastic relations describing the one-dimensional stressed state of the canopy fabric. The other model includes equations of flexible shells and initial data on the loading and configuration of the parachute during opening that are determined by using the first model. The

solution algorithm is based on the discrete vortex and finite difference methods. V.L.

A88-17877
ADVANCED TECHNOLOGY ALUMINUM MATERIALS FOR AEROSPACE APPLICATIONS
T. R. PRITCHETT (Kaiser Aluminium and Chemical Corp., Pleasanton, CA) IN: Aluminium technology '86; Proceedings of the International Conference, London, England, Mar. 11-13, 1986 . London, Institute of Metals, 1986, p. 51-57. refs

Advanced-technology aluminum materials suitable for aircraft applications are discussed, including rapidly solidifying high-strength and/or high-melting alloys (such as Al-Cu-Mg alloys containing Zn, Co, and Zr and the alloys of Al-Fe-X composition), aluminum metal matrix composites (in which high-strength materials such as SiC, Al2O3, B4C, or B are embedded in Al alloys), and light-weight Li-containing alloys (such as Al-Cu-Li and Al-Li-Cu-X alloys). It is concluded that performance and cost considerations favor the light-weight Al-Li alloys, which provide the opportunity of achieving 8 to 10 percent weight savings and 15 percent greater stiffness, and meet other performance criteria of the aerospace industry. In addition, conventional aircraft assembly methods can be employed with Al-Li, thus avoiding the heavy costs associated with the use of carbon resin composites. I.S.

A88-17902
7075-101-T73 - TOUGH PLATES AND FORGINGS WITH IMPROVED FATIGUE STRENGTH FOR AIRFRAME APPLICATIONS
B. DUBOST, J. BOUVAIST (Cegedur Pechiney, Voreppe, France), R. MACE (Cegedur Pechiney, Issoire, France), and M. O. CHARUE (Societepour le Forgeage et l'Estampage des Aliages Legers, Issoire, France) IN: Aluminium technology '86; Proceedings of the International Conference, London, England, Mar. 11-13, 1986 . London, Institute of Metals, 1986, p. 459-467. Research supported by the Service Technique des Programmes Aeronautiques. refs

Special processing of a medium purity alloy is combined with final overaging to the T73(5X) condition. Typical properties of thick plates and forgings in alloy 7075-101-T73(5X) are given. Important improvements in short-transverse elongation and overall fracture toughness as well as significant increases in fatigue crack initiation strength on notched and smooth specimens are achieved over conventional 7175-T73(5X), together with equivalent tensile strength, resistance to stress corrosion cracking and fatigue crack propagation behavior. The reduction in crack initiation sites resulting from extensive dissolution of constituent particles through special processing is favored by overaging. Hence 7075-101-T73(5X) compares favorably with higher purity conventional 7XXX alloys, especially when superior fatigue strength is needed, and provides cost effective improvements in damage tolerance and fatigue behavior of airframes. Author

A88-17903
FRACTURE PROCESSES OF RECENT 2000 AND 7000 AIRCRAFT ALLOYS UNDER STATIC AND DYNAMIC STRESSES
M. BURATTI, E. DI RUSSO, and G. GIORDANO (Aluminia, Istituto Sperimentale dei Metalli Leggeri, Novara, Italy) IN: Aluminium technology '86; Proceedings of the International Conference, London, England, Mar. 11-13, 1986 . London, Institute of Metals, 1986, p. 468-477. refs

The present paper describes a series of tensile, fracture toughness, fatigue, and stress corrosion cracking tests performed on forgings produced with four high strength 7000 alloys (7012, 7010A, 7050, and 7475) and one 2000 alloy (2124), respectively in T73 and T8 tempers. The forgings were produced and heat treated in such a way as to make their comparison most significant. In this way it has been possible to overcome all the uncertainties and the possible mistakes related to these kind of investigations. Author

A88-17914
STRAIN ANALYSIS IN DEFORMED ALUMINIUM ALLOYS
H. A. LAIRD, K. R. GILMOUR, and D. MCKEAG (Ulster, University, Coleraine, Northern Ireland) IN: Aluminium technology '86; Proceedings of the International Conference, London, England, Mar. 11-13, 1986 . London, Institute of Metals, 1986, p. 650-655.

Aluminum alloys are widely used in the production of the complex components which make up so many of today's motor vehicles and aircraft. Many of these components are produced by forming processes where more than one operation is required to produce the finished component. A detailed knowledge of the strains in the component is necessary to minimize the number of stages in a forming operation without causing material failure. The key to accurate measurement of these strains is the use of a grid of well-defined lines and small spacings applied to the surface of the metal using electrochemical etching. It is difficult to obtain good quality, contrasting lines on aluminum alloys by this method because of the color of the oxide produced by the aluminum during the etching process. However, an etching fluid has been produced which enables a clearly defined pattern to be produced on the alloy and hence accurate strain values can be obtained. Author

A88-18143
WORKING SOCIETY FOR HEAT-RESISTANT STEELS AND WORKING SOCIETY FOR HIGH-TEMPERATURE MATERIALS, LECTURE SESSION, 9TH, DUESSELDORF, FEDERAL REPUBLIC OF GERMANY, DEC. 5, 1986, REPORTS ARBEITSGEMESISCHAFT FUER HOCHTEMPERATURWERK-STOFFE, UNG, 9TH, DUESSELDORF, FEDERAL REPUBLIC OF GERMANY, DEC. 5, 1986, VORTRAEGE]
Lecture Session organized by the Verein Deutscher Eisenhuettenleute. Duesseldorf, Federal Republic of Germany, Verein Deutscher Eisenhuettenleute, 1987, 161 p. In German. For individual items see A88-18144 to A88-18150.

Recent theoretical and experimental investigations of the high-temperature mechanical behavior of metals are discussed in reviews and reports. Topics addressed include the creep behavior of highly alloyed stainless steels and Ni alloys, X 10 NiCrAlTi 32 20 in sulfur-containing atmospheres at high temperatures, and the effectiveness of protective surface coatings on high-strength materials for gas turbines. Consideration is given to single-crystal turbine blades for aircraft engines, damage analysis of components subject to creep, the development of steels with 9 percent Cr for high-temperature applications, and the effect of microstructure on the creep and fatigue behavior of steel with 1 percent CrMoV. T.K.

A88-18149#
EXPERIENCE WITH SINGLE-CRYSTAL TURBINE BLADES FOR AIRCRAFT ENGINES [ERFAHRUNGEN MIT EINKRISTALLINEN TURBINENSCHAUFELN FUER FLUGTRIEBWERKE]
J. WORTMANN IN: Working Society for Heat-Resistant Steels and Working Society for High-Temperature Materials, Lecture Session, 9th, Duesseldorf, Federal Republic of Germany, Dec. 5, 1986, Reports . Duesseldorf, Federal Republic of Germany, Verein Deutscher Eisenhuettenleute, 1987, p. 76-88. In German. refs

The casting, processing, and performance of single-crystal (1C) turbine blades of Ni-based alloys are discussed in a general overview and illustrated with graphs, diagrams, and micrographs. Topics addressed include directional solidification techniques; design constraints imposed by the use of 1Cs; 1C heat treatment methods; the macroscopic elastic and plastic properties of 1C alloys; and the dynamic strength of the blade. The microstructures of the 1C alloys are described in detail. Operational experience shows that 1C techniques increase the pure creep life of turbine blades by a factor of 6-8 and the thermal fatigue life and oxidation resistance by a factor of 10 or more, but that the fatigue strength can be reduced by 10-20 percent by the relatively rapid opening of large-angle grain boundaries (making 1C blades with such

boundaries unusable). Outstanding problems in manufacturing and NDE of 1C blades are indicated. T.K.

A88-18152
AIR FORCE REQUIREMENTS FOR NDE OF COMPOSITES
D. E. CHIMENTI (USAF, Materials Laboratory, Wright-Patterson AFB, OH) IN: Solid mechanics research for quantitative non-destructive evaluation . Dordrecht, Martinus Nijhoff Publishers, 1987, p. 13-21.

This paper covers Air Force requirements and future needs for NDE of composite materials. Although composites have received only limited use in current airframe structures (vertical and horizontal stabilizers of fighter aircraft for example) aircraft on the drawing board or in testing employ graphite-fiber-reinforced composites much more extensively. To anticipate the inspection requirements of these complex materials is not an easy task. Yet many years of materials testing and the experience gained through limited service application certainly indicate the directions this work should take. Author

A88-18245
LAMB WAVE AND LEAKY LAMB WAVE CHARACTERIZATION OF FIBER REINFORCED COMPOSITES
LASZLO ADLER, WADE R. ROSE, S. I. ROKHLIN, and PETER B. NAGY (Ohio State University, Columbus) IN: Advanced composites: The latest developments; Proceedings of the Second Conference, Dearborn, MI, Nov. 18-20, 1986 . Metals Park, OH, ASM International, 1986, p. 263-267.

The measurement of Lamb wave phase and group velocities is presently used to study the anisotropy of graphite/epoxy composite plates of three types: unidirectional, two-directional with orthogonal fibers, and quasi-isotropic. The single-mode experimental method used obtains the phase and group velocities, and the angle of deviation between them, on the basis of angle-variable contact ultrasonic transducers on the surface of the plate. The multimode method uses a novel broadband single-transducer immersion technique to obtain the phase velocity dispersion curve together with polar characteristics. The Lamb wave technique is able to measure the in-plane anisotropic properties of thin composite plates typical of aircraft applications. O.C.

A88-18484#
CARS STUDY OF PREMIXED TURBULENT COMBUSTION IN A HIGH VELOCITY FLOW
P. MAGRE, P. MOREAU, G. COLLIN, R. BORGHI, M. PEALAT (ONERA, Chatillon-sous-Bagneux, France) et al. (Journee sur les Ecoulements Reactifs, Rouen, France, July 7-10, 1987) ONERA, TP, no. 1987-99, 1987, 15 p. refs
(ONERA, TP NO. 1987-99)

CARS measurement results on the fluctuating temperature in premixed turbulent flames in a high-velocity flow are reported. The experimental setup is described, including the combustor and the CARS system and optical arrangement. The results are analyzed in terms of the structure of the developing flame and the temperature field within the recirculation zone. C.D.

A88-18544#
THE INFLUENCE OF MICROSTRUCTURE ON TENSILE PROPERTIES OF AN ALUMINUM-LITHIUM ALLOY
T. S. SRIVATSAN (Akron, University, OH) and C. W. MEYERS (Georgia Institute of Technology, Atlanta) ASME, Transactions, Journal of Engineeering Materials and Technology (ISSN 0094-4289), vol. 109, Oct. 1987, p. 350-352. refs

The double ligament tensile (DLT) test was used to evaluate the tensile properties and anisotropy of a lithium-containing aluminum alloy in the three orthogonal directions of the wrought ingot metallurgical plate. In order to minimize uncertainties associated with results obtained from this test, comparisons are made with results obtained from the conventional tensile test. Variation in tensile properties with direction of stressing are discussed in terms of the specific role of specimen size and configuration, and intrinsic microstructural features. Author

A88-18757
THE SIMULATION OF AIRCRAFT ENGINE OIL DEPOSITS UNDER STATIC CONDITIONS AND THEIR INFLUENCING FACTORS
E. JANTZEN (DFVLR, Stuttgart, Federal Republic of Germany) IN: ASLE, Annual Meeting, 42nd, Anaheim, CA, May 11-14, 1987, Technical Preprints . Park Ridge, IL, American Society of Lubrication Engineers, 1987, 5 p. Research supported by the Bundesministerium der Verteidigung. refs
(ASLE PAPER 87-AM-5A-1)

An overview about the different types of aircraft engine oil deposits is given. Furthermore, the simulation of static deposits is explained, and a new test device is shown in detail. The test methods and reproducibility of the results are discussed. Results will be shown about influence of surface temperature, test duration, oil amount and air. In addition, the influence of different ester-oil structures and the results with elemental and infrared spectroscopic analysis of different deposits will be discussed. Author

A88-18758
PUMP EVALUATION OF HYDROGENATED POLYALPHAOLEFIN CANDIDATES FOR A -54 C TO 135 C FIRE-RESISTANT AIR FORCE AIRCRAFT HYDRAULIC FLUID
LOIS J. GSCHWENDER, CARL E. SNYDER, JR. (USAF, Aeronautical Laboratories, Wright-Patterson AFB, OH), and SHASHI K. SHARMA (Dayton, University, OH) IN: ASLE, Annual Meeting, 42nd, Anaheim, CA, May 11-14, 1987, Technical Preprints . Park Ridge, IL, American Society of Lubrication Engineers, 1987, 6 p. refs
(ASLE PREPRINT 87-AM-5A-2)

Pump tests were performed on candidate formulations for a -54 C to 135 C operating temperature range fire-resistant hydraulic fluid developed for the U.S. Air Force. The program rationale is summarized and the results of the various candidates are given. Besides ranking fluid formulations, the pump tests provided insight into the lubricating properties of viscosity-index and nonviscosity-index improved formulations. Lubrication of the modern aerospace hydraulic pump used was dependent on the base stock visocsity, as opposed to measured kinematic viscosity of the fluid. Author

A88-18842
THERMAL PERFORMANCE OF CYANATE FUNCTIONAL THERMOSETTING RESINS
D. A. SHIMP SAMPE Quarterly (ISSN 0036-0821), vol. 19, Oct. 1987, p. 41-46. refs

Polycyanurate thermoset plastics prepared by the cyclotrimerization of aryl dicyanates are compared to toughened bismaleimides and a tetrafunctional epoxy for both short and long term aspects of thermal performance. Oligomers of three aryl dicyanates, including a flame retardant sulfur-linked bisphenol derivative, developed superior cured-state properties when catalyzed with specific metal acetylacetonates and phenolic catalysts. Author

A88-19306
EFFECT OF COLD-WORKING BY HOLE EXPANSION ON FATIGUE LIFE OF ALZN-ALLOY LUGS UNDER MANEUVER LOADING
A. BUCH and A. BERKOVITS (Technion - Israel Institute of Technology, Haifa) IN: Fatigue prevention and design; Proceedings of the International Conference, Amsterdam, Netherlands, Apr. 21-24, 1986 . Warley, England, Engineering Materials Advisory Services, Ltd., 1986, p. 107-114. refs

The effect of cold working by hole expansion on the fatigue life of aircraft lugs under maneuver loading was investigated. Of the two nominal expansion levels used, 2-percent expansion resulted in greater life improvement than the larger expansion of 3.3 percent. The reason for this was the relatively small w/d ratio and lug head shape distortion caused by the larger expansion. The hole expansion had a more beneficial effect in the case of lugs with 1 mm deep initial flaws than lugs without flaws. Hole expansion considerably improved the damage tolerance of the

lugs investigated, in spite of the fact that the lug head parameters of the tested lugs (w/d = 2, c/d = 0.5, h/d = 0.65) were not optimal for cold working with hole expansion. Author

A88-19324
FATIGUE STRENGTH OF CAST TITANIUM COMPONENTS
R. H. COLLEY (TiTech International, Inc., Pomona, CA) IN: Fatigue prevention and design; Proceedings of the International Conference, Amsterdam, Netherlands, Apr. 21-24, 1986 . Warley, England, Engineering Materials Advisory Services, Ltd., 1986, p. 427-436. refs

The design and fatigue performance of cast Ti components for aircraft applications are described and illustrated with diagrams, drawings, graphs, and photographs. It is pointed out that the mechanical properties of forged and cast annealed Ti-6Al-4V alloys are virtually identical, while the ability of casting to produce complex shapes facilitates the design of components with ribs or hollow sections to resist fatigue loads. Some typical cast components are shown, and quality-control measures such as process control, inspection, postcasting treatment, and casting-factor specifications are discussed. T.K.

A88-19641
FORMATION OF ALUMINA ON TI-AL ALLOYS
R. A. PERKINS, K. T. CHIANG (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA), and G. H. MEIER (Pittsburgh, University, PA) Scripta Metallurgica (ISSN 0036-9748), vol. 21, Nov. 1987, p. 1505-1510. Research supported by the Lockheed Independent Research and Development Program. refs

The formation of Al2O3 on arc-melted Ti-Al alloys which are predominantly beta-phase was studied, with particular consideration given to the effects of alloying additions of Cr and V on the transition from internal to external aluminum oxidation. It was found that external alumina scales can be formed on Ti-Al alloys with 21-30 wt pct Al, at 1100-1400 C in air, by increasing the low aluminum diffusivity atom fraction through the retention of a bcc beta-Ti structure as a major phase and simultaneously decreasing the high oxygen solubility and high oxygen diffusivity fractions in the beta phase through alloying additions of Cr and V (with Cr more effective than V). Additions of V are detrimental in alloys which do not contain sufficient amounts of the beta structure because of the accelerating effect of V on the formation of transient oxides. I.S.

A88-20321*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MACH 2 COMBUSTION CHARACTERISTICS OF HYDROGEN/HYDROCARBON FUEL MIXTURES
GLENN S. DISKIN, G. BURTON NORTHAM (NASA, Langley Research Center, Hampton, VA), and RANDY A. BELL (George Washington University, Hampton, VA) Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee, Combustion Meeting, 24th, Monterey, CA, Oct. 5-8, 1987, Paper. 14 p. refs

The combustion of H2/CH4 and H2/C2H4 mixtures containing 10-70 vol pct hydrocarbon at cumbustor inlet Mach number 2 and temperatures 2000-4000 R is investigated experimentally, applying direct-connect test hardware and techniques similar to those described by Diskin and Northam (1987) in the facilities of the NASA Langley Hypersonic Propulsion Branch. The experimental setup, procedures, and data-reduction methods are described; and the results are presented in extensive tables and graphs and characterized in detail. Fuel type and mixture are found to have little effect on the wall heating rate measured near the combustor exit, but H2/C2H4 is shown to burn much more efficiently than H2/CH4, with no pilot-off blowout at equivalence ratios greater than 0.5. It is suggested that H2/hydrocarbon mixtures are feasible fuels (at least in terms of combustion efficiency) for scramjet SSTO vehicles operating at freestream Mach numbers above 4. T.K.

N88-13396# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
A HYBRID FIBREGLASS-CFRP CLOTH FOR NEW FURNISHINGS
M. J. FRUSTIE 1987 9 p
(SNIAS-872-111-109; ETN-88-91191) Avail: NTIS HC A02/MF A01

A glass fiber CFRP hybrid was chosen to replace aramid for aircraft cabin furnishings to comply with FAR 25 amendement 61 and FAR 121 amendement 189 concerning heat release. The material has the same weight as 181 style aramids (175 g/sqm) but the use of the carbon fiber glass hybrid with thin fiber glass plies eliminates local reinforcements on parts to obtain a weight slightly lower than obtained with aramid. Mechanical performance is a good as aramid, and production is simpler. ESA

N88-13397# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
SURFACE TREATMENT PROBLEMS FOUND IN NEW AIRCRAFT DESIGNED USING STRUCTURAL COMPOSITES [PROBLEMES DE TRAITEMENTS DE SURFACE RENCONTRES SUR LES MATERIAUX COMPOSITES STRUCTURAUX DANS LES NOUVEAUX AVIONS]
G. HELLARD 1987 12 p In FRENCH Presented at the 6th Journees Internationales d'Etude sur les Traitements de Surfaces dans l'Industrie Aeronautique et Spatiale
(SNIAS-872-111-113; ETN-88-91194) Avail: NTIS HC A03/MF A01

Problems found in designing aircraft with organic matrix composite materials are presented. The main categories of problems include erosion, lightning, airtightness, and painting. The problems vary with the type of composites and must be treated at the beginning of the aircraft design. ESA

N88-13400# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
PHILOSOPHY AND PRACTICE OF NONDESTRUCTIVE TESTS OF COMPOSITE MATERIAL STRUCTURES AT AEROSPATIALE AQUITAINE [PHILOSOPHIE ET PRATIQUE DES CND DES STRUCTURES EN MATERIAUX COMPOSITES A L'AEROSPATIALE AQUITAINE]
C. LEFLOCH 1987 6 p In FRENCH Presented at the Journees sur Controle Non Destructif et Materiaux Composites, Paris, France, 7 Apr. 1987
(SNIAS-872-430-105; ETN-88-91216) Avail: NTIS HC A02/MF A01

The nondestructive test implementing the quality control procedures of an aircraft manufacturer are described. These are mainly X-ray or ultrasonic procedures. Procedures being studied or in development are discussed, including photothermic analysis, photoacoustics, acoustic microscopy, diffused X-rays, neutrongraphy, and nuclear magnetic resonance. ESA

N88-13403# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
MEASUREMENT AND CONTROL OF DAMAGE IN COMPOSITE MATERIALS: NONDESTRUCTIVE CONTROLS BY THERMOGRAPHY, HOLOGRAPHY, AND RADIOGRAPHY [MESURE ET SUIVI DE L'ENDOMMAGEMENT DES MATERIAUX COMPOSITES. CONTROLES NON DESTRUCTIFS PAR: THERMOGRAPHIE, HOLOGRAPHIE, RADIOGRAPHIE]
D. LOUBET 1987 39 p In FRENCH
(SNIAS-872-430-110; ETN-88-91221) Avail: NTIS HC A03/MF A01

The nondestructive quality control methods used in an aerospace manufacturing plant are discussed. These include thermography, holography, and radiography. Inspection of carbon fiber/epoxy resin composite components used in Airbus aircraft structures and the measuring system are described. ESA

N88-13410 Virginia Polytechnic Inst. and State Univ., Blacksburg.
IGNITION AND FLAMEHOLDING IN SUPERSONIC FLOW BY INJECTION OF DISSOCIATED HYDROGEN Ph.D. Thesis
TIMOTHY CHARLES WAGNER 1987 202 p
Avail: Univ. Microfilms Order No. DA8719075

The use of free radicals for ignition and flameholding in supersonic flow was investigated analytically and experimentally. An analytical investigation of the effects of adding small quantities of radicals to a stoichiometric mixture of hydrogen and air was performed using a finite-rate chemical kinetics code. The results of these calculations indicate the small additions of hydrogen atoms, oxygen atoms, nitrogen atoms, or hydroxyl radicals are effective in promoting ignition. These analytical results were qualitatively verified in a Mach 2 flow experiment using hydrogen atoms generated by a plasma torch. The supersonic combustion tests were conducted in a direct-connect mode at atmospheric pressure with either ambient temperature air or burner-heated vitiated air with total temperatures from 1200 to 4000 R. The experimental results indicate that hydrogen atoms from a low-power plasma torch provide an effective ignition and flameholding source for hydrogen-fueled Mach 2 flows at total temperatures as low as 1065 R, the lowest temperature tested. A piloted fuel injector configuration design to take maximum advantage of the hydrogen atoms from the plasma torch was conceived and fabricated. Hydrogen atoms generated by the plasma torch proved to be the most effective ignition source. The combination of hydrogen atoms and the piloted fuel injector was shown to be a very effective igniter and flameholder for scramjet operation over a simulated flight envelope. Dissert. Abstr.

N88-13461# Pratt and Whitney Aircraft, West Palm Beach, Fla. Government Products Div.
DEVELOPMENT OF IRON ALUMINIDES Final Report, 1 Sep. 1981 - 31 Jan. 1986
R. G. BOURDEAU, C. M. ADAM, M. J. BLACKBURN, C. V. LAW, and E. R. SLAUGHTER May 1987 287 p
(Contract F33615-81-C-5110)
(AD-A185190; PW/GRD-FR-18807; AFWAL-TR-87-4009) Avail: NTIS HC A13/MF A01 CSCL 11F

This program addresses the development of iron aluminide base alloys by rapid solidification and the determination of their potential for use in aircraft turbine engines as alternatives to high chromium steels and nickel-base alloys. The program was divided into three tasks. A process and model development task to define thermomechanical processing requirements for Fe3A1 base alloys, a task to produce and deliver to the Air Force Materials Laboratory a number of alloys produced by the P&W rapidly solidified powder process and a task for the development of austenitic Fe-Mn-A1 alloys with improved elevated temperature properties. GRA

N88-13466 Prins Maurits Lab. TNO, Rijswijk (Netherlands).
RESISTANCE OF CANOPY MATERIALS AGAINST CHEMICALS [BESTENDIGHEID VAN CANOPY-MATERIALEN TEGEN CHEMICALIEEN]
J. W. VANDERSLIKKE Apr. 1985 39 p In DUTCH; ENGLISH summary
(PML-1985-22; TDCK-93458; ETN-88-90863) Avail: Issuing Activity

The effects of chemicals on transparent polymers, viz. helicopter and canopy parts as well as commercially available Perspex (polymethyl methacrylate) and Lexan (polycarbonate) were investigated. The used chemicals are liquid chemicals used by the Air Force, chemical warfare agents, and chemicals that can be used as solvent or thickener. The chemicals can adversely affect transparency. Perspex and Lexan react differently with several of the chemicals. The degradation of F-16 canopy material is substantially less than that of commercial sheet Lexan; this finding is not explained. ESA

N88-13470# Societe Nationale Industrielle Aerospatiale, Suresnes (France). Direction Centrale de la Qualite.
PAINTS REQUIRED FOR AERONAUTICAL CONSTRUCTION [LES BESOINS DE L'AERONAUTIQUE EN MATIERE DE PEINTURES]
C. BEZAUD and J. J. BODU 7 Apr. 1987 16 p In FRENCH Presented at Journee AFTPV Les Besoins en Peinture de Grandes Administrations, de Quelques Entreprises Nationalisees, et des Unites Urbaines, 8 Apr. 1987
(SNIAS-872-551-102; C-49-541; ETN-88-91234) Avail: NTIS HC A03/MF A01

Aeronautical paint performance required, the main categories of products involved, and the special requirements introduced with the adoption of composite materials are described. Recently designed aircraft, such as the A-320, use mostly epoxy anticorrosion primers and polyurethane finishing. ESA

N88-13475# North Dakota Univ., Grand Forks. Energy Research Center.
PRODUCTION OF JET FUELS FROM COAL DERIVED LIQUIDS. VOLUME 1: MARKET ASSESSMENT FOR LIQUID BY-PRODUCTS FROM THE GREAT PLAINS GASIFICATION PLANT Interim Report, 20 Jan. - 30 Apr. 1987
J. E. SINOR Aug. 1987 227 p Prepared in cooperation with Sinor (J. E.) Consultants, Inc. Niwot, Conn.
(Contract MIPR-FY1455-86-N0657; DA PROJ. 2480)
(AD-A184846; AFWAL-TR-87-2042-VOL-1) Avail: NTIS HC A11/MF A01 CSCL 21D

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 production of jet fuel from the liquid by-product streams produced by the gasification of lignite at the Great Plains Gasification Plant in Buelah, 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 effort of JE Sinor Consultants, who, as a subcontractor to the DOE contract with the University of North Dakota Energy Research Center (UNDERC), determined the market potential of these by-product streams. This report describes the market potential of the by-product streams for the production of phenols, benzene, cresote, cresylic acids, coal tar pitch, paving materials, carbon black, naphthalene, rubber processing oils, as well as jet fuels. GRA

N88-14144* General Dynamics Corp., San Diego, Calif. Convair Div.
TIME-TEMPERATURE-STRESS CAPABILITIES OF COMPOSITE MATERIALS FOR ADVANCED SUPERSONIC TECHNOLOGY APPLICATION
JAMES R. KERR and JAMES F. HASKINS May 1987 675 p
(Contract NAS1-12308)
(NASA-CR-178272; NAS 1.26:178272; GDC-CRAD-85-005)
Avail: NTIS HC A99/MF E03 CSCL 11D

Advanced composites will play a key role in the development of the technology for the design and fabrication of future supersonic vehicles. However, incorporating the material into vehicle usage is contingent on accelerating the demonstration of service capacity and design technology. Because of the added material complexity and lack of extensive data, laboratory replication of the flight service will provide the most rapid method to document the airworthiness of advanced composite systems. Consequently, a laboratory program was conducted to determine the time-temperature-stress capabilities of several high temperature composites. Tests included were thermal aging, environmental aging, fatigue, creep, fracture, tensile, and real-time flight simulation exposure. The program had two phases. The first included all the material property determinations and aging and simulation exposures up through 10,000 hours. The second continued these tests up to 50,000 cumulative hours. This report presents the results of the Phase 1 baseline and 10,000-hr aging and flight simulation studies, the Phase 2 50,000-hr aging studies, and the Phase 2 flight simulation tests, some of which extended to almost 40,000 hours. Author

N88-14155*# National Academy of Sciences - National Research Council, Washington, D. C. Committee on the Status and Viability of Composite Materials for Aircraft Structures.
ADVANCED ORGANIC COMPOSITE MATERIALS FOR AIRCRAFT STRUCTURES: FUTURE PROGRAM
1987 112 p
(Contract NASW-4003)
(NASA-CR-181467; NAS 1.26:181467) Avail: NTIS HC A06/MF A01 CSCL 11D

Revolutionary advances in structural materials have been responsible for revolutionary changes in all fields of engineering. These advances have had and are still having a significant impact on aircraft design and performance. Composites are engineered materials. Their properties are tailored through the use of a mix or blend of different constituents to maximize selected properties of strength and/or stiffness at reduced weights. More than 20 years have passed since the potentials of filamentary composite materials were identified. During the 1970s much lower cost carbon filaments became a reality and gradually designers turned from boron to carbon composites. Despite progress in this field, filamentary composites still have significant unfulfilled potential for increasing aircraft productivity; the rendering of advanced organic composite materials into production aircraft structures was disappointingly slow. Why this is and research and technology development actions that will assist in accelerating the application of advanced organic composites to production aircraft is discussed. Author

N88-14157*# Douglas Aircraft Co., Inc., Long Beach, Calif.
A STUDY OF THE UTILIZATION OF ADVANCED COMPOSITES IN FUSELAGE STRUCTURES OF COMMERCIAL AIRCRAFT Final Report
D. J. WATTS, P. T. SUMIDA, B. L. BUNIN, G. S. JANICKI, J. V. WALKER, and B. R. FOX Jan. 1985 183 p
(Contract NAS1-17416)
(NASA-CR-172405; NAS 1.26:172405; ACEE-30-FR-3313) Avail: NTIS HC A09/MF A01 CSCL 11D

A study was conducted to define the technology and data needed to support the introduction of advanced composites in the future production of fuselage structure in large transport aircraft. Fuselage structures of six candidate airplanes were evaluated for the baseline component. The MD-100 was selected on the basis of its representation of 1990s fuselage structure, an available data base, its impact on the schedule and cost of the development program, and its availability and suitability for flight service evaluation. Acceptance criteria were defined, technology issues were identified, and a composite fuselage technology development plan, including full-scale tests, was identified. The plan was based on composite materials to be available in the mid to late 1980s. Program resources required to develop composite fuselage technology are estimated at a rough order of magnitude to be 877 man-years exclusive of the bird strike and impact dynamic test components. A conceptual composite fuselage was designed, retaining the basic MD-100 structural arrangement for doors, windows, wing, wheel wells, cockpit enclosure, major bulkheads, etc., resulting in a 32 percent weight savings. Author

N88-14181# Societe Nationale Industrielle Aerospatiale, Suresnes (France). *Direction Centrale de la Qualite.*
STUDY OF SURFACE TREATMENT BEFORE BONDING OF LIGHT ALLOYS Test Report [ETUDE DES TRAITEMENTS DE SURFACE AVANT COLLAGE DES ALLIAGES LEGERS]
J. ODORICO, J. M. CUNTZ, and M. VILLATTE 10 Mar. 1987 64 p In FRENCH
(Contract DRET-85-34-444)
(DCQ/L-48-287/F; ETN-88-91173) Avail: NTIS HC A04/MF A01

The mechanical behavior of aluminum alloy bonded junctions such as those employed in aircraft structures was related to previous surface treatment. The treatment consists of phosphoric medium anodizing. The effects of time, heat, and moisture were studied, showing that 48 hr in dry atmosphere does not affect bonding characteristics, while a hot and humid medium significantly affects the physical and chemical characteristics of the surface layer as well as the resulting mechanical properties of the bonded joints. ESA

N88-14211# Ashland Petroleum Co., Ky.
AVIATION TURBINE FUELS FROM TAR SANDS BITUMEN AND HEAVY OILS. PART 2: LABORATORY SAMPLE PRODUCTION Technical Report, 1 Apr. 1984 - 31 May 1985
H. F. MOORE, C. A. JOHNSON, D. A. FABRY, M. H. CHAFFIN, and W. A. SUTTON Jul. 1987 136 p
(Contract F33615-83-C-2301)
(AD-A185744; AFWAL-TR-84-2070-PT-2) Avail: NTIS HC A07/MF A01 CSCL 21D

Phase 2 work performed on small bench scale laboratory units was to validate the process variables identified in Phase 1. As a part of this effort, samples (quanity 500 ML to 1000 ML) of JP4, JP8, were produced and submitted to AFWAL for their evaluation. Detailed characterizations of the tar sand feedstocks and product samples were performed. From the data generated in Phase 2, specific goals and tests were outlined for Phase 3 of the program. GRA

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ENGINEERING

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

A88-16920
ELECTROMAGNETIC COMPATIBILITY MODELING FOR FUTURE AVIONICS SYSTEMS
ALLEN LOCKYER (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Avionics in conceptual system planning; Proceedings of the Eighth Annual IEEE Symposium, Dayton, OH, Dec. 3, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 79-89. refs

Two computer programs have been developed which can model a weapon system's electromagnetic compatibility and can be used to identify potential electromagnetic interference problems in the conceptual phase of avionic system planning. The Intrasystem Electromagnetic Compatibility Analysis Program (IEMCAP) is designed for overall intrasystem electromagnetic compatibility prediction; the General Electromagnetic Model for Analysis of Complex Systems (GEMACS) can model detailed coupling problems that have been identified by IEMCAP. Some useful code enhancements illustrating the growing importance of computer graphics in electromagnetic analysis are also discussed. V.L.

A88-17463
CYCLIC STRUCTURAL ANALYSIS OF GAS TURBINE NOZZLE
S. AKSOY, C. ANEKWE, J. O'CONNOR, and D. SCHWARTZ (Textron, Inc., Avco Lycoming Textron, Stratford, CT) (International Association for Computational Mechanics, Congress on Computational Mechanics, 1st, Austin, TX, Sept. 22-26, 1986) Computers and Structures (ISSN 0045-7949), vol. 27, no. 1, 1987, p. 165-170. refs

Transient temperature and cyclic stress-strain distributions in a gas turbine nozzle were calculated for a typical engine mission cycle. The generalized plane strain finite element formulation was used to analyze the air cooled airfoil. A procedure for evaluating damage due to low cycle fatigue and stress rupture was developed and employed to predict the failure location, which was compared to in-house test experience. Author

A88-17553
STRUCTURAL DESIGN OF A HIGH PERFORMANCE MICROSTRIP ANTENNA
P. R. COWLES (Canadian Astronautics, Ltd., Ottawa, Canada) IN: International Conference on Antennas and Propagation, 5th, York, England, Mar. 30-Apr. 2, 1987, Proceedings. Part 1 . London, Institution of Electrical Engineers, 1987, p. 229-232. refs

The general aspects of series array design are considered from the viewpoint of structure and materials and a particular solution which has been adapted in the case of an 'azimuth' microwave landing system (MLS) antenna is described. The antenna, about one third the mass of a conventional slotted waveguide array, assists frangibility which is an important property of equipment placed on the center-line of an airport runway. K.K.

A88-17856
TRENDS IN THE IMPROVEMENT OF GYROSCOPES AND GYROSTABILIZED PLATFORMS [TENDENTSII SOVERSHENSTVOVANIIA GIROSKOPOV GIROSTABILIZIROVANNYKH PLATFORM]
D. P. LUK'IANOV, L. A. SEVEROV, E. L. SMIRNOV, and A. V. TIL' (Leningradskii Institut Aviatsionnogo Priborostroeniia, Leningrad, USSR) Priborostroenie (ISSN 0021-3454), vol. 30, Oct. 1987, p. 46-56. In Russian. refs

The main trends in the improvement of the engineering and operating characteristics of gyroscopes and gyrostabilized platforms for use in inertial navigation systems are examined. The recent literature on the subject is briefly reviewed. B.J.

A88-17945
PRACTICAL SOLUTIONS TO PROBLEMS IN EXPERIMENTAL MECHANICS, 1940-85: A HISTORY
GIVEN ANKENY BREWER (Brewer Engineering Laboratories, Inc., Marion, MA) New York, Vantage Press, 1987, 250 p. refs

Advances in stress/strain measurement technology are recalled in a collection of the author's previously published papers. Topics discussed include photogrid determination of strain distribution, measurement of strain in the plastic range, the use of stainless steel in jet-aircraft structures, operating stresses in ship propellers, and dynamic-pressure measurement in a liquid-Na pipe using an electromechanical dilatometer. Consideration is given to bonded resistance strain gages for use on offshore oil platforms, power-plant vibration absorber systems, and residual-stress measurement in rapid-transit axles. Each paper is provided with a brief historical/autobiographical introduction. T.K.

A88-18227
COMPOSITE MATERIAL SPRING FOR 767 ENTRY AND SERVICE DOOR COUNTERBALANCE MECHANISM
JOHN A. ENNES (Boeing Commercial Airplane Co., Seattle, WA) IN: Advanced composites: The latest developments; Proceedings of the Second Conference, Dearborn, MI, Nov. 18-20, 1986 . Metals Park, OH, ASM International, 1986, p. 5-14.

The composite spring has been developed as a lightweight means of storing the energy required for lifting the entry and service doors of the 767 aircraft, in lieu of a Ti alloy spring. The spring is of graphite fiber-reinforced epoxy, and its specific composition was arrived at in view of numerous environmental degradation-resistance, strength, and flammability requirements. A 113-lb weight saving was accomplished, together with a factor-of-four improvement in fatigue life; cost savings are anticipated through further materials and design innovations. O.C.

A88-18386
FREE VIBRATION AND FLUTTER OF LAMINATED QUADRILATERAL PLATES
R. S. SRINIVASAN and B. J. C. BABU (Indian Institute of Technology, Madras, India) Computers and Structures (ISSN 0045-7949), vol. 27, no. 2, 1987, p. 297-303. refs

Free vibration and flutter of laminated quadrilateral plates with clamped edges have been investigated in this paper. Differential equations of motion in quadrilateral coordinates are derived and solved by the use of the integral equation technique. The results of free vibration analysis and flutter are compared with the values given in the available references. The behavior of trapezoidal plates with different numbers of layers has been studied. Author

A88-18477#
REVIEW OF AERONAUTICAL FATIGUE - INVESTIGATIONS IN FRANCE DURING THE PERIOD 1985-1987
R. LABOURDETTE (ONERA, Chatillon-sous-Bagneux, France) (International Committee on Aeronautical Fatigue, Conference, 20th, Ottawa, Canada, June 8, 9, 1987) ONERA, TP, no. 1987-91, 1987, 19 p. refs
(ONERA, TP NO. 1987-91)

The need to account for the behavior of structural components in the characterization of alloys has involved the study of a specimen called 'standard spar'. This specimen choice is justified by typical sizes of a wing spar of military aircraft (which are also representative of large components of civil aircraft), simple shapes, and a simple test rig. Computation models for the crack growth rate under variable amplitude loading are presented. K.K.

A88-18498#
C3I OFFERS SPINOFFS TO ENTREPRENEURS
CHARLES M. JOHNSON (ANSER Corp., Arlington, VA) Aerospace America (ISSN 0740-722X), vol. 25, Nov. 1987, p. 30-32.

The commercial applicability of SDI-related communications and control technologies is explored. Space-to-space and space-to-ground or -aircraft communications by means of electronically agile antenna technology in the 60-GHz band are typical of the SDI network technologies that are seen as capable of satisfying civilian requirements in such fields as air traffic control/communications, real-time banking transactions, law enforcement and antiterrorist operations, direct TV broadcasting to subscribers, and wide area, wide bandwidth data networks connecting hundreds of processing gateways. O.C.

A88-18550
AN IMPROVED BOUNDARY ELEMENT FORMULATION FOR CALCULATING STRESS INTENSITY FACTORS - APPLICATION TO AEROSPACE STRUCTURES
M. H. ALIABADI (Southampton, University, England), D. P. ROOKE (Royal Aircraft Establishment, Materials and Structures Dept., Farnborough, England), and D. J. CARTWRIGHT (Bucknell University, Lewisburg, PA) Journal of Strain Analysis for Engineering Design (ISSN 0309-3247), vol. 22, Oct. 1987, p. 203-207. Research supported by the Ministry of Defence Procurement Executive. refs

In order to compute stress intensity factors accurately, the standard boundary element method is modified to take explicit account of the singularity in the stresses at a crack-tip. The known expansion terms of the crack tip displacement and stress fields are subtracted to remove the numerical difficulties associated with the representation of a singular stress field at the crack-tip. Hence the accuracy of calculation is much improved, without appreciably increasing the amount of computation involved. Furthermore, the stress intensity factor is directly obtained as a part of a solution and no extrapolations are required. The improved formulation is applied to a configuration, which is representative of a part of the wing in a civil transport aeroplane. This configuration consists of a pair of circular cut-outs (supply ports) near to which smaller holes exist; these small holes are particularly susceptible to cracking. Author

A88-18751
ASLE, ANNUAL MEETING, 42ND, ANAHEIM, CA, MAY 11-14, 1987, TECHNICAL PREPRINTS
Meeting sponsored by ASLE. Park Ridge, IL, American Society of Lubrication Engineers, 1987, 380 p. For individual items see A88-18752 to A88-18763.

Various papers on lubrication engineering are presented. The general topics addressed include: aerospace lubrication, ceramics technology, engine and drive train lubricants, fluid film bearings,

fluids for metal working, hydraulics and machine tools, lubrication equipment and practices, lubrication fundamentals, power generation, petroleum and chemicals, rolling bearings, seals, solid lubricants, steel, and wear. C.D.

A88-19262
COMPUTATIONAL METHODS IN MODERN REPAIR TECHNOLOGY
R. JONES, R. BAILEY, and J. D. ROBERTS (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) Computational Mechanics (ISSN 0178-7675), vol. 2, no. 4, 1987, p. 247-252. refs

Numerical modeling techniques for bonded repairs of cracked metallic components (mainly on aircraft) are described and demonstrated. A two-dimensional formulation for the FEM analysis of bonded repairs to cracked wing skins is shown to be compatible with most current FEM codes and to give results in good agreement with experimental measurements; for repairs of surface flaws in thick sections, however, fully three-dimensional analysis is required. Both analyses employ directionally reduced integration to overcome problems associated with large aspect ratios. Typical results are presented in tables and graphs and briefly characterized. T.K.

A88-19301
FATIGUE PREVENTION AND DESIGN; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, AMSTERDAM, NETHERLANDS, APR. 21-24, 1986
J. T. BARNBY, ED. Conference sponsored by Fatigue Technology, Inc., Airtech Precision Shot Peening, Inc., Dartec, Ltd., et al. Warley, England, Engineering Materials Advisory Services, Ltd., 1986, 465 p. For individual items see A88-19302 to A88-19324.

Techniques for estimating and extending the fatigue life (FL) of metallic structures are discussed in reviews and reports of recent theoretical and experimental investigations. Topics addressed include cold-worked holes, design concepts, surface treatments, and material selection. Consideration is given to the fatigue of aircraft structures, the interaction of processing and design in powder metallurgy, FL enhancement by cold expansion of holes, fatigue-strength prediction for tension-type connections, fatigue design of hydraulic turbine components, increasing aircraft life with crack growth inhibitors, the effect of shot peening on the high-temperature FL of Ti alloys, the contact fatigue resistance of high-Mn steels, and the fatigue strength of cast Ti components. T.K.

A88-19302
FATIGUE OF AIRCRAFT STRUCTURES
J. SCHIJVE (Delft, Technische Hogeschool, Netherlands) IN: Fatigue prevention and design; Proceedings of the International Conference, Amsterdam, Netherlands, Apr. 21-24, 1986 . Warley, England, Engineering Materials Advisory Services, Ltd., 1986, p. 3-34. refs

Fatigue of aircraft structures is discussed from a design point of view. The various steps of the fatigue analysis are indicated, including mission analysis and load spectra, conceptual aspects of designing against fatigue, predictions of fatigue lives and crack growth, and experimental verifications. The significance of fatigue load monitoring and flight-simulation testing is emphasized. Author

A88-19308
FATIGUE LIFE ENHANCEMENT BY THE COLD-EXPANSION OF HOLES - RESEARCH AND CASE STUDY
P. W. BEAVER, J. Y. MANN, and J. G. SPARROW (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Fatigue prevention and design; Proceedings of the International Conference, Amsterdam, Netherlands, Apr. 21-24, 1986 . Warley, England, Engineering Materials Advisory Services, Ltd., 1986, p. 123-136. refs

The cold expansion of holes is a common technique for increasing the fatigue lives of aircraft structural members. This paper outlines the results of research at the Aeronautical Research Laboratories (ARL) on the split-sleeve hole cold-expansion process. It involved a study of the surface strains at the mandrel inlet and outlet faces of thick specimens of an aluminum alloy and within the shear discontinuities associated with the split in the sleeve. Complementary fatigue tests were carried out to evaluate the influence of split orientation, postcold-expansion reaming and the removal of the z-direction surface displacement on the fatigue behavior of open hole specimens. An example is given of the application of the technique to improve the fatigue performance of an aircraft wing structure. Author

A88-19316
STRESS EFFECT ON FATIGUE LIFE SCATTER
V. SEDLACEK (Ceske Vysoke Uceni Technicke, Prague, Czechoslovakia), V. NEJEDLY, and J. BEHAL (Vyzkumny a Zkusebni Letecky Ustav, Prague, Czechoslovakia) IN: Fatigue prevention and design; Proceedings of the International Conference, Amsterdam, Netherlands, Apr. 21-24, 1986 . Warley, England, Engineering Materials Advisory Services, Ltd., 1986, p. 247-256. refs

The paper presents some results of Czechoslovak research in the field of AlCu4MgIMnI alloy development. The problem, a departure of fatigue lives distribution at lower level of stress from the assumed normal one, is solved on the basis of both, the mechanical testing and microstructure analysis approach. From crack growth model, which was developed, follows that the main part of variance of fatigue life can be explained by conditions of initiation and propagation of short cracks. Author

A88-19318
EFFECTS OF CLADDING AND ANODISING ON FLIGHT SIMULATION FATIGUE OF 2024-T3 AND 7475-T761 ALUMINIUM ALLOYS
R. J. H. WANHILL (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Fatigue prevention and design; Proceedings of the International Conference, Amsterdam, Netherlands, Apr. 21-24, 1986 . Warley, England, Engineering Materials Advisory Services, Ltd., 1986, p. 323-332. refs

Effects of cladding and anodizing on flight simulation fatigue of notched specimens and riveted lap joints of 2024-T3 and 7475-T761 sheet were investigted. Cladding and anodizing had very large effects on the fatigue lives and were always detrimental for notched specimens. For lap joints cladding was detrimental only in combination with anodizing. Anodizing was very beneficial for lap joints assembled for bare alloy sheets. With equivalent surface treatments 2024-T3 specimens had longer average fatigue lies than 7475-T761 specimens. Author

A88-19320
INCREASING AIRCRAFT LIFE WITH CRACK GROWTH INHIBITORS
R. N. MILLER (Lockheed-Georgia Co., Marietta) IN: Fatigue prevention and design; Proceedings of the International Conference, Amsterdam, Netherlands, Apr. 21-24, 1986 . Warley, England, Engineering Materials Advisory Services, Ltd., 1986, p. 353-362. refs

The use of inhibitors to slow crack growth in aluminum and steel alloys is reviewed and the mechanisms of their action is described. Experimental data showing the effect of a crack growth inhibiting sealant on the fatigue cracking of 7075-T6 and 7075-T73 aluminum is presented. The test procedures and specimen configurations are described. Best results were obtained with a complex amine inhibitor added to a polysulfide sealant. Author

A88-19325
THE DEVELOPMENT OF ELECTROMECHANICAL ACTUATION FOR AIRCRAFT SYSTEMS
J. A. P. WHITE (Dowty Electrics, Ltd., Cheltenham, England) Aerospace (UK) (ISSN 0305-0831), vol. 14, Nov. 1987, p. 8-13.

An assessment is made of the design development status and characteristic performance features of advanced aircraft electromechanical actuators (EMAs) employing such rare earth permanent magnet materials as samarium-cobalt in compact, powerful motors. Attention is given to the design of both linear,

screwjack-employing and rotary, epicyclic drivetrain-employing EMAs, as well as to methods that impart artificial 'feel' to actuation tasks for better interface with pilots, highly automated 'smart' EMA architectures, and the emerging possibilities for the design of an all-electric aircraft control system whose actuators are supplied with power from a 270-V dc system. O.C.

A88-19668#
REDUCTION OF THE ULTIMATE FACTOR BY APPLYING A MAXIMUM LOAD CONCEPT
OTTO SENSBURG, OTTO BARTSCH, and HANS BERGMANN (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Journal of Aircraft (ISSN 0021-8669), vol. 24, Nov. 1987, p. 759-767. refs

A probabilistic approach and a maximum load concept are used to show that the same structural safety can be achieved on an aircraft with a load-limiting, carefree-handling, artificially stabilizing system with an ultimate factor of 1.3 as on one without such a system (stable aircraft) and a factor of 1.5. It is noted that a factor of 1.4 (with a load-limiting system) will give a safer aircraft standard than that achieved for contemporary combat aircraft. b.

A88-19702* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPECTRAL METHODS AND THEIR IMPLEMENTATION TO SOLUTION OF AERODYNAMIC AND FLUID MECHANIC PROBLEMS
C. L. STREETT (NASA, Langley Research Center, Hampton, VA) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 7, Nov. 1987, p. 1159-1189. refs

Fundamental concepts underlying spectral collocation methods, especially pertaining to their use in the solution of partial differential equations, are outlined. Theoretical accuracy results are reviewed and compared with results from test problems. A number of practical aspects of the construction and use of spectral methods are detailed, along with several solution schemes which have found utility in applications of spectral methods to practical problems. Results from a few of the successful applications of spectral methods to problems of aerodynamic and fluid mechanic interest are then outlined, followed by a discussion of the problem areas in spectral methods and the current research under way to overcome these difficulties. Author

A88-19806#
INELASTIC FINITE DEFLECTIONS OF CANTILEVER BEAMS
T. K. VARADAN (Indian Institute of Technology, Madras, India) and DESHANE JOSEPH (Alabama, University, Huntsville) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 39, Feb. 1987, p. 39-41. refs

A closed-form solution for nonlinear bending of cantilever beams made of Ludwick type material was obtained using the indirect approach of Prathap and Varadan (1976), in the sense that the original configuration was obtained from the deformed configuration. Two cases of beam material of Ludwick type are considered: when the applied load is an end moment and when the applied load is a vertical concentrated load at the tip. In addition, a case when the beam material physical properties are given by Ramberg-Osgood relation and the applied load is an end moment is discussed. Plots showing tip deflection - end moment relations for linear- and nonlinear-material cantilevers, and with large and small deformations, are presented. I.S.

A88-19884
CRITICAL PATH ACCELERATION AND SIMULATION IN AIRCRAFT TECHNOLOGY PLANNING
ROBERT G. BATSON (Alabama, University, Tuscaloosa) IEEE Transactions on Engineering Management (ISSN 0018-9391), vol. EM-34, Nov. 1987, p. 244-251. Research supported by Lockheed-Georgia Co. refs

Critical path methods have been in common use in the aircraft industry for a number of years, but most often after a program enters preliminary design. In aircraft technology development studies, critical path acceleration is shown to be a natural and, in fact, necessary method for planning. An implementation of a time-cost trade-off algorithm of Tufekci is discussed. Because of inherent time uncertainty, network simulation should also be performed to develop a confidence band on the traditional time-cost trade-off curve. The network simulation package VERT is available for this purpose. Two instances of applying these two methods to plans for advanced materials technology development are reported as case studies. Author

A88-20476
LASER GYROS AND FIBRE OPTIC GYROS; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, FEB. 25, 1987
London, Royal Aeronautical Society, 1987, 131 p. For individual items see A88-20477 to A88-20482.

Various papers on laser gyros and fiber optic gyros are presented. The topics addressed include: optical gyroscopes in context, fiber optic gyroscopes using integrated optics, optical fiber ring resonator gyroscopes, ring laser gyro geometry and size, the relative merits of ring laser gyroscopes and 'iron-wheel' gyroscopes in application to medium accuracy INS for combat aircraft, the development of small ring laser gyroscopes, fiber optic gyroscopes in inertial navigation, and design and performance of a serrodyne fiber optic gyroscope. C.D.

A88-20481
THE RELATIVE MERITS OF RING LASER GYROSCOPES AND 'IRON-WHEEL' GYROSCOPES IN APPLICATION TO MEDIUM ACCURACY INS FOR COMBAT AIRCRAFT
NORMAN F. WATSON (Ferranti Defence Systems, Ltd., Edinburgh, Scotland) IN: Laser gyros and fibre optic gyros; Proceedings of the Symposium, London, England, Feb. 25, 1987 . London, Royal Aeronautical Society, 1987, p. 5.1-5.31. refs

The relative merits of gimballed INS based on mechanical gyroscopes and strapdown INS based on ring laser gyroscopes are compared with regard to their use in 1 nm/hr combat aircraft navigation. Navigation performance, velocity performance, attitude performance, body axis outputs, environmental influences, reliability and maintainability, cost, and physical parameters are taken into consideration. Some of the advantages which have been claimed elsewhere for the laser INS, such as dramatically lower life cycle costs than for gimballed INS, are shown to be unrealistic under reasonable assumptions. C.D.

N88-13533 Georgia Inst. of Tech., Atlanta.
SOLUTION PROCEDURE FOR THE NAVIER-STOKES EQUATIONS APPLIED TO ROTORS Ph.D. Thesis
BRIAN ERNEST WAKE 1987 204 p
Avail: Univ. Microfilms Order No. DA8718467

A solution procedure for the unsteady, three-dimensional Navier-Stokes equations was developed and applied to helicopter rotors. The procedure is an efficient hybrid ADI scheme in which the radial and viscous terms are treated explicitly. This procedure solves the Navier-Stokes equations in a time-accurate manner. Steady solutions are obtained by marching through time and asymptotically converging to steady state. Turbulence is included by an algebraic eddy-viscosity model. An unsteady grid is utilized to incorporate the blade motion. Arbitrary motions due to cyclic pitch, flapping, lead-lag motions, and aeroelastic deflections can also be incorporated into the unsteady grid terms. The equations are formulated for a curvilinear coordinate system, enabling completely arbitrary rotor-blade geometries. To account for the effect of the rotor wake, the transpiration-velocity technique is used. Quasi-steady Euler calculations were made for a high-speed nonlifting ONERA blade. Unsteady Euler and Navier-Stokes calculations were also performed for this configuration to examine the viscous and unsteady effects. Lifting hover results were made for a two-bladed rotor with 0012 blade airfoil sections. For this case, a detailed qualitative comparison with experimental results in the tip region is done. Also, unsteady Euler results were obtained for a lifting OLS rotor. Dissert. Abstr.

N88-13547# Universite de Technologie de Compiegne (France).
UTILIZATION OF A HIGH RATE VECTOR COMPUTER IN COMPUTATIONAL FLUID MECHANICS FOR AERONAUTICS Final Report [UTILISATION D'UN PROCESSEUR VECTORIEL A GRAND DEBIT POUR DES CALCULS EN MECANIQUE DES FLUIDES A FINALITE AERONAUTIQUE]
MICHEL VAYSSADE 1986 68 p In FRENCH
(Contract DRET-84-164)
(ETN-88-91171) Avail: NTIS HC A04/MF A01

A finite element numerical model, used for the solution of Navier-Stokes equation for incompressible flow was adapted to the FPS-164 vector computer and optimized. The computer capacity is 99 megaflops and is equipped with 4 matrix algebra acceleration (MAX) cards operating in SIMD mode. The results obtained are limited due to disk unit input-output delay and problems derived from the MAX card architecture. ESA

N88-13549*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VORTICAL FLOWS RESEARCH PROGRAM OF THE FLUID DYNAMICS RESEARCH BRANCH
Aug. 1986 28 p
(NASA-TM-88332; A-86324; NAS 1.15:88332) Avail: NTIS HC A03/MF A01 CSCL 20D

The research interests of the staff of the Fluid Dynamics Research Branch in the general area of vortex flows are summarized. A major factor in the development of enchanced maneuverability and reduced drag by aerodynamic means is the use of effective vortex control devices. The key to control is the use of emerging computational tools for predicting viscous fluid flow in close coordination with fundamental experiments. In fact, the extremely complex flow fields resulting from numerical solutions to boundary value problems based on the Navier-Stokes equations requires an intimate relationship between computation and experiment. The field of vortex flows is important in so many practical areas that a concerted effort in this area is justified. A brief background of the research activity undertaken is presented, including a proposed classification of the research areas. The classification makes a distinction between issues related to vortex formation and structure, and work on vortex interactions and evolution. Examples of current research results are provided, along with references where available. Based upon the current status of research and planning, speculation on future research directions of the group is also given. Author

N88-13552*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEASUREMENT OF LOCAL CONVECTIVE HEAT TRANSFER COEFFICIENTS FROM A SMOOTH AND ROUGHENED NACA-0012 AIRFOIL: FLIGHT TEST DATA
JAMES E. NEWTON, G. JAMES VANFOSSEN, PHILLIP E. POINSATTE, and KENNETH J. DEWITT (Toledo Univ., Ohio.) 1988 17 p Presented at the 26th Aerospace Sciences Meeting, Reno, Nev., 11-14 Jan. 1988; sponsored by AIAA
(NASA-TM-100284; E-3924; NAS 1.15:100284; AIAA-88-0287)
Avail: NTIS HC A03/MF A01 CSCL 20D

Wind tunnels typically have higher free stream turbulence levels than are found in flight. Turbulence intensity was measured to be 0.5 percent in the NASA Lewis Icing Research Tunnel (IRT) with the cloud making sprays off and around 2 percent with cloud making equipment on. Turbulence intensity for flight conditions was found to be too low to make meaningful measurements for smooth air. This difference between free stream and wing tunnel conditions has raised questions as to the validity of results obtained in the IRT. One objective of these tests was to determine the effect of free stream turbulence on convective heat transfer for the NASA Lewis LEWICE ice growth prediction code. These tests provide in-flight heat transfer data for a NASA-0012 airfoil with a 533 cm chord. Future tests will measure heat transfer data from the same airfoil in the Lewis Icing Research Tunnel. Roughness was obtained by the attachment of small, 2 mm diameter hemispheres of uniform size to the airfoil in three different patterns. Heat transfer measurements were recorded in flight on the NASA Lewis Twin Otter Icing Research Aircraft. Measurements were taken for the smooth and roughened surfaces at various aircraft speeds and angles of attack up to four degrees. Results are presented as Frossling number versus position on the airfoil for various roughnesses and angles of attack. Author

N88-13599# Scientific Research Associates, Inc., Glastonbury, Conn.
THREE-DIMENSIONAL DYNAMIC LABYRINTH SEAL ANALYSIS Final Report, 1 Jul. - 31 Dec. 1986
Y. T. CHAN, R. C. BUGGELN, and H. MCDONALD 2 Jan. 1987 50 p
(Contract F33615-86-C-2665)
(AD-A185353; SRA-910017; AFWAL-TR-87-2009) Avail: NTIS HC A03/MF A01 CSCL 11A

A transient capability has been developed for fluid flow analysis in a labyrinth seal configuration with a whirling rotor. The technique utilizes a moving coordinate system that allows transient calculations of the flow and pressure fields. Two sample calculations with different rotor oscillation displacements are presented and the results demonstrate the potential of this analysis. GRA

N88-13643 Georgia Inst. of Tech., Atlanta.
COUPLED ELASTIC ROTOR/BODY VIBRATIONS WITH INPLANE DEGREES OF FREEDOM Ph.D. Thesis
MING-SHENG HUANG 1987 132 p
Avail: Univ. Microfilms Order No. DA8718452

A complete set of nonlinear, integro-partial differential equations of motion is derived for an elastic rotor with inplane degrees of freedom in both hover and forward flight conditions. The hub equations are also derived. The coupled elastic rotor-fuselage vibrations are solved by harmonic balance and impedance matching for a soft-inplane rotor (Lambda sub 1 = 0.008, Lambda sub 2 = 0.012), and stiff inplane rotor (Lambda sub 1=0.08, Lambda sub 2 =0.12). The results are presented as functions of both fuselage vertical constrained frequency and fuselage pitch constrained frequency. For comparison purposes, the results are also given as a function of vertical constrained frequency with no nonlinear terms. Also, vibrations with hub offsets h bar =0.4, d bar sub p =0.0, d bar sub f=0.2) are presented. All calculations are in forward flight conditions (mu = 0.3). Dissert. Abstr.

N88-13645# Virginia Univ., Charlottesville.
FATIGUE 87, VOLUME 1 Final Report, 1 Jun. 1987 - 1 May 1988
R. O. RITCHIE, ed. and E. A. STARKE, JR., ed. 1987 615 p Presented at the Third International Conference on Fatigue and Fatigue Thresholds, Charlottesville, Va., 28 Jun. - 3 Jul. 1987
(Contract DAAL03-87-G-0102)
(AD-A184045; ARO-24134.1-MS-CF-VOL-1) Avail: NTIS HC A99/MF A01 CSCL 20K

A wide range of diverse views of the fundamental and applied aspects of fatigue are discussed. Questions of cyclic deformation, crack initiation and propagation, small cracks, crack closure, variable amplitude effects, and environmentally influenced behavior are covered.

N88-13686# Portsmouth Polytechnic (England). Dept. of Mechanical Engineering.
CRACK GROWTH IN CONTRASTING TITANIUM ALLOYS UNDER THE CONJOINT ACTION OF HIGH AND LOW CYCLE FATIGUE
B. E. POWELL *In* Virginia Univ., Fatigue 87, Volume 1 p 443-452 1987
(Contract F49620-85-C-0116; AF-AFOSR-0077-82)
Avail: NTIS HC A99/MF A01 CSCL 20K

Fatigue crack propagation rates were measured for Ti-6Al-4V and Ti-5331S aircraft engine disc materials using compact tension and corner notched tensile test pieces. The loadings used simulate both the start-stop operations of aircraft engines which lead to low cycle fatigue and the in-flight vibrations which may cause high cycle fatigue. It is suggested that the different fatigue crack

growth behavior of Ti-5331S, relative to that of Ti-6Al-4V, arises largely from the greater proportion of crack closure and short crack growth occurring in this alloy. Author

N88-13687# Coast Guard Academy, New London, Conn.
VARIABLE AMPLITUDE FATIGUE CRACK GROWTH IN ALUMINUM ALLOYS 2090-T8E41 AND 7075-T651
J. S. THOMAS, JR., J. C. VANSICE, and A. F. GRANDT, JR. (Purdue Univ., West Lafayette, Ind.) *In* Virginia Univ., Fatigue 87, Volume 1 p 453-460 1987
Avail: NTIS HC A99/MF A01 CSCL 20K

Fatigue crack growth experiments were conducted to compare the variable amplitude fatigue crack growth behavior of aluminum-lithium alloy 2090-T8E41 and aluminum alloy 7075-T651. Fixed-end single edge-notch tension specimens were subjected to the MINITWIST loading spectrum. The results indicate that the 2090-T8E41 alloy has significantly superior fatigue crack growth resistance to the MINITWIST load history. Author

N88-13688# Virginia Univ., Charlottesville.
CRACK GROWTH PREDICTION IN 3D STRUCTURES UNDER AERONAUTICAL-TYPE SPECTRUM LOADINGS
R. LABOURDETTE, G. BAUDIN, and M. ROBERT (Office National d'Etudes et de Recherches Aerospatiales, Paris, France) *In its* Fatigue 87, Volume 1 p 461-470 1987
Avail: NTIS HC A99/MF A01 CSCL 20K

A model describing crack growth in 3D structures submitted to aeronautical spectrum loadings is presented. Examples of predictions for 7075-T7351 alloy bending specimens undergoing FALSTAFF and mini-TWIST sequences are compared with experimental results. The general accuracy of predictions appears reasonably good since almost all points fall in the classical area. Suggested improvements can result from a description of plastic behavior. Author

N88-13689# Academia Sinica, Beijing (China). Inst. of Mechanics.
FATIGUE OF 30CRMNSINI2A NOTCHED SPECIMENS UNDER SPECTRUM LOADING
Y. S. WU, J. H. HUAN, and A. H. ZHOU *In* Virginia Univ., Fatigue 87, Volume 1 p 471-478 1987
Avail: NTIS HC A99/MF A01 CSCL 20K

The fatigue tests of 30CrMnSiNi2A notched specimens were performed under a maneuver loading spectrum. The stress-strain behavior at the notch under the load spectrum was studied. The fatigue crack initiation and growth was observed microscopically and macroscopically. The fatigue crack initiation life was estimated by a simplified local stress-strain method. The fatigue crack growth life was estimated by the fracture mechanics method. The estimated results and the test results were compared. The size of the initiation crack was determined based on the size of fatigue crack initiation zone in the fracture surface of the specimen. Author

N88-13753*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A COMPUTER PROGRAM FOR CALCULATING UNSTEADY AERODYNAMIC COEFFICIENTS FOR CASCADES IN SUPERSONIC AXIAL FLOW
JOHN K. RAMSEY and ROBERT E. KIELB Dec. 1987 54 p
(NASA-TM-100204; E-3801; NAS 1.15:100204) Avail: NTIS HC A04/MF A01 CSCL 01A

Recent interest in supersonic and hypersonic flight has renewed interst in developing propulsion systems which include a supersonic axial flow compressor. An important design consideration for the blades in such a compressor is aeroelastic stability. Described is a computer program which calculates the lift and moment coefficients for an oscillating cascade with a supersonic leading edge locus. A brief discussion of the theory (Lane's method) is presented, along with program logic, user instructions, and test cases. Author

N88-14251# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
FLIGHTPATH RECONSTRUCTION AND SYSTEMATIC RADAR ERROR ESTIMATION FROM MULTIRADAR RANGE-AZIMUTH MEASUREMENTS
J. J. RENES, P. VANDEKRAAN, and C. EYMANN 19 Aug. 1985 8 p *Presented at the 24th Conference on Decision and Control* (CDC), Fort Lauderdale, Fla., 11-13 Dec. 1985 Previously announced in IAA as A86-42966
(Contract A0/12/AN/82)
(NLR-MP-85064-U; ETN-88-91326) Avail: NTIS HC A02/MF A01

The MURATREC facility for the off-line reconstruction of aircraft trajectories in an absolute reference frame, based on the processing of range and azimuth measurements of opportunity traffic in a multiradar environment is described. It comprises the estimation of systematic radar errors, their covariance matrix, and B-spline series approximating the reconstituted trajectories. The main algorithms are described. Results of validating MURATREC against high precision test flights are discussed. Absolute accuracies up to the radar resolution or better are obtained despite the error patterns that can occur in live radar data. ESA

N88-14293 Texas A&M Univ., College Station.
AN INVESTIGATION OF THE EFFECTS OF THE PROPELLER SLIPSTREAM ON A WING BOUNDARY LAYER Ph.D. Thesis
RICHARD MOORE HOWARD 1987 134 p
Avail: Univ. Microfilms Order No. DA8720903

The behavior of a wing boundary layer immersed in a propeller slipstream has been studied experimentally. Airfoil surface static pressure measurements were made for time-averaged effects, and time-dependent measurements were made with hot-film anemometer sensors for the determination of instantaneous velocities. Vertical boundary layer traverses were made at fixed chord locations for the determination of velocity profiles and for values of the turbulence intensity. The boundary layer has a coherent, time-dependent cycle of transitional behavior, varying from laminar to turbulent. This layer shows similarities to those disturbed by high levels of external flow turbulence and to those in a relaminarizing environment. Profile drag coefficients determined from the time-dependent ensemble-average velocity profiles for the freewheeling propeller case show the drag in the propeller slipstream varies from the undisturbed laminar value to a value less than that predicted for fully turbulent flow. Drag values determined from the low Reynolds number thrusting propeller case in the wind tunnel show that the effects of the slipstream are to enhance the stability of the boundary layer and to reduce the drag coefficient in the laminar portion of the slipstream cycle below its undisturbed value. Dissert. Abstr.

N88-14322*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EULER SOLUTION OF MULTIBLADE ROTOR FLOW
C. L. CHEN, W. J. MCCROSKEY, and S. X. YING (Sterling Software, Palo Alto, Calif.) Jan. 1988 18 p Presented at the 13th European Rotorcraft Forum, Arles, France, 8-11 Sep. 1987
(NASA-TM-100014; A-87307; NAS 1.15:100014; USAAVSCOM-TR-87-A-15) Avail: NTIS HC A03/MF A01 CSCL 20D

A numerical method for solving the Euler equations for multiblade rotors has been developed and some preliminary results reported. The numerical scheme is a combination of several recent methods and algorithm improvements, adapted to the particular requirements of rotor-body interactions. A cylindrical basic grid has been used to study conventional multiblade helicopter rotors. Test calculations have been made for two- and six-blade rotors in hover and for a two-blade rotor in forward flight, under transonic tip conditions but without lift. The results show good agreement with experimental data. Author

N88-14323*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CHARACTERISTICS OF A SEPARATING CONFLUENT BOUNDARY LAYER AND THE DOWNSTREAM WAKE
DESMOND ADAIR and W. CLIFTON HORNE Dec. 1987 91 p (NASA-TM-100046; A-88034; NAS 1.15:100046) Avail: NTIS HC A05/MF A01 CSCL 20D

Measurements of pressure and velocity characteristics are presented and analyzed for flow over and downstream of a NACA 4412 airfoil equipped with a NACA 4415 single-slotted flap at high angle of attack and close to maximum lift. The flow remained attached over the main element while a large region of recirculating flow occurred over the aft 61 percent of the flap. The airfoil configuration was tested at a Mach number of 0.09 and a chord Reynolds number of 1.8x10 to the 6th power in the NASA Ames Research Center 7- by 10-Foot Wind Tunnel. Measurement of mean and fluctuation velocities were obtained in regions of recirculation and high turbulence intensity using 3-D laser velocimetry. In regions where the flow had a preferred direction and relatively low turbulence intensity, hot-wire anemometry was used. Emphasis was placed on obtaining characteristics in the confluent boundary layer, the region of recirculating flow, and in the downstream wake. Surface pressure measurements were made on the main airfoil, flap, wind tunnel roof and floor. It is thought likely that because the model is large when compared to the wind tunnel cross section, the wind tunnel floor and ceiling interference should be taken into account when the flow field is calculated. Author

N88-14367# Sundstrand Turbo, Pacoima, Calif.
PERFORMANCE OF SUPERSONIC IMPINGEMENT RADIAL TURBINES
COLIN RODGERS *In* Von Karman Inst. For Fluid Dynamics, Small High Pressure Ratio Turbines 28 p 1987
Avail: NTIS HC A17/MF A01

The generic development path of auxiliary power units and super integrated power units used to supply secondary aircraft power and main engine start is described. An improved understanding of impingement start systems for radial inflow compressors and radial airflow turbines was obtained. Test data for supersonic side admission impingement nozzles mounted on the stationary shrouds of a small gas turbine using single stage radial flow indicate that expansion efficiencies of the order of 40% are attainable. ESA

N88-14368# Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec).
CONCLUSIONS FROM A RESEARCH PROGRAM ON MIXED FLOW GAS GENERATOR TURBINES
U. OKAPUU *In* Von Karman Inst. for Fluid Dynamics, Small High Pressure Ratio Turbines 26 p 1987
Avail: NTIS HC A17/MF A01

Variations of efficiency with pressure ratio and rotor design were studied. The base prototype is a 600 hp turboprop single stage aircraft engine. Rotating rig testing shows that a mixed flow turbine is capable of surpassing the aerodynamic efficiency of the axial turbine by a significant margin, and matching that of the radial turbine. Development trends are discussed. ESA

N88-14374# Societe Rateau, La Courneuve (France).
DEVELOPMENT OF A SUPERSONIC STEAM TURBINE WITH A SINGLE STAGE PRESSURE RATIO OF 200 FOR GENERATOR AND MECHANICAL DRIVE
G. VERDONK and T. DUFOURNET *In* Von Karman Inst. for Fluid Dynamics, Small High Pressure Ratio Turbines 55 p 1987
Avail: NTIS HC A17/MF A01

A steam turbine with a stage pressure ratio of 200 was designed and tested. The aerodynamic design of the turbine stage is described. The main geometrical and aerodynamic parameters are discussed. The analysis of the supersonic flow in the nozzle guide vane and in the rotor is presented. Test facilities were specially built to evaluate the aerodynamic performances of the stator and rotor at design and off design conditions. An overall isentropic efficiency a little higher than the aimed value of 64.6% is reached. ESA

N88-14425# Brown, Boveri und Cie, A.G., Baden (Switzerland). Metallurgical Lab.
HIGH TEMPERATURE LOW CYCLE FATIGUE BEHAVIOR AND CREEP-FATIGUE INTERATION OF MA 6000 ODS ALLOY
M. NAZMY, W. EBELING, and M. STAUBLI *In* Virginia Univ., Fatigue 87, Volume 2 p 1067-1076 1987
Avail: NTIS HC A24/MF A01 CSCL 20K

The high temperature low cycle fatigue (HTLCF) behavior, under different types of strain wave shapes, in the oxide dispersion strengthened (ODS) alloy MA 6000 was investigated at 950 C. The cycles with tensile hold times were the most effective regarding the internal damage. Three models for the HTLCF lifetime were evaluated for their ability to correlate the fatigue data on MA 6000. These models are strain range partitioning (SRP), the frequency separation (FS) and the frequency modified damage function (FMDF). In general, the three models correlated the HTLCF data relatively well. Author

N88-14426# Central Electricity Generating Board, Bristol (England). Scientific Services Dept.
CREEP-FATIGUE CRACKING IN HIGH TEMPERATURE TURBINE ROTORS
A. T. STEWART, D. A. MILLER, D. C. MARTIN, and G. WIGMORE *In* Virginia Univ., Fatigue 87, Volume 2 p 1077-1086 1987
Avail: NTIS HC A24/MF A01 CSCL 20K

The mechanisms by which creep-fatigue damage can arise in high temperature rotors in power plants are presented. Different failure modes are described. Life prediction methods based on life fraction and ductility exhaustion techniques of damage summation are described and applied to one particular instance of cracking. The importance of creep ductility of high temperature materials is stressed. Author

N88-14431# Institute of Aeronautical Materials, Beijing (China).
AN ANALYSIS OF TEMPERATURE EFFECT ON LCF CRACK GROWTH RATES IN SUPERALLOY GH36
JIZHOU XIE and SHAOLUN LIU *In* Virginia Univ., Fatigue 87, Volume 2 p 1133-1142 1987
Avail: NTIS HC A24/MF A01 CSCL 20K

The low cycle fatigue crack growth rates of a superalloy GH36 was determined by the D. C. potential drop method in the temperature range 160 to 600 C. It was found that the high temperature growth rates of alloy GH36 can be characterized by stress intensity factor range delta kappa. The coefficient and exponent in Paris' formula are functions of temperature. An expression for Paris' formula of alloy GH36 over a wide range of temperature is proposed. Author

N88-14442# Societe Nationale Industrielle Aerospatiale, Suresnes (France). Direction Centrale de la Qualite.
STUDY OF THE EVOLUTION OF SHORT CRACKS IN FATIGUE ANALYSIS [ETUDE DE L'EVOLUTION DES FISSURES COURTES EN FATIGUE]
A. LEFRANCOIS, G. PONS, D. ALIAGA, A. PINEAU, and R. LABOURDETTE 15 Jan. 1987 220 p In FRENCH
(Contract DRET-83-34-323)
(DCQ/L-46-555; ETN-88-90651) Avail: NTIS HC A10/MF A01

Thin plate fatigue is studied considering the joint effects of load spectra and ellipsoidal crack fronts. The fatigue study is carried out using the 2124 T 351 and the 7475 T 7351 aluminum alloys. The results show a short crack effect on the 7475 under constant amplitude loading and on the 2124 for the case of overloading. The mechanisms are discussed, suggesting that the differences are explained by different closing mechanisms, plasticity in one case and microstructure in the other. ESA

N88-14447*# AiResearch Mfg. Co., Torrance, Calif.
ADVANCED FABRICATION TECHNIQUES FOR HYDROGEN-COOLED ENGINE STRUCTURES Final Report, Oct. 1975 - Jun. 1982
O. A. BUCHMANN, V. V. AREFIAN, H. A. WARREN, A. A. VUIGNER, and M. J. POHLMAN Nov. 1985 123 p
(Contract NAS1-14180)
(NASA-CR-3949; NAS 1.26:3949; AMC-81-17928) Avail: NTIS HC A06/MF A01 CSCL 20K

Described is a program for development of coolant passage geometries, material systems, and joining processes that will produce long-life hydrogen-cooled structures for scramjet applications. Tests were performed to establish basic material properties, and samples constructed and evaluated to substantiate fabrication processes and inspection techniques. Results of the study show that the basic goal of increasing the life of hydrogen-cooled structures two orders of magnitude relative to that of the Hypersonic Research Engine can be reached with available means. Estimated life is 19000 cycles for the channels and 16000 cycles for pin-fin coolant passage configurations using Nickel 201. Additional research is required to establish the fatigue characteristics of dissimilar-metal coolant passages (Nickel 201/Inconel 718) and to investigate the embrittling effects of the hydrogen coolant. Author

N88-14450# Centre de Recherches de l'Inst. Superieur Industriel Catholique du Hainaut (Belgium).
STRESSES AND DISPLACEMENTS IN TWO, THREE AND FOUR LAYERED STRUCTURES SUBMITTED TO FLEXIBLE OR RIGID LOADS Final Report, Sep. 1986 - Sep. 1987
F. VANCAUWELAERT, F. DELAUNOIS, and L. BEAUDOINT 30 Sep. 1987 180 p
(Contract DAJA45-86-M-0483; DA PROJ. 1L1-61102-BH-57)
(AD-A185707; R/D-5441-EN-01) Avail: NTIS HC A09/MF A01 CSCL 20K

A computer program written in FORTRAN 77 and recorded on diskettes compatible with an IBM PC computer was run efficiently. A Handbook was written containing: all expressions of stress, strains and displacements in close form with an analysis of the manner how they were obtained and all the required theoretical references; a complete layout of program; a printed list of program; and an instruction list for its utilization. GRA

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GEOSCIENCES

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

A88-18671
APPLICATION OF THE STOKES DRAG ON SPHEROIDS TO THE DRAG ON DISKS AND CYLINDERS
ANDREW J. WEINHEIMER (National Center for Atmospheric Research, Boulder, CO) Journal of the Atmospheric Sciences (ISSN 0022-4928), vol. 44, Sept. 15, 1987, p. 2674-2676.

The measured drag forces on cylinders and disks obtained by Jayaweera and Cottis (1969) and by Kajikawa (1971) are compared with those computed for Stokes flow around equivalent spheroids. For both the disks and cylinders, comparisons are made both for flow parallel to and perpendicular to the solids' symmetry axes. The ratios of measured to Stokes drag forces range from 0.59 to 1.14 and cover Reynolds numbers ranging from 0.0016 to 0.2. These results allow for the convenient calculation, using the Stokes drag expression, of the terminal velocities of ice crystals falling in the atmosphere with major dimensions of up to a few tens of microns. Author

A88-20215
IT'S THE FAULT OF THE WIND [C'EST LA FAUTE DU VENT]
M. REDDAN (Air France, Direction des Operations Aeriennes, Roissy, France) La Meteorologie (ISSN 0026-1181), June-Aug. 1987, p. 1-8. In French. refs

The characteristics, causes, and detection of wind shear are discussed. Three types of wind shear are distinguished: vertical shear, vertical wind shear, and horizontal shear. Detection of wind shear from sources including storms, gust fronts, and frontal masses is presently possible up to several hours in advance. Difficulties in the detection of microbursts (characterized by their intensity and limited dimensions and duration) are considered, and it is noted that the LLWSS detection system cannot detect microbursts. The use of Doppler sodar systems (for the measurement of the vertical wind structure) and on-board wind-shear detection devices is also discussed. R.R.

N88-13796*# National Oceanic and Atmospheric Administration, Washington, D. C.
TOMS AND THE NOAA/FAA VOLCANO SUPPORT PLAN Abstract Only
MICHAEL MATSON *In* NASA. Goddard Space Flight Center, Scientific and Operational Requirements for TOMS Data p 70 Dec. 1987
Avail: NTIS HC A06/MF A01 CSCL 04A

A plan to detect volcanic ash clouds that are aircraft hazards is discussed. The plan utilizes NOAA satellite data and trajectory analysis. Because current operational satellite sensors cannot unambiguously distinguish volcanic eruptions from meteorological clouds, the plan is designed to react to known eruptions rather than detect eruptions. However, the Total Ozone Mapping Spectrometer (TOMS) instrument has been used to detect sulfur dioxide clouds from volcanic eruptions regardless of cloudiness. If TOMS was flown on an operational NOAA satellite, NOAA would have an automated volcanic eruption detection system which could more effectively support the Federal Aviation Administration.
Author

N88-13829# GEOMET Technologies, Inc., Germantown, Md.
ZEUS: A KNOWLEDGE-BASED EXPERT SYSTEM THAT ASSISTS IN PREDICTING VISIBILITY AT AIRBASES Final Report, Dec. 1985 - Dec. 1986
MARK J. STUNDER, ROBERT C. KOCH, TIMOTHY N. SLETTEN, and SANG M. LEE 15 Jan. 1987 162 p
(Contract F19628-86-C-0033)
(AD-A184197; GEOMET-EAF-1725; AFGL-TR-87-0019) Avail: NTIS HC A08/MF A01 CSCL 04B

Artificial Intelligence (AI) knowledge-based expert system (KBES) was developed to demonstrate the feasibility of using this approach to assist forecasters in predicting local visibility. The study developed a knowledge structure for handling rules and data needed to advise on advective and radiation fog formation processes. A review of alternatives for developing the needed software led to selection of the EXSYS, AI programming shell for developing and running a KBES on PC-compatible computers. The KBES for advising forecasters is called Zeus and was developed in three versions to be used at each of three airbases: Dover, Seymour Johnson, and Fort Bragg. The system was enthusiastically used at the bases for a 2-mo period as reported in a user survey. The Zeus forecast produced overall skill scores of 0.35 and 0.38, respectively. The skill scores were significantly better than for forecasters (at one of the bases) during the user test period. A drawback of the system is a tendancy to underpredict the frequency of occurrences of low-visibility categories. The good performance and the high user acceptance demonstrates a successful proof-of-concept. Further development of the approach is recommended. Author (GRA)

N88-13830# Air Weather Service, Scott AFB, Ill.
ISENTROPIC ANALYSIS AND INTERPRETATION: OPERATIONAL APPLICATIONS TO SYNOPTIC AND MESOSCALE FORECAST PROBLEMS
JAMES T. MOORE Aug. 1987 89 p
(AD-A184814; AWS/TN-87/002) Avail: NTIS HC A05/MF A01 CSCL 04B

A basic review of the isentropic coordinate system, including its advantages and disadvantages for operational use. The primitive equations in isentropic coordinate form are discussed with emphasis on their physical meaning and interpretation. Isentropic analysis techniques for horizontal and cross sectional perspectives are described as aids for diagnostic analysis of synoptic scale weather systems. Numerous diagnostic variables are discussed; all can be excellent tools in identifying synoptic scale features helpful in forecasting cyclogenesis and regions susceptible to strong convection. The final section presents specialized applications of isentropic techniques to weather analysis and forecasting, including: trajectory analysis, tropopause folding process, short-term forecasting of severe weather threat areas, and aviation forecasting. GRA

N88-14586# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
ACQUISITION OF GUST STATISTICS FROM AIRCRAFT INTEGRATED DATA SYSTEMS (AIDS) RECORDED DATA
J. B. DEJONGE, J. J. P. VANDERWEKKEN, and R. NOBACK 28 Jul. 1986 18 p Presented at the 63rd AGARD Structures and Materials Panel Meeting, Athens, Greece, Sep. 1986
(NLR-MP-86048-U-ISS-2; B8709828; ETN-88-91329) Avail: NTIS HC A03/MF A01

The procedures applied to reduce B-747 acceleration data from greater than 100,000 flight hours to derived gust velocities are described. The results are presented and compared with other data sources. The validity of the assumptions made in the derivation are discussed. ESA

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A88-16912
AVIONICS IN CONCEPTUAL SYSTEM PLANNING; PROCEEDINGS OF THE EIGHTH ANNUAL IEEE SYMPOSIUM, DAYTON, OH, DEC. 3, 1986
Symposium sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, Inc., 1986, 92 p. For individual items see A88-16913 to A88-16920.

The papers presented in this volume deal with various aspects of the problem of integrating avionics into total system design during the concept formulation stage, with particular attention given to impacts upon definition of requirements; future avionics concepts; tradeoffs between the vehicle, propulsion, and avionics; integration of supportability into the design; and acquisition strategies. Papers are included on system architecture design and tools for a distributed avionics system; the design agent process as a strategy for future avionics competition enhancement and quality assurance; the avionics acquisition process beyond the year 2000; and electromagnetic compatibility modeling for future avionics systems. V.L.

A88-16914
REQUIREMENTS DEFINITION PROCESS...OR HOW TO SEE THE FOREST FOR THE TREES
HARVEY M. PASKIN (Westinghouse Electric Corp., Systems Development Dept., Pittsburgh, PA) IN: Avionics in conceptual system planning; Proceedings of the Eighth Annual IEEE Symposium, Dayton, OH, Dec. 3, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 21-26.

This paper addresses the avionics requirements definition process, at the conceptual level, in light of changing threats, technology, and business environments. The objective is to provide a perspective of total integrated system performance which illuminates broad requirements issues rather than specific subsystem specifications. The fundamental premise is that avionics requirements are driven by four factors: information and data sources, control opportunities and information needs, concepts and algorithmic techniques, and realization technologies. These four factors are set in a systems structure which shows their interrelationships and provides the framework for conceptualizing avionics system solutions to meet particular mission needs. Three generic mission areas are considered and an examination is made of the issues of fielding and affording the solution with specific emphasis on architecture, fusion, production, and support. Author

A88-16916
SYSTEM ARCHITECTURE DESIGN AID TOOLS FOR A DISTRIBUTED AVIONICS SYSTEM
LARRY D. BROCK (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Avionics in conceptual system planning; Proceedings of the Eighth Annual IEEE Symposium, Dayton, OH, Dec. 3, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 37-42. refs

Avionics systems are becoming an increasingly important component of advanced aircraft and thus an important part of the planning for these new aircraft. Methods and tools are needed to support the definition of avionics systems architectures in the early planning stages. Techniques using a flexible distributed processing architecture concept based on generic building blocks are described to meet this need. A two stage process is outlined. The first stage uses structured analysis techniques to describe the functional design of the system. The second stage maps these functional processes into the physical components of the architecture. A prototype tool to aid these design techniques is described. Author

A88-16917
THE AVIONICS ACQUISITION PROCESS BEYOND THE YEAR 2000
R. P. LAVOIE and A. M. CULP IN: Avionics in conceptual system planning; Proceedings of the Eighth Annual IEEE Symposium, Dayton, OH, Dec. 3, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 45-49.

The current weapon system acquisition and support process is examined with emphasis on problems related to the useful life of microelectronic component technology, requirements changes, and technology obsolescence. The need for changes in the present acquisition process is emphasized, and it is shown that a good solution should accept the reality of long development programs and adjust the process to deal with rapidly developing technology, requirements changes, and obsolescence. The critical elements of the solution are long-term planning, sustained investment for improving systems, managed change, and incremental transfer of system responsibility. V.L.

A88-18897
OPTIMUM STEADY STATE POSITION, VELOCITY, AND ACCELERATION ESTIMATION USING NOISY SAMPLED POSITION DATA
K. V. RAMACHANDRA (Electronics and Radar Development Establishment, Radar C Div., Bangalore, India) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-23, Sept. 1987, p. 705-708.

A one-dimensional tracking filter based on the Kalman filtering techniques for tracking of a dynamic target such as an aircraft is discussed. The target is assumed to be moving with constant acceleration and is acted upon by a plant noise which perturbs its constant acceleration motion. The plant noise accounts for maneuvers and/or other random factors. Analytical results for estimating optimum steady state position, velocity, and acceleration of the target are obtained. Author

A88-18899
SAMPLED DATA IMPLEMENTATION OF EIGENSTRUCTURE ASSIGNMENT TECHNIQUE
WILLIAM W. CIMINO and DOUGLAS A. HOSKINS (Boeing Aerospace Co., Seattle, WA) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-23, Sept. 1987, p. 710-712.

A discrete time implementation of the eigenstructure assignment technique for diagonalizable systems is presented. Good agreement with continuous time implementations is demonstrated with sample rates as low as twice the Nyquist frequency. Author

A88-19264
THREE-DIMENSIONAL UNSTEADY TRANSONIC FLOW - AN INTEGRAL EQUATION FORMULATION
J. A. GEAR (Royal Melbourne Institute of Technology, Australia) Computational Mechanics (ISSN 0178-7675), vol. 2, no. 4, 1987, p. 268-270. refs

The unsteady transonic small perturbation differential equation has been converted into an integrodifferential equation by application of the classical Green's function method. After assuming that the motion consists of infinitesimal perturbations around a thin, nearly-planar body a simplified integral equation is obtained for the streamwise velocity component, which is suitable for fast numerical computations. Author

A88-20283* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ON THE USE OF COMPOSITE GRID SCHEMES IN COMPUTATIONAL AERODYNAMICS
JOSEPH L. STEGER (NASA, Ames Research Center, Moffett Field, CA) and JOHN A. BENEK (Calspan Corp., Arnold Air Force Station, TN) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 64, Oct. 1987, p. 301-320. refs

Some of the composite grid approaches used in aerodynamic applications and the associated advantages and difficulties are reviewed. In particular, attention is given to patched grid schemes, overset grid schemes, and the computational aspects of composite grid schemes. As an example of a computational procedure, an algorithm is presented for constructing a hole in a grid caused by a body overset onto another grid. V.L.

N88-13269# National Aerospace Lab., Tokyo (Japan).
PROGRAMMING TECHNIQUES FOR HIGH-SPEED PROCESSING OF LARGE SCALE NUMERICAL SIMULATION ON SUPERCOMPUTERS
KINUYO NAKAMURA and MASAHIRO YOSHIDA *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 129-136 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A method is presented for improving algorithms and programming techniques which permits the efficient use of supercomputers. The method is illustrated by an example of a numerical analysis of codes of transonic full potential flows about wings. Author

N88-13276# National Aerospace Lab., Tokyo (Japan).
COMPUTER GRAPHICS FOR COMPUTATIONAL AERODYNAMICS
KAZUYO SUEMATSU and TOSIO ISOBE *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 181-189 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A graphic software package was developed to easily display various kinds of figures, such as grid distributions, pressure contours, oilflow patterns, and streamlines, which are often used in the field of computational aerodynamics. Author

N88-13278# Fujitsu Ltd., Tokyo (Japan).
VISUALIZATION OF AN AIRCRAFT ACCIDENT BASED ON DIGITAL FLIGHT DATA RECORDER INFORMATION
MIKIO SASAKI, TAKAMITSU OKADA, KENJI KIRA, and TOSHIYUKI SAKAMOTO (Japan Broadcasting Corp., Tokyo.) *In* National Aerospace Lab., Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 197-201 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

An aircraft accident which occurred on August 12th 1985 in Japan was visualized using computer graphics. The animation was made as realistic as possible. The shaking of the aircraft at the outset of the accident and the dutch roll and fugoid oscillation could be observed. The data which were used to make the animation (taken from the onboard digital flight data recorder) and the method by which the animation was generated are given. Author

N88-13287# National Aerospace Lab., Tokyo (Japan).
ANALYTICAL METHOD FOR GENERATING COMPUTATIONAL GRIDS ABOUT COMPLETE AIRCRAFT CONFIGURATIONS
SUSUMU TAKANASHI and TAKAO ISAWA (Nippon Time Share Co., Japan) *In its* Proceedings of the 4th NAL Symposium on Aircraft Computational Aerodynamics p 281-288 Dec. 1986 In JAPANESE; ENGLISH summary
Avail: NTIS HC A14/MF A01

A method for constructing boundary-fitted grids for realistic aircraft configurations is described in this paper. The present grid generation procedure is based on the successive use of Caughey's wind tunnel mapping. The major advantage of the method is that the whole flow field can be transformed into a single rectangular computational domain, even for complex geometries such as that of the ONERA M-5 model. Typical examples of nearly orthogonal grid systems hitherto obtained are also presented. Author

N88-13872*# Illinois Univ., Urbana-Champaign. Coordinated Science Lab.
ERROR PROPAGATION IN A DIGITAL AVIONIC MINI PROCESSOR M.S. Thesis
DALE L. LOMELINO Dec. 1987 47 p
(Contract NAG1-602)
(NASA-CR-181565; NAS 1.26:181565; UILU-ENG-87-2270; CSG-74) Avail: NTIS HC A03/MF A01 CSCL 09B

A methodology is introduced and demonstrated for the study of error propagation from the gate to the chip level. The importance of understanding error propagation derives from its close tie with system activity. In this system the target system is BDX-930, a digital avionic multiprocessor. The simulator used was developed at NASA-Langley, and is a gate level, event-driven, unit delay, software logic simulator. An approach is highly structured and easily adapted to other systems. The analysis shows the nature and extent of the dependency of error propagation on microinstruction type, assembly level instruction, and fault-free gate activity. Author

N88-13878# Naval Research Lab., Washington, D.C.
SOFTWARE DESIGN FOR AN AIRBORNE GRAVITY MEASUREMENT SYSTEM Final Report, 1 Jul. 1986 - 28 Feb. 1987
MARY F. PETERS, JOHN M. BROZENA, and J. D. CLAMONS 12 Aug. 1987 37 p
(AD-A185000; NRL-9049) Avail: NTIS HC A03/MF A01 CSCL 09B

This report describes the results of a software design study for an airborne gravity measurement system. The software is intended for data acquisition and monitoring aboard a fixed-wing aircraft over oceanic areas, and for the postflight processing required to compute gravity along a flight track. Various requirements of the postflight processing system are discussed. A method to compute gravity from airborne measurements is outlined; as some quantities can be derived from more than one measurement, alternative algorithms, to be used in cases of poor quality or missing data, are given. Author (GRA)

N88-13883# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
OVERALL DESCRIPTION OF THE COMPUTER AIDED DESIGN AND MANUFACTURING SYSTEMS ASSOCIATED WITH THE A320 PROGRAM AT AEROSPATIALE AND ITS PARTNERS [PRESENTATION GENERALE DES SYSTEMES CFAO ASSOCIES AU PROGRAMME A320 DE L'AEROSPATIALE ET CHEZ LES PARTENAIRES]
ROGER BERGOEND 1987 13 p In FRENCH
(SNIAS-872-111-104; ETN-88-91186) Avail: NTIS HC A03/MF A01

Computer aided design and manufacturing of the A-320 aircraft is described. It is used along all design and manufacturing steps including preliminary design, aerodynamics, shape design, structural computation, electrical design, specifications, tool design, quality control, and final technical documentation. Several data banks are described including the design bank, running on a CDC computer and a total of 8500 megaoctets. ESA

N88-13884# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
PRESENTATION OF SIGMA (INTERACTIVE ASSISTED GEOMETRY SYSTEM). A COMPUTER ASSISTED SHAPE DESIGN PROGRAM DEVELOPED AT THE AEROSPATIALE AIRCRAFT DIVISION [PRESENTATION DE SIGMA (SYSTEME INTERACTIF DE GEOMETRIE ASSISTEE). LOGICIEL DE CFAO DEVELOPPE A LA DIVISION AVIONS DE L'AEROSPATIALE]
RENE GANDOU 1987 27 p In FRENCH
(SNIAS-872-111-110; ETN-88-91192) Avail: NTIS HC A03/MF A01

A real time highly interactive shape design program which does not require computer operation training is described. A local knowledge data bank which grows with accumulated experience is available. The geometrical design of ATR42 and A-320 aircraft was done with this system. ESA

N88-13885# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
STRUCTURAL OPTIMIZATION IN THE DESIGN PROCESS
J. LOCATELLI 1987 15 p
(SNIAS-872-111-115; ETN-88-91196) Avail: NTIS HC A03/MF A01

Computer aided design of aircraft structures to assure static and dynamic behavior control in order to reduce operating costs is reviewed. The evaluation of interactions of the external shape, aerodynamic loads, structural geometry, internal loads, and mass distributions needs different black boxes, which are executed consecutively: a strength analysis program, a modal analysis for characteristic vibration behavior (each based on the finite element method) and an aeroelastic investigation program using matrix methods (and in particular the stiffness matrix of the structural model). Each program performs successive analyses and resizing functions for the optimization run, in a single computer submission. They are prerequisites for performance of the sensitivity analysis and the computation of constraint derivatives. ESA

N88-14638*# PRC Kentron, Inc., Hampton, Va.
DIAGNOSTIC EMULATION: IMPLEMENTATION AND USER'S GUIDE
BERNICE BECHER Dec. 1987 172 p
(Contract NAS1-18000)
(NASA-CR-178391; NAS 1.26:178391) Avail: NTIS HC A08/MF A01 CSCL 09B

The Diagnostic Emulation Technique was developed within the System Validation Methods Branch as a part of the development of methods for the analysis of the reliability of highly reliable, fault tolerant digital avionics systems. This is a general technique which allows for the emulation of a digital hardware system. The technique is general in the sense that it is completely independent of the particular target hardware which is being emulated. Parts of the system are described and emulated at the logic or gate level, while other parts of the system are described and emulated at the functional level. This algorithm allows for the insertion of faults into the system, and for the observation of the response of the system to these faults. This allows for controlled and accelerated testing of system reaction to hardware failures in the target machine. This document describes in detail how the algorithm was implemented at NASA Langley Research Center and gives instructions for using the system. 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.

A88-17278
AEROACOUSTICS - HISTORICAL PERSPECTIVE AND IMPORTANT ISSUES
JOHN W. LEVERTON (E.H. Industries, Inc., Arlington, VA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 18 p. refs

Theoretical and experimental studies of helicopter rotor noise are reviewed, covering the period 1962-1987. Topics examined include the increased importance of rotor-induced noise with the advent of gas-turbine-powered helicopters in the early 1960s, the impact of improved acoustic instruments, harmonic analyses of rotor noise, aeroacoustic theory, rotational noise, fluctuating forces, broadband noise, blade slap, blade-vortex interaction, thickness noise, tail-rotor noise, and main-rotor-wake/tail-rotor interaction. It is suggested that the tip speed and number of blades of rotors for large helicopters can be selected to minimize noise at little loss of performance, but that this is not the case for smaller helicopters. In the latter case, greater attention to operational aspects in the overall design and greater cooperation between aerodynamicists and acoustic engineers are recommended. T.K.

A88-17282* Boeing Vertol Co., Philadelphia, Pa.
BLADE-VORTEX INTERACTION NOISE PREDICTIONS USING MEASURED BLADE SURFACE PRESSURES
PERRY R. ZIEGENBEIN (Boeing Vertol Co., Philadelphia, PA) and BYUNG K. OH (Boeing Computer Services Co., Philadelphia, PA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 11 p. refs
(Contract NAS1-17147; NASA TASK 5)

The generation of helicopter noise by blade-vortex interactions during descent under impulsive conditions is investigated analytically. A noise-prediction technique is developed on the basis of the dipole source term of the Ffowcs-Williams/Hawkings

equation and applied to data from simultaneous blade-pressure and acoustic measurements obtained by Cowan et al. (1986) on a 10-ft-diameter 4-blade rotor model in a wind tunnel. Preliminary results show that input-blade-airload azimuth resolution of 1 deg or better and computational azimuth step size of 2 deg or less are required to achieve good agreement between predicted and recorded acoustic time histories. The need for more sophisticated methods to model chordwise input data and for a more extensive experimental data base is indicated. T.K.

A88-17284* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE PHASE II ROTONET SYSTEM
ROBERT A. GOLUB (NASA, Langley Research Center, Hampton, VA) and DONALD S. WEIR (PRC Kentron, Inc., Hampton, VA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 10 p. refs

The improvements introduced in Phase II of ROTONET, a comprehensive computer program developed at NASA Langley for predicting helicopter noise, are reviewed and demonstrated. The ROTONET functional modules for lifting-rotor performance, lifting-rotor noise, rotor loads, rotor inflow, rotor rigid dynamics, rotor wake geometry, rotor tone noise, and rotor broadband noise are briefly characterized; the construction of an acoustics data base from measurements taken in flight tests of a NASA/MDHC 500E helicopter is described; and the validation tests are summarized. Good agreement between flight-test data and ROTONET predictions is obtained. T.K.

A88-17298
TRANSONIC BLADE-VORTEX INTERACTIONS - THE FAR FIELD
A. S. LYRINTZIS and A. R. GEORGE (Cornell University, Ithaca, NY) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 21 p. Research supported by the McDonnell Douglas Helicopter Co. refs

Numerical techniques are developed to predict midfield and far-field helicopter noise due to main-rotor blade-vortex interaction (BVI). The extension of the two-dimensional small-disturbance transonic flow code VTRAN2 (George and Chang, 1983) to the three-dimensional far field (via the Green-function approach of Kirchhoff) is described, and the treatment of oblique BVIs is discussed. Numerical results for a NACA 64A006 airfoil at Mach 0.82 are presented in extensive graphs and characterized in detail. The far-field BVI signature is shown to begin with a strongly forward-directed primary wave (from the original BVI), with an additional downward-directed wave in the case of type C shock motion on the blade. T.K.

A88-17299
APPLICATION OF HIGH RESOLUTION AIRLOAD CALCULATIONS TO HELICOPTER NOISE PREDICTION
A. C. PIKE (Westland, PLC, Yeovil, England) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 8 p. Research supported by the Ministry of Defence.

Recent studies of blade/vortex interactions have resulted in the development of aerodynamic models with which the very detailed loading data necessary for noise predictions can be calculated. The methods employed not only obviate the need for some of the simplifying assumptions that have previously reduced the precision and sensitivity of acoustic calculations but also achieve this improvement at little cost in computing power. Although development of the aeroacoustic techniques is not yet complete, it has been established that highly detailed predictions can be made as a matter of routine. Applications of these techniques in light of the growing requirement for noise prediction methods and the penalty incurred by manufacturers if they are not available at the design stage of a new helicopter project are described. Author

A88-17300* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE USES AND ABUSES OF THE ACOUSTIC ANALOGY IN HELICOPTER ROTOR NOISE PREDICTION
F. FARASSAT and KENNETH S. BRENTNER (NASA, Langley Research Center, Hampton, VA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 9 p. refs

The generation of noise by helicopter rotor blades is considered theoretically, reviewing recent analyses based on the acoustic analogy (where the effect of fluid motion is replaced by fictitious sources in an undisturbed fluid). The fundamental principles of the acoustic approach are explained and illustrated with diagrams; the governing Ffowcs-Williams/Hawkings equations are written with a reformulated quadrupole term; and the directivity of noise produced (1) by regions with steep gradients (such as shock surfaces) and (2) by boundary-layer quadrupoles (tip-vortex and blade wakes) is shown to be the same as that of thickness noise. The need to include both (1) and (2) in acoustic-analogy computations is indicated. T.K.

A88-17302
EXPERIMENTAL AND ANALYTICAL, TRANSONIC AERODYNAMIC AND ACOUSTIC RESULTS FOR RECTANGULAR AND SWEPT ROTOR BLADE TIPS
J. PRIEUR, P. LAFON, M. CAPLOT, and A. DESOPPER (ONERA, Chatillon-sous-Bagneux, France) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 14 p. refs
(ONERA, TP NO. 1987-16)

This paper presents some experimental and theoretical studies dealing with both acoustics and aerodynamics of helicopter rotor blades in high-speed forward flight. Experimental results in S2Ch acoustically treated wind tunnel concern a comparison between a rectangular blade tip and a parabolic sweptback one, with an anhedral effect, named PF1. They show an increase in aerodynamic performances for the PF1 blades, which is due to a decrease of the transonic flow intensity on the advancing blade side. These results are confirmed by calculation with a transonic small disturbance code. Acoustic measurements show a noise reduction for the PF1 blades. This tendency appears also through calculation. An analytical study evaluates the influence of blade tip shape on the generated thickness noise. Assessment of compressibility effects by quadrupolar noise calculations for several blade tips is presented; the limitations of the use of the Lighthill's acoustic analogy are discussed. Author

A88-17303
THE FREQUENCY DOUBLING OF HELICOPTER ROTOR NOISE DUE TO RETREATING BLADE STALL
GEORGE P. SUCCI (Technology Integration and Development Group, Inc., Billerica, MA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 7 p. refs

A detailed examination of the measured blade noise of a helicopter in forward flight is presented. The data was acquired during the AH-1G helicopter operational loads survey. For certain level flight conditions, the fundamental period of the acoustic signal appears to be at half the blade passing period. This effect is demonstrated by showing that the autocorrelation function of this signal has a peak at this interval. This phenomenon is apparently due to retreating-blade stall. Acoustical calculations based on the measured blade loads show that this effect occurs only when loading noise is greater than thickness noise. Furthermore, by basing the calculation on the measured blade loads that include retreating blade stall, it was possible to analytically reproduce the observed effect. Y.r.g.

A88-17305* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LOW-FREQUENCY ROTATIONAL NOISE IN CLOSED-TEST-SECTION WIND TUNNELS
MARIANNE MOSHER (NASA, Ames Research Center, Moffett Field, CA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 13 p. refs

The effects of closed-section wind-tunnel walls on the sound field radiated from a helicopter rotor are investigated by means of numerical simulations, summarizing the findings reported by Mosher (1986). The techniques used to model the rotor and the test section (including geometry, wall absorption, and measurement location) are outlined, and the results are presented in extensive tables and graphs. It is found that first-harmonic acoustic measurements obtained in a hard-walled wind tunnel twice as wide as the rotor diameter do not accurately represent the free-field rotational noise, that the relationship between the sound-pressure levels in the wind tunnel and in the free field is complex, that multiple near-field measurements are needed to characterize the direct acoustic field of the rotor, and that absorptive linings are of little value in enlarging the accurate-measurement zone. T.K.

A88-17306* Textron Bell Helicopter, Fort Worth, Tex.
EXTERNAL NOISE EVALUATION OF THE XV-15 TILTROTOR AIRCRAFT
JOHN T. BRIEGER (Bell Helicopter Textron, Fort Worth, TX), MARTIN D. MAISEL (NASA; Ames Research Center; U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA), and RONALD GERDES (NASA, Ames Research Center, Moffett Field, CA) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 13 p. refs

The noise emission of the XV-15 in both helicopter and airplane operation and in level and constant-slope descending flight is measured (as sound exposure levels) in a series of test flights over a ground microphone array. The aircraft characteristics, test facility, and procedures are described, and the results are presented in extensive graphs and characterized in detail. Consideration is given to engine-rpm and nacelle-tilt effects, noise duration, sideline radiation, altitude effects, acoustic waveforms, and variations with glideslope. The XV-15 is found to produce less noise in its airplane mode than in the helicopter mode, where the noise levels are similar to those of other helicopters. T.K.

A88-17307
EVALUATION OF ROTOR BROADBAND NOISE PREDICTIONS
H. TADGHIGHI and D. S. JANAKIRAM (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, TX, Feb. 25-27, 1987, Proceedings . Alexandria, VA, American Helicopter Society, 1987, 15 p. refs

The noise emission of an MD500E helicopter is characterized experimentally in ground (whirl-stand) and flight tests, and the results are used to assess the accuracy of theoretical models of HF and LF rotor broadband noise. The theoretical framework of the models is outlined, with particular attention to blade self-noise and noise due to inflow turbulence; the experimental setup and procedures are described and illustrated with drawings and photographs; and the results are presented in extensive graphs and discussed in detail. In general, the performance of compact and noncompact noise-prediction models (including those using empirical inflow-turbulence data as input) is found to be inadequate, except in the case of LF broadband noise from a helicopter in flight. T.K.

A88-18651*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
QUADRUPOLE SOURCE IN PREDICTION OF THE NOISE OF ROTATING BLADES - A NEW SOURCE DESCRIPTION
F. FARASSAT (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 13 p. refs
(AIAA PAPER 87-2675)

The aim of this paper is to perform a theoretical study of the quadrupole term of the Ffowcs Williams-Hawkings (FW-H) equation to obtain practical results for applications to rotating blades. The quadrupole term of the FW-H equation is algebraically manipulated into volume, surface and line sources using generalized function theory and differential geometry. The volume source is of the type in Lighthill's jet noise theory. The surface sources are on the blade and shock surfaces and the line source is at the trailing edge. It is shown that contribution of volume sources in the boundary layer and wakes can be written in the form of surface integrals. It is argued that the surface and line sources and the part of the volume sources in the boundary layer, wakes and vortices near the blades should be sufficient in calculation of the noise of high speed rotating blades. The integrals correspoding to the various sources appearing in the formula for calculation of the acoustic pressure are briefly derived. Author

A88-18652*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF VELOCITY PROFILE ON BOUNDARY-LAYER SHIELDING
GERRY L. MCANINCH (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 12 p. refs
(AIAA PAPER 87-2678)

A simple uniform flow boundary-layer model is used to study the effects on the acoustic field at the aircraft fuselage of placing Large Eddy Break Up devices in the boundary layer. The introduction of velocity defects into the boundary layer is shown to enhance boundary-layer shielding. Furthermore, shielding improvements are found to occur by moving the velocity defect further from the wall, by increasing its extent within the boundary layer, and by decreasing the minimum velocity in the defect. R.R.

A88-18653#
RECENT DEVELOPMENTS IN SOURCE LOCATION
P. M. W. PACK and P. J. R. STRANGE (Rolls-Royce, PLC, Derby, England) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 9 p. refs
(AIAA PAPER 87-2685)

Atmospheric propagation effects detrimental to the preservation of acoustic signal coherence dictate that microphone arrays deployed in static engine source location tests be positioned in the geometric near field of the noise source. Source location by the polar correlation technique, traditionally a farfield method, has been reformulated for near field situations and implemented in the analysis of static engine data. Significant improvements in the accuracy and consistency of source component breakdowns are shown to result from these modifications. Author

A88-18657*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ROTOR NOISE MEASUREMENT USING A DIRECTIONAL MICROPHONE ARRAY
MICHAEL A. MARCOLINI and THOMAS F. BROOKS (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 12 p. refs
(AIAA PAPER 87-2746)

A directional array of microphones was used to measure the noise from a 40 percent scale model rotor in a large aeroacoustic wind tunnel. The development and design of this directional array is described. A design goal was that the array focus on a constant sensing area over a broad frequency range. The implementation of the array design is presented, followed by sample results for

several different rotor test conditions. The directional array spectral results are compared with predictions of broadband self noise, and with total rotor noise measurements obtained from individual microphones of the array. The directional array is demonstrated to be a useful tool in examining noise source distributions. Author

A88-19667#
GROUND PLANE MICROPHONE FOR MEASUREMENT OF AIRCRAFT FLYOVER NOISE
BELUR SHIVASHANKARA and GENE W. STUBBS (Boeing Airplane Co., Seattle, WA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Nov. 1987, p. 751-758. Previously cited in issue 01, p. 75, Accession no. A85-1088.

A88-20178#
CALCULATION OF FAR-FIELD NOISE USING THE KIRCHHOFF METHOD
A. S. LYRINTZIS and A. R. GEORGE (Cornell University, Ithaca, NY) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 15 p. Research supported by McDonnell Douglas Helicopter Co. refs
(AIAA PAPER 87-2673)

A study is made of the applications of the Kirchhoff method for the calculation of far-field noise. Kirchhoff method has the advantage of including the non-linear effects of the aerodynamic near-field to the linear acoustic far-field using a surface integral around a control surface which encloses the non-linear near-field. A spherically symmetric sine wave is used as a test case to show the effects of mesh size, wave thickness, analytical or numerical expression of the normal and time derivatives and the tips of the control surface. The edge term in Farassat's formulation is also discussed and its computational importance is evaluated. Results for a C mesh are also obtained. Finally, a simple example of noise calculation from a rotating source shows the viability of the method for three-dimensional calculation. A set of portable Kirchhoff subroutines can be developed for the calculation of far-field noise using input given from any aerodynamic near/mid-field code. Author

A88-20187#
NUMERICAL PREDICTION OF AIRBORNE NOISE TRANSMISSION INTO A FUSELAGE
GAUTAM SENGUPTA and WARREN H. WEATHERILL (Boeing Commercial Airplane Co., Seattle, WA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 19 p. Research supported by the Boeing Commercial Airplane Co. refs
(AIAA PAPER 87-2736)

The basic methodology for numerical prediction of airborne noise transmission into an elastic structure, including the scattering effects, is established in this paper. The methodology is validated by considering the problem of scattering of noise from a line source by an infinitely long, thin cylinder, with transmission into its interior. Excellent agreement between numerical and analytical solutions for the two-dimensional problem suggests that it should be feasible to use such computational tools for three-dimensional problems of practical importance, such as airborne noise transmission into an aircraft fuselage at the propeller blade passage frequency and above. C.D.

A88-20189*# Polytechnic Univ., Brooklyn, N.Y.
GEOMETRICAL ACOUSTICS AND TRANSONIC HELICOPTER SOUND
MORRIS ISOM (New York, Polytechnic University, Brooklyn), TIMOTHY W. PURCELL, and ROGER C. STRAWN (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 13 p. . refs
(AIAA PAPER 87-2748)

A new method is presented for predicting the impulsive noise generated by a transonic rotor blade. The method is a combined approach involving computational fluid dynamics and geometrical acoustics. A full-potential finite-difference method is used to obtain the pressure field close to the blade. A Kirchhoff integral formulation is then used to extend these finite-difference results into the far field. This Kirchhoff formula is based on geometrical acoustics approximations. It requires initial data across a plane at the sonic radius in a blade-fixed coordinate system. This data is provided by the finite-difference solution. Acoustic pressure predictions show good agreement with hover experimental data for cases with hover tip Mach numbers of 0.88 through 0.96. The cases above 0.92 tip Mach number are dominated by non-linear transonic effects seen as strong shocks on and off the blade tip. This paper gives the first successful predictions of far-field acoustic pressures for high-speed impulsive noise over a range of Mach numbers after delocalization. Author

N88-13959# Metraflu, Ecully (France).
COMPRESSOR LARGE BANDWIDTH NOISE EMISSION MECHANISMS Final Report [MECANISMES D'EMISSION LARGE BANDE DES COMPRESSEURS]
MICHEL ROGER Apr. 1987 37 p In FRENCH
(Contract DRET-83-34-497-00-470-75-01)
(ETN-88-91177) Avail: NTIS HC A03/MF A01

Noise generated by a double flow turboreactor fan was studied. Results of a numerical analysis of the noise due to preturbulence, the noise irradiated by turbulent wakes, a modal analysis of the propagation of noise through a rotating flow, and the analysis of the inertial stability of the rotating flow at the fan outlet and the noise generated by those instabilities are described. It is shown that the propagation of noise through a rotating flow is not limited to the acoustic modes, and the cut-off frequencies of the acoustic modes are different from those in steady flow. ESA

N88-13960*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH SPEED PROPELLER PERFORMANCE AND NOISE PREDICTIONS AT TAKEOFF/LANDING CONDITIONS
M. NALLASAMY (Sverdrup Technology, Inc., Cleveland, Ohio.), R. P. WOODWARD, and J. F. GROENEWEG 1987 17 p Prepared for presentation at the 26th Aerospace Sciences Meeting, Reno, Nev., 11-14, Jan. 1988; sponsored by AIAA
(NASA-TM-100267; E-3898; NAS 1.15:100267) Avail: NTIS HC A03/MF A01 CSCL 20A

The performance and noise of a high speed SR-7A model propeller under takeoff/landing conditions are considered. The blade loading distributions are obtained by solving the three-dimensional Euler equations and the sound pressure levels are computed using a time domain approach. At the nominal takeoff operating point, the blade sections near the hub are lightly or negatively loaded. The chordwise loading distributions are distinctly different from those of cruise conditions. The noise of the SR-7A model propeller at takeoff is dominated by the loading noise, similar to that at cruise conditions. The waveforms of the acoustic pressure signature are nearly sinusoidal in the plane of the propeller. The computed directivity of the blade passing frequency tone agrees fairly well with the data at nominal takeoff blade angle. Author

N88-13961*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NOISE OF A MODEL COUNTERROTATION PROPELLER WITH REDUCED AFT ROTOR DIAMETER AT SIMULATED TAKEOFF/APPROACH CONDITIONS (F7/A3)
RICHARD P. WOODWARD and ELIOTT B. GORDON (Sverdrup Technology, Inc., Cleveland, Ohio.) 1988 31 p Presented at the 26th Aerospace Sciences Meeting, Reno, Nev., 11-14 Jan. 1988; sponsored by AIAA
(NASA-TM-100254; E-3880; NAS 1.15:100254; AIAA-88-0263)
Avail: NTIS HC A03/MF A01 CSCL 20A

A model high-speed advanced counterrotation propeller, F7/A3, was tested in the NASA Lewis Research Center 9 by 15 foot Anechoic Wind Tunnel at simulated takeoff/approach conditions of 0.2 Mach number. Acoustic measurements were taken with an axially translating microphone probe, and with a polar microphone probe which was fixed to the propeller nacelle and could take both sideline and circumferential acoustic surveys. Aerodynamic

measurements were also made to establish propeller operating conditions. The propeller was run at two setting angles (front angle/rear angle) of 36.4/43.5 and 41.1/46.4 degrees, forward rotor tip speeds from 165 to 259 m/sec, rotor spacings from 8.48 to 14.99 cm based on pitch change axis separation, and angles of attack to 16 degrees. The aft rotor diameter was 85 percent of the forward rotor diameter to reduce tip vortex-aft rotor interaction as a major interaction noise source. Results are compared with equal diameter F7/A7 data which was previously obtained under similar operating conditions. The aft rotor-alone tone was 7 dB lower for the reduced diameter aft rotor, due to reduced tip speed at constant rpm. Interaction tone levels for the F7/A3 propeller were higher at minimum row spacing and lower at maximum spacing. Author

N88-13962*# National Aeronautics and Space Administration. *Langley Research Center, Hampton, Va.*

FLUCTUATING PRESSURE LOADS UNDER HIGH SPEED BOUNDARY LAYERS

WILLIAM E. ZORUMSKI Oct. 1987 15 p Presented at the AIAA 11th Aeroacoustics Conference Workshop on Sonic Fatigue and Hypersonic Acoustic Loads, Sunnyvale, Calif. 19-21 Oct. 1987

(NASA-TM-100517; NAS 1.15:100517) Avail: NTIS HC A03/MF A01 CSCL 20A

Aeroacoustic fatigue is anticipated to control the design of significant portions of the structures of high-speed vehicles. This is due to contemplated long-duration flights at high dynamic pressures and Mach numbers with related high skin temperatures. Fluctuating pressure loads are comparatively small beneath attached turbulent boundary layers, but become important in regions of flow separation such as compression and expansion corners on elevons and rudders. The most intense loads are due to shock/boundary-layer interaction. These flows may occur in the engine-exhaust wall jet and in flows over control surfaces. A brief review is given of available research in these areas with a description of work under way at Langley Research Center. Author

N88-14762* United Technologies Corp., Stratford, Conn. Sikorsky Aircraft Div.

DEVELOPMENT OF ROTORCRAFT INTERIOR NOISE CONTROL CONCEPTS. PHASE 3: DEVELOPMENT OF NOISE CONTROL CONCEPTS Final Report

CHARLES A. YOERKIE, P. J. GINTOLI, S. T. INGRAHAM, and J. A. MOORE (Cambridge Collaborative, Inc., Mass.) Jul. 1986 148 p

(Contract NAS1-16932)

(NASA-CR-178172; NAS 1.26:178172) Avail: NTIS HC A07/MF A01 CSCL 20A

The goal of this research is the understanding of helicopter internal noise mechanisms and the development, design, and testing of noise control concepts which will produce significant reductions in the acoustic environment to which passengers are exposed. The Phase 3 effort involved the identification and evaluation of current and advanced treatment concepts, including isolation of structure-borne paths. In addition, a plan was devised for the full-scale evaluation of an isolation concept. Specific objectives were as follows: (1) identification and characterization of various noise control concepts; (2) implementation of noise control concepts within the S-76 SEA (statistical energy analysis) model; (3) definition and evaluation of a preliminary acoustic isolation design to reduce structure-borne transmission of acoustic frequency main gearbox gear clash vibrations into the airframe; (4) formulation of a plan for the full-scale validation of the isolation concept; and (5) prediction of the cabin noise environment with various noise control concepts installed. Author

N88-14766 Cornell Univ., New York, N.Y.

A STUDY OF ROTOR BROADBAND NOISE MECHANISMS AND HELICOPTER TAIL ROTOR NOISE Ph.D. Thesis

SHAU-TAK RUDY CHOU 1987 189 p

Avail: Univ. Microfilms Order No. DA8715625

A study is made of the relative problems of rotor broadband noise mechanisms and helicopter tail rotor noise. The rotor broadband noise mechanisms considered are: (1) lift fluctuation due to turbulence ingestion, (2) boundary layer/trailing edge interaction, (3) tip vortex formation, and (4) turbulent vortex shedding from blunt trailing edge. Predictions are compared to available experimental data and show good agreement. The study shows that inflow turbulence is the most important broadband noise source for typical helicopters' main rotors at low- and mid-frequencies. Trailing edge noise and tip vortex noise are found to be important at high frequencies; they are also very sensitive to rotor blade angle of attack. Trailing edge thickness noise is also very important; it generates a large spectrum hump, and is very sensitive to any change of the trailing edge thickness. Dissert. Abstr.

N88-14769*# Sikorsky Aircraft, Stratford, Conn.

DEVELOPMENT OF ROTORCRAFT INTERIOR NOISE CONTROL CONCEPTS. PHASE 2: FULL SCALE TESTING, REVISION 1 Contractor Report, May 1983 - Dec. 1985

C. A. YOERKIE, P. J. GINTOLI, and J. A. MOORE (Cambridge Collaborative, Inc., Mass.) Feb. 1986 284 p

(Contract NAS1-16932)

(NASA-CR-172594-REV-1; NAS 1.26:172594-REV-1; SER-760703) Avail: NTIS HC A13/MF A01 CSCL 20A

The phase 2 effort consisted of a series of ground and flight test measurements to obtain data for validation of the Statistical Energy Analysis (SEA) model. Included in the gound tests were various transfer function measurements between vibratory and acoustic subsystems, vibration and acoustic decay rate measurements, and coherent source measurements. The bulk of these, the vibration transfer functions, were used for SEA model validation, while the others provided information for characterization of damping and reverberation time of the subsystems. The flight test program included measurements of cabin and cockpit sound pressure level, frame and panel vibration level, and vibration levels at the main transmission attachment locations. Comparisons between measured and predicted subsystem excitation levels from both ground and flight testing were evaluated. The ground test data show good correlation with predictions of vibration levels throughout the cabin overhead for all excitations. The flight test results also indicate excellent correlation of inflight sound pressure measurements to sound pressure levels predicted by the SEA model, where the average aircraft speech interference level is predicted within 0.2 dB. Author

N88-14770# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

MEASURING THE ANNOYANCE OF AIRCRAFT NOISE M.S. Thesis

RUSSELL K. MARCKS 1986 96 p

(AD-A185494; AFIT/CI/NR-87-71T) Avail: NTIS HC A05/MF A01 CSCL 20A

This report addresses the jet engine noise levels in the proximity of airports. Noise measurements are given and the relation of noise levels to atmospheric conditions is related. This information is compiled to aid engineers in the construction of buildings near airports for maximum sound attenuation. GRA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

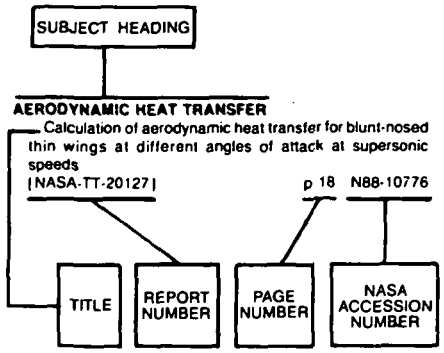
A88-18237
THERMOPLASTICS VS THERMOSETS PROCESS ECONOMICS AEROSPACE/AIRCRAFT AND AUTOMOTIVE EXTERIOR PANELS
JAMES M. MARGOLIS (Margolis Marketing and Research Co., New York) IN: Advanced composites: The latest developments; Proceedings of the Second Conference, Dearborn, MI, Nov. 18-20, 1986 . Metals Park, OH, ASM International, 1986, p. 133-139.

An evaluation is made of the differences in industrial production process economics between aeronautical and automotive composite structures, which extend even to the bases on which their substitution of conventional metallic alternatives is justifiable. The crux of improved process economics is identified as the implementation of CAD/CAM in automotive composite structures' production. Automotive space frame/composite body panel systems have demonstrated favorable overall process economics in the case of the Pontiac Fiero model; this composite structure-employing system will be further applied in the GM80 F-models. O.C.

N88-14036# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
OPERATIONAL GROUPS AT THE AEROSPATIALE AIRCRAFT DIVISION [LES GROUPES OPERATIONNELS A LA DIVISION AVIONS DE L'AEROSPATIALE]
R. DEQUE 1987 9 p In FRENCH Presented at the 8th Congres AFCIQ: Porte Ouverte sur la Reconquete
(SNIAS-872-111-107; ETN-88-91189) Avail: NTIS HC A02/MF A01

The design to cost method and the role of operational groups, adopted by aircraft construction management as the basic organization tool for design groups are explained. The system was used for the design of A310 and ATR42 aircraft. ESA

Typical Subject Index Listing



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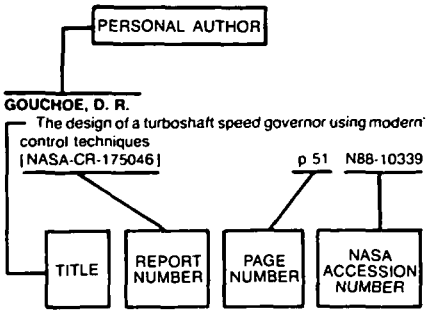

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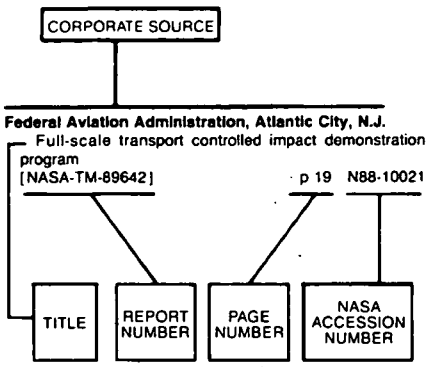

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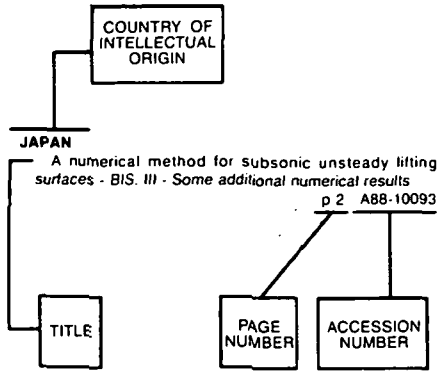

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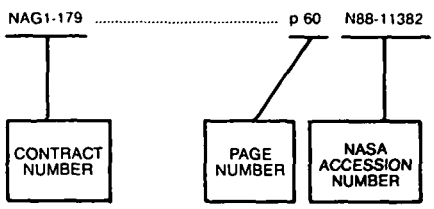

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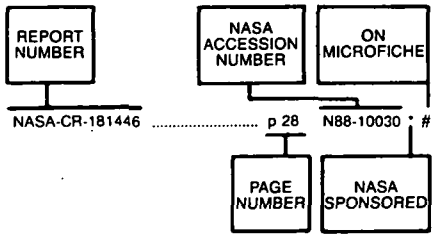

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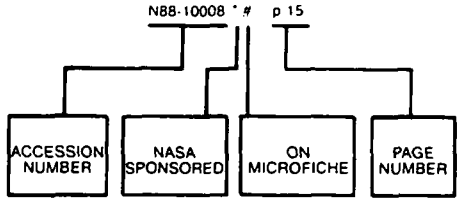

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