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A Continuing Bibliography with Indexes

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ACCESSION NUMBER RANGES

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

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NASA SP-7037(256)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 256)

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 August 1990 in

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

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
Washington, DC 1990

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 426 reports, journal articles and other documents originally announced in August 1990 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

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

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

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

An annual cumulative index will be published.

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

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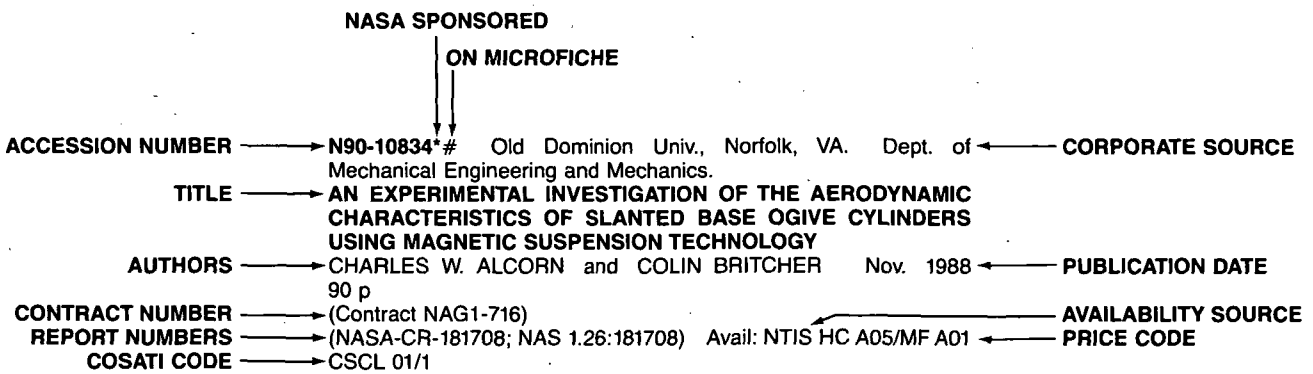
TYPICAL REPORT CITATION AND ABSTRACT



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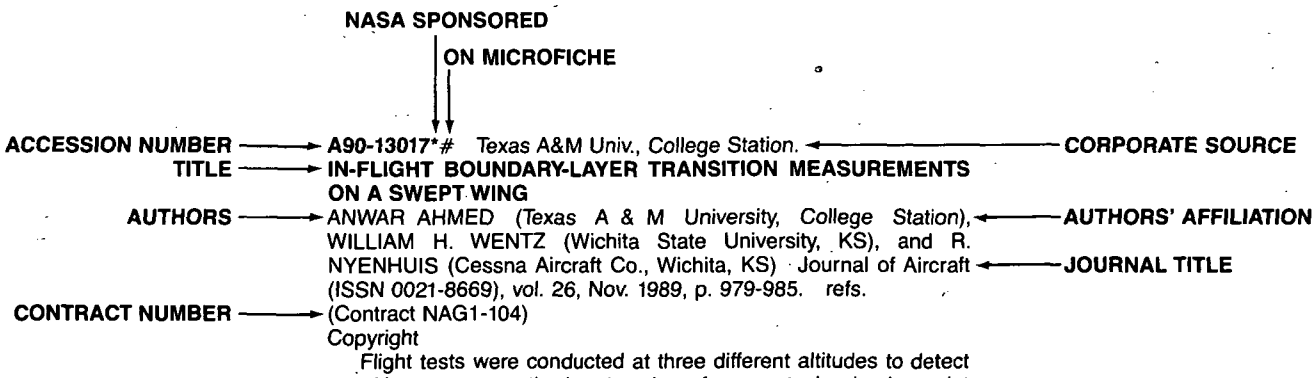

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 256)

SEPTEMBER 1990

01

AERONAUTICS (GENERAL)

A90-35685
BASIC AREAS OF RESEARCH IN THE DEVELOPMENT OF A FUTURE ATM SYSTEM
T. G. ANODINA (International Scientific Experimental Centre for Air Traffic Control, USSR) ICAO Bulletin (ISSN 0018-8778), vol. 44, Dec. 1989, p. 13-17.
Copyright

The development of an air traffic management (ATM) system for future use in the USSR is discused. The task of designing an ATM system is examined, focusing on the identification of the shortcomings of the present system, the determination of the services to correct these shortcomings, and the development of a strategy for the transition to the future ATM system. The basic requirements of a future ATM system are presented and a methodology for validating an ATM system is proposed. The plans for development of an ATM and the phases involved in the development program are described. R.B.

A90-36300
CANADIANS DEVELOP COMPOSITE TECHNIQUES FOR CF-18 BATTLE DAMAGE REPAIR PROGRAM
DAVID HUGHES Aviation Week and Space Technology (ISSN 0005-2175), vol. 132, May 21, 1990, p. 106, 107, 109.
Copyright

Approximately 40 percent of the CF-18 aircraft's exterior is covered with composite skin, including the vertical stabilizer, rudder, horizontal stabilator, trailing edge flap, and both the inner and outer wing skin sections. The primary repair technique currently available for rapid repair of composite structures punctured by projectiles is the same as has been used for years on metal structures. There are drawbacks, however, because this technique is not tailored to the needs of composite structures. Aircraft Battle Damage Repair (ABDR) is concerned with restoring the static strength of the structure rather than the strength needed to resist fatigue over time. One new technique the Canadians are experimenting with involves filling holes in graphite epoxy composite skin with fiberglass paste or adhesive and then covering this with an aluminum patch, which is riveted on or bonded on with fast drying epoxy. The RAF relies on metal patches to make composite battle repair while in the U.S. composite repair efforts focus on thermoplastic materials. R.E.P.

A90-37899
AUTOMATED AIRCRAFT HYDRAULICS TESTING
Aerospace Engineering (ISSN 0736-2536), vol. 10, June 1990, p. 14-16.
Copyright

A prime example of systems that are critical to flight safety is the aircraft hydraulic system as it relates to the flight control system. Researchers are studying ways of integrating more effective testing into the development, maintenance, and overhaul of hydraulic systems. The dissemination of industry-wide standards offers much potential for both manufacturers and end users of hydraulic components. In addition, a logical by-product of standardization is its use in the design of automated test equipment that is used in the testing of hydraulic devices. The general concept is that, if the same basic procedure can be used to perform a given test, independent of the unit under test (UUT), then in an automated environment, a single algorithm can be developed to run that test on any one of hundreds of UUTs belonging to the same general family. In conjunction with the wider use of automated test systems, researchers are convinced that this trend toward increased standardization will ultimately enhance airline safety. R.E.P.

A90-38526
NATIONAL TECHNICAL SPECIALISTS' MEETING ON TACTICAL V/STOL, NEW BERN, NC, SEPT. 19-21, 1989, PROCEEDINGS
Meeting sponsored by AHS and U.S. Marine Corps Aviation Association. Alexandria, VA, American Helicopter Society, 1989, 279 p. For individual items see A90-38527 to A90-38542.

Among the topics discussed at the meeting are air-to-air combat tactics and tests, tilt rotor technology, aircraft combat maintenance and battle damage repair, automated helicopter concept, vertical and short takeoff and landing aircraft, and engine design and repair issues. In addition, certification procedures are discussed, and data bases used in aircraft analyses are considered along with data processing techniques employed in aircraft analyses. Emphasis is placed on combat close engagement tactics for advanced rotorcraft, the application of tilt rotor technology to the next generation of tactical aircraft, flight/propulsion control integration for vertical and short takeoff and landing fighter/attack aircraft, tilt rotor requirements on engine design and qualifications, and low-speed maneuverability and agility design considerations for vertical and short takeoff and landing aircraft. V.T.

A90-38542#
AV-8B COMPOSITE REPAIR PROGRAM
LEANNA E. RADFORD and TODD D. PRICE (U.S. Navy, Naval Aviation Depot, Cherry Point, NC) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 10 p.

Composite-repair personnel and facilities, standard AV-8B composite repairs, larger-scope repair-verification programs, and major crash-damage repair are discussed. Typical standard composite repairs include a standard surface gouge repair, loose or missing anchor nut/fastener repair, fuel sealing/nylon plug repair, edge delamination repair, and lap and flush plate bolted repair. Large-scope repair development programs including a horizontal-stabilator life-assurance test program, forward-fuselage repair verification program, and wing repair verification are addressed. The most extensive composite repair - two crash-damaged aircraft, with repairs ranging from simple hand layups to more complex substructure bonded and bolted repairs, is described. V.T.

N90-21724*# Purdue Univ., West Lafayette, IN.
WINCOF-I CODE FOR PREDICTION OF FAN COMPRESSOR UNIT WITH WATER INGESTION Interim Report
S. N. B. MURTHY and A. MULLICAN Mar. 1990 88 p

(Contract NAG3-481; DTFA03-83-A-00328)
(NASA-CR-185157; NAS 1.26:185157; DOT/FAA/CT-TN89/63; M/NAFA/89-1) Avail: NTIS HC A05/MF A01 CSCL 01B

The PURDUE-WINCOF code, which provides a numerical method of obtaining the performance of a fan-compressor unit of a jet engine with water ingestion into the inlet, was modified to take into account: (1) the scoop factor, (2) the time required for the setting-in of a quasi-steady distribution of water, and (3) the heat and mass transfer processes over the time calculated under 2. The modified code, named WINCOF-I was utilized to obtain the performance of a fan-compressor unit of a generic jet engine. The results illustrate the manner in which quasi-equilibrium conditions become established in the machine and the redistribution of ingested water in various stages in the form of a film out of the casing wall, droplets across the span, and vapor due to mass transfer. Author

N90-21725*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PERFORMANCE CHARACTERISTICS OF A ONE-THIRD-SCALE, VECTORABLE VENTRAL NOZZLE FOR SSTOVL AIRCRAFT
BARBARA S. ESKER and JACK G. MCARDLE 1990 12 p Proposed for presentation at the 26th Joint Propulsion Conference, Orlando, FL, 16-18 Jul. 1990; cosponsored by AIAA, ASME, SAE, and ASEE
(NASA-TM-103120; E-5448; NAS 1.15:103120; AIAA-90-2271) Avail: NTIS HC A03/MF A01 CSCL 01B

Several proposed configurations for supersonic short takeoff, vertical landing aircraft will require one or more ventral nozzles for lift and pitch control. The swivel nozzle is one possible ventral nozzle configuration. A swivel nozzle (approximately one-third scale) was built and tested on a generic model tailpipe. This nozzle was capable of vectoring the flow up to + or - 23 deg from the vertical position. Steady-state performance data were obtained at pressure ratios to 4.5, and pitot-pressure surveys of the nozzle exit plane were made. Two configurations were tested: the swivel nozzle with a square contour of the leading edge of the ventral duct inlet, and the same nozzle with a round leading edge contour. The swivel nozzle showed good performance overall, and the round-leading edge configuration showed an improvement in performance over the square-leading edge configuration. Author

N90-22530# Federal Aviation Administration, Washington, DC. Office of Aviation Policy and Plans.
FAA (FEDERAL AVIATION ADMINISTRATION) AVIATION FORECASTS, FISCAL YEARS 1990-2001
Mar. 1990 250 p
(AD-A219165; FAA-APO-90-1) Avail: NTIS HC A11/MF A02 CSCL 01/5

The Fiscal Years 1990 to 2001 Federal Aviation Administration (FAA) forecasts of aviation activity at FAA facilities is presented. These include airports with FAA control towers, air route traffic control centers, and flight service stations. Detailed forecasts were made for the four major users of the National Aviation System: air carriers, air taxi-commuters, general aviation and the military. The forecasts were prepared to meet the budget and planning needs of the constituent units of the FAA and to provide information that can be used by state and local authorities, by the aviation industry, and by the general public. The overall outlook for the forecast period is the continued economic growth, rising real fuel prices, and moderate inflation. Based upon these assumptions, aviation activity by fiscal year 2001 is forecast to increase by 29.0 percent at towered airports (commuters, 48.2 percent; air carriers, 33.6 percent; general aviation, 25.4 percent; military, 0.0 percent), 30.1 percent at air route traffic control centers (commuters, 51.9 percent; air carriers, 33.1 percent; general aviation 30.5 percent; military, 0.0 percent), and 5.1 percent in flight services performed. Hours flown by general aviation are forecast to increase 19.2 percent and revenue passenger miles (RPM's) are forecast to increase 67.8 percent, with scheduled international RPM's forecast to increase by 113.2 percent; and regionals/commuters RPM's forecast to increase by 157.1 percent. GRA

02

AERODYNAMICS

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

A90-35137
THRUST GENERATION BY AN AIRFOIL IN HOVER MODES
P. FREYMUTH (U.S. Air Force Academy, Colorado Springs, CO) Experiments in Fluids (ISSN 0723-4864), vol. 9, no. 1-2, April 1990, p. 17-24. refs
(Contract F49620-84-C-0065)
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A small airfoil is operated in combined harmonic plunging and pitching motions to generate thrust in a still air environment. By full utilization of dynamic stall vortices large thrust coefficients were attained. The vortical signature of thrust is a simple vortex street with the character of a jet stream. Author

A90-35140
DYNAMIC STALL EXPERIMENTS ON THE NACA 23012 AEROFOIL
J. G. LEISHMAN (Glasgow, University, Scotland) Experiments in Fluids (ISSN 0723-4864), vol. 9, no. 1-2, April 1990, p. 49-58. Research supported by the Royal Aircraft Establishment and Ministry of Defence of England. refs
Copyright

An experimental investigation was conducted to examine the dynamic stall characteristics of a NACA 23012 aerofoil section at a Reynolds number of 1.5 million. Time-dependent data were obtained from thirty miniature pressure transducers and three hot film gauges situated at the mid-span of the wing. The static stall mechanism of the NACA 23012 was determined to be via abrupt upstream movement of trailing edge separation. Under dynamic conditions, stall was found to occur via leading edge separation, followed by a strong suction wave that moved across the aerofoil. This suction wave is characteristic of a strong moving vortex disturbance. Evidence of strong secondary vortex shedding was also found to occur, and this appears symptomatic of dynamic stall only at low Mach numbers. Some evidence of flow reversals over the trailing edge of the aerofoil were indicated prior to the development of leading edge separation and dynamic stall. Author

A90-35193#
BOUNDARY LAYER TURBULENCE STRUCTURE IN THE PRESENCE OF EMBEDDED STREAMWISE VORTEX PAIRS
WAYNE R. PAULEY (Pennsylvania State University, University Park) and JOHN K. EATON (Stanford University, CA) IN: Symposium on Turbulent Shear Flows, 7th, Stanford, CA, Aug. 21-23, 1989, Proceedings. Volume 1. University Park, PA, Pennsylvania State University, 1989, p. 5.2.1-5.2.6. refs
(Contract DE-FG03-86ER-13608)

Consideration is given to the mechanisms by which embedded streamwise vortices forestall boundary layer separation and modify heat transfer. Pairs of vortices were generated in an otherwise two-dimensional turbulent boundary layer by half-delta-wing vortex generators mounted on the test wall at angle of attack. The three-dimensional fields of mean velocity and turbulent Reynolds stresses were measured. The results are used to study the development and interaction of embedded streamwise vortices and their effect on boundary layer structure. R.B.

A90-35205#
TURBULENCE STATISTICS IN A SHOCK WAVE BOUNDARY LAYER INTERACTION

M. ELENA and P. RAKOTO (Institut de Mecanique Statistique de la Turbulence, Marseille, France) IN: Symposium on Turbulent Shear Flows, 7th, Stanford, CA, Aug. 21-23, 1989, Proceedings. Volume 1. University Park, PA, Pennsylvania State University, 1989, p. 8.2.1-8.2.5. Research supported by ONERA and Institut de Mecanique Statistique de la Turbulence. ,refs

The interaction between a turbulent boundary layer flow and a shock wave is studied with a one-component laser anemometer operating in a forward-scatter mode. A supersonic turbulent boundary layer is compressed on a ramp with a 6-deg incline. The upstream free stream Mach number is 2.3. The mean velocity distributions and turbulent field characteristics are examined. Consideration is given to longitudinal and transverse fluctuations of velocity, skewness and flatness factors of longitudinal velocities, and the geometrical representation of the Reynolds tensor. The results are used to describe the main phenomena observed in the flow-shock wave interaction, including level amplification and the return of the boundary layer to a new equilibrium state. R.B.

A90-35212*# Stanford Univ., CA.
DIRECT NUMERICAL SIMULATIONS OF TRANSITION IN A COMPRESSIBLE WAKE
JACQUELINE H. CHEN, BRIAN J. CANTWELL (Stanford University, CA), and NAGI N. MANSOUR (NASA, Ames Research Center, Moffett Field, CA) IN: Symposium on Turbulent Shear Flows, 7th, Stanford, CA, Aug. 21-23, 1989, Proceedings. Volume 1. University Park, PA, Pennsylvania State University, 1989, p. 9.4.1-9.4.6. refs

Direct numerical simulations of a compressible wake are performed to determine the sensitivity of large-scale motions to initial phase lags between the most unstable two-dimensional wave and a pair of oblique waves, and to determine the effect of Mach number on the development of three-dimensional motions. The vorticity dynamics of the flow are studied, and it is determined that, depending upon the initial phase lag, the interaction of the streamwise vorticity with the spanwise vortices may result in the formation of closed vortex loops, or in the removal of streamwise vorticity from the saddle region between the spanwise vortices. Due to lower growth rates experienced at high Mach numbers, the roll-up process is delayed, and the resultant nonlinear motions are much more diffuse. Author

A90-35262#
TURBULENT PLANE JET EXCITED MECHANICALLY BY AN OSCILLATING THIN PLATE IN THE POTENTIAL CORE
M. MIYATA, N. KURITA (Yamanashi University, Kofu, Japan), and I. NAKAMURA (Nagoya University, Japan) IN: Symposium on Turbulent Shear Flows, 7th, Stanford, CA, Aug. 21-23, 1989, Proceedings. Volume 2. University Park, PA, Pennsylvania State University, 1989, p. 25.2.1-25.2.6. refs

A two-dimensional rectangular jet excited mechanically by an oscillating thin plate in the jet core region is investigated experimentally. The plate is driven at both ends by stepping motors which enable control of torsion free rotational oscillation about mean position set at zero angle of attack. The maximum attack angle is nominally 1.8 degrees for the plates at 15 Hz and 27 Hz and zero for the stationary plate. The effects of excitation are salient and first appear as a periodic deflection of the jet near the nozzle exit, which is amplified downstream and gives notable effects on the development of the jet. The rate of increase in jet half-width reaches more than 5 times the value for an undisturbed jet at the excitation frequency of 27 Hz. Author

A90-35274#
AN EXPERIMENTAL STUDY OF A TURBULENT JET IMPINGING ON A WEDGE
HIROYA YAMADA, HARUHISA YANO (Daido Institute of Technology, Nagoya, Japan), IKUO NAKAMURA, and SHINTARO YAMASHITA (Nagoya University, Japan) IN: Symposium on Turbulent Shear Flows, 7th, Stanford, CA, Aug. 21-23, 1989, Proceedings. Volume 2. University Park, PA, Pennsylvania State University, 1989, p. 28.4.1-28.4.6. refs

An experimental study has been performed on the turbulence properties and the turbulent energy budget in a jet field impinging on a wedge whose included angle is 90 deg. The mean flow properties on the center-line of the jet approaching the wedge begin to undergo the wedge effect at about 50 mm upstream of the wedge-vertex. Near the stagnation point, the turbulence intensity in y-direction becomes larger than that in x-direction, the opposite of the case of a jet impinging perpendicular on an infinite plane. A region with the negative turbulent energy production exists near the vertex of the wedge, and this is considered to be related to an edge-tone phenomenon. Author

A90-35752*# Old Dominion Univ., Norfolk, VA.
UNSTEADY INVISCID AND VISCOUS COMPUTATIONS FOR VORTEX-DOMINATED FLOWS
OSAMA A. KANDIL and H. ANDREW CHUANG (Old Dominion University, Norfolk, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 387, 388.
(Contract NAG1-648)
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The unsteady supersonic flow around a rigid sharp-edged delta wing is solved using the unsteady Euler and thin-layer Navier-Stokes equations. The problem is formulated relative to a moving frame of reference so that computation of the grid motion is not required. A three-dimensional, implicit, approximately factored, central-differencing, finite-volume scheme is used to obtain the time-accurate, unsteady, locally conical flow. The inviscid and viscous results are compared during the periodic response of a wing undergoing forced rolling-oscillation motion. The results show substantial differences in the surface pressure results and other distributed flow characteristics. These differences are attributed to the inviscid and viscous flow predictions in the vortex-dominated regions. The results of the total loads do not show any significant differences. Author

A90-35754#
DYNAMIC STALL OF A CONSTANT-RATE PITCHING AIRFOIL
MIGUEL R. VISBAL (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 400-407. Previously cited in issue 07, p. 928, Accession no. A88-22094. refs

A90-35755*# San Diego State Univ., CA.
EFFECT OF VERTICAL-EJECTOR JET ON THE AERODYNAMICS OF DELTA WINGS
JOSEPH KATZ (San Diego State University, CA) and DIETER KERN Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 408-412. Previously cited in issue 20, p. 3343, Accession no. A88-48840. refs
(Contract NCC2-458)
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A90-35759#
CONTROL OF ASYMMETRIC VORTICAL FLOWS OVER DELTA WINGS AT HIGH ANGLES OF ATTACK
N. J. WOOD, L. ROBERTS, and Z. CELIK (Stanford University, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 429-435. Previously cited in issue 21, p. 3259, Accession no. A89-49102. refs
(Contract F49620-86-K-0020)
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A90-35766#
LOW-SPEED PRESSURE DISTRIBUTION ON SEMI-INFINITE TWO-DIMENSIONAL BODIES WITH ELLIPTICAL NOSES
ERIC S. LARSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 464-466. Research supported by the Forsvarsdepartementet.
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A semiempirical analytical representation of the numerical solution to the incompressible potential flow equation is presently obtained, for the case of the pressure distribution on semiinfinite, two-dimensional bodies with elliptical noses. Results are presented

for nose-slenderness ration of up to unity. A strong dependence of the nose pressure-drag coefficient on the nose slenderness ratio is noted, together with the generation of large suction forces by the slender noses. O.C.

A90-35768#
FREESTREAM TURBULENCE EFFECTS ON AIRFOIL BOUNDARY-LAYER BEHAVIOR AT LOW REYNOLDS NUMBERS
RICHARD M. HOWARD and DAVID W. KINDELSPIRE (U.S. Naval Postgraduate School, Monterey, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 468-470. refs

Wind-tunnel experiments have been conducted on the effect of turbulence length scales at elevated turbulence levels on the transitional behavior of flow over an airfoil at relatively low Reynolds number. Attention is given to velocity profiles measured at nine stations along the airfoil surface for four different conditions of turbulence intensity and length scale. The boundary layer with greatest growth was not that with highest turbulence intensity. The dependence of transitional behavior and boundary layer growth on the freestream turbulence structure is not a simple one. O.C.

A90-35770*# PRC Kentron, Inc., Hampton, VA.
CONNECTION BETWEEN LEADING-EDGE SWEEP, VORTEX LIFT, AND VORTEX STRENGTH FOR DELTA WINGS
MICHAEL J. HEMSCH (PRC Kentron, Inc., Aerospace Technologies Div., Hampton, VA) and JAMES M. LUCKRING (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 473-475. refs
(Contract NAS1-18000)
Copyright

An effort is made to clarify the effect of leading-edge sweep on the vortex lift and leading-edge vortex strength of a slender wing; while it is often assumed that increasing sweep enhances vortex lift and strength, the opposite is the case. The suction analogy is used in association with numerical and experimental data to derive simple formulas yielding the actual relationship for delta wings. The difference between vortex lift and nonlinear lift is highlighted. O.C.

A90-35771*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NONLINEAR EFFECTS IN THE TWO-DIMENSIONAL ADAPTIVE-WALL OUTER-FLOW PROBLEM
EDWARD T. SCHAIRER (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 475-477. refs
Copyright

The importance of nonlinear effects to the solution of two-dimensional adaptive-wall outer-flow problems is presently evaluated by comparing outer-flow solutions computed on the basis of the transonic small perturbation equations with solutions based on the linear Prandtl-Glauert equation. Both methods are applied to simulated measurements of transonic flow past a two-dimensional airfoil in free air. Nonlinear effects are found to be important in the outer-flow solution only where the outer flow included supersonic flow. O.C.

A90-35772#
COMMENT ON 'IMPROVED THIN-AIRFOIL THEORY'
A. PLOTKIN (San Diego State University, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 478, 479; Authors' Reply, p. 479, 480. refs
Copyright

A90-35830#
BOUNDARY ELEMENT METHOD FOR SOLVING DIRECT AERODYNAMIC PROBLEM OF AEROFOIL CASCADES ON AN ARBITRARY STREAM SURFACE OF REVOLUTION
REN QIN, FENGMING YI, and XIAOCHENG QIN (Harbin Institute of Technology, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, Feb. 1990, p. 41-43. In Chinese, with abstract in English. refs

A90-35868#
THE TSP METHODS APPLIED TO THE CALCULATION OF TRANSONIC FLOW ABOUT WING/BODY/NACELLE/PYLON-CONFIGURATIONS
WANG DIEQIAN (Northwestern Polytechnical University, Xian, People's Republic of China) and SVEN G. HEDMAN (Flygtekniska Forsoksanstalten, Bromma, Sweden) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 8, April 1990, p. 121-131. In Chinese, with abstract in English. refs

Due to the mixed character of transonic flow, load determination by approaches emphasizing the use of more exact flow equations is quite difficult for complex configurations. Transonic Small Perturbation (TSP) methods are cost-effective in repeated numerical calculations for complex geometries such as wing/body/nacelle/pylon configurations. Here, a better, simplified model for TSP computation is reported. With the present method, the small-disturbance equation for nacelle calculation can be made compatible with the leading edge boundary condition and with a large longitudinal disturbance velocity for the intake flow field. The boundary condition is expressed in terms of the tangential velocities at the contour obtained through directional derivatives, avoiding the use of the dummy potential. This feature of the method improves the pressure distribution accuracy and convergence also. C.D.

A90-35902* Imperial Coll. of Science and Technology, London (England).
ON THE INSTABILITY OF HYPERSONIC FLOW PAST A WEDGE
STEPHEN COWLEY (Imperial College of Science, Technology, and Medicine, London, England) and PHILIP HALL (Exeter University, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 214, May 1990, p. 17-42. refs
(Contract NAS1-18107)
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The instability of a compressible flow past a wedge is investigated in the hypersonic limit. Particular attention is paid to Tollmien-Schlichting waves governed by triple-deck theory though some discussion of inviscid modes is given. It is shown that the attached shock can have a significant effect on the growth rates of Tollmien-Schlichting waves. Moreover, the presence of the shock allows for more than one unstable Tollmien-Schlichting wave. Indeed an infinite discrete spectrum of unstable waves is induced by the shock, but these modes are unstable over relatively small but high frequency ranges. The shock is shown to have little effect on the inviscid modes considered by previous authors and an asymptotic description of inviscid modes in the hypersonic limit is given. Author

A90-35916* Manchester Univ. (England).
THE INVISCID AXISYMMETRIC STABILITY OF THE SUPERSONIC FLOW ALONG A CIRCULAR CYLINDER
PETER W. DUCK (Manchester, University, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 214, May 1990, p. 611-637. refs
(Contract NAS1-18605; NAS1-18107)
Copyright

The supersonic flow past a thin straight circular cylinder is investigated. The associated boundary-layer flow (i.e. the velocity and temperature field) is computed; the asymptotic, far downstream solution is obtained, and compared with the full numerical results. The inviscid, linear, axisymmetric (temporal) stability of this boundary layer is also studied. A so-called 'doubly generalized' inflexion condition is derived, which is a condition for the existence of so-called 'subsonic' neutral modes. The eigenvalue problem (for the complex wavespeed) is computed for two free-stream Mach numbers (2.8 and 3.8), and this reveals that curvature has a profound effect on the stability of the flow. The first unstable inviscid mode is seen to disappear rapidly as curvature is introduced, while the second (and generally the most important) mode suffers a substantially reduced amplification rate. Author

A90-35917
BROWNIAN MOTION FAR FROM EQUILIBRIUM - A HYPERSONIC APPROACH
P. RIESCO-CHUECA and J. FERNANDEZ DE LA MORA (Yale University, New Haven, CT) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 214, May 1990, p. 639-663. Research supported by the U.S.-Spanish Joint Committee for Cultural and Educational Cooperation. refs
(Contract NSF CBT-86-12151; DE-FG02-87ER-14550)
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The effects of Brownian agitation in the motion of small particles in a carrier gas are investigated analytically for far-from-equilibrium situations. The smallness of the thermal agitation speed of the particles allows a systematic hypersonic closure. The hypersonic equations are solved for two known cases where the kinetic Fokker-Planck equation describing the nonequilibrium particle distribution function admits exact solutions. In both cases, good agreement is obtained between the kinetic and the hydrodynamic solutions for all the conditions tested. V.L.

A90-36065
A STUDY OF BOUNDARY LAYER STABILITY IN THE CASE OF AN INCREASED INCOMING STREAM TURBULENCE IN GRADIENT FLOWS [ISSLEDOVANIE USTOICHIVOSTI POGRANICHNOGO SLOIA PRI POVYSHENNOI STEPENI TURBULENTNOSTI NABEGAIUSHCHEGO POTOKA V GRADIENTNOM TECHENII]
G. R. GREK, V. V. KOZLOV, and M. P. RAMAZANOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Mar.-Apr. 1990, p. 52-58. In Russian. refs
Copyright

Results of experimental studies of boundary layer stability in gradient flows with high incoming stream turbulence are reported. In particular, attention is given to the possibility of the artificial generation of Tollmien-Schlichting waves in the boundary layer of a wing profile with an incoming flow turbulence of 1.75 percent and their effect on the laminar-turbulent transition. The susceptibility of the flow to perturbations and the use of boundary layer suction for perturbation control are discussed. V.L.

A90-36184#
EFFECTIVENESS OF PASSIVE DEVICES FOR AXISYMMETRIC BASE DRAG REDUCTION AT MACH 2
P. R. VISWANATH and S. R. PATIL (National Aeronautical Laboratory, Bangalore, India) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, May-June 1990, p. 234-237. Research supported by the Aeronautical Development Agency. refs
Copyright

Experiments have been made to assess the effectiveness of passive devices for reducing base and total afterbody drag at Mach 2. The devices examined include primarily base cavities and ventilated cavities. Results show that ventilated cavities offer significant base-drag reduction and net-drag reduction of engineering value. A correlation of base- and net-drag reduction for ventilated cavities has been suggested. Typical effects of these devices on boat-tailed and flared bases have also been assessed. Author

A90-36251*# Vigyan Research Associates, Inc., Hampton, VA.
NAVIER-STOKES COMPUTATION OF FLOW AROUND A ROUND-EDGED DOUBLE-DELTA WING
C.-H. HSU (Vigyan, Inc., Hampton, VA) and C. H. LIU (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 961-968. Previously cited in issue 16, p. 2597, Accession no. A88-40767. refs
(Contract NAS1-17919)
Copyright

A90-36252*# Ohio State Univ., Columbus.
STRUCTURE OF A REATTACHING SUPERSONIC SHEAR LAYER
M. SAMIMY (Ohio State University, Columbus) and B. A. K. ABU-HIJLEH AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 969, 970. Abridged. Previously cited in issue 20, p. 3345, Accession no. A88-48901.
(Contract NAG3-764; N00014-87-K-0168)
Copyright

A90-36255#
MEASUREMENT OF THE INTERACTION BETWEEN A ROTOR TIP VORTEX AND A CYLINDER
S. G. LIOU, N. M. KOMERATH, and H. M. MCMAHON (Georgia Institute of Technology, Atlanta) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 975-981. refs
(Contract DAAG29-82-K-0084)
Copyright

The transient interaction between a cylinder and the trailing vortex from a rotor in forward flight is studied. Phase-averaged laser velocimetry and surface pressure measurements made with flush-mounted microphones are used to study the velocity and pressure variations during such an interaction. Vorticity contours constructed from the velocity measurements exhibit the presence of a secondary structure with vorticity opposite in sense to that of the primary tip vortex. This structure moves rapidly around the tip vortex from upstream to downstream. The pressure variations caused by the tip vortex on the surface of the cylinder are smooth as the vortex core passes by, and no evidence is found of fine structure inside the vortex core region. After vortex interaction, the secondary structure causes large variations in the surface pressure before being dissipated. Calculations using measured vortex strength and speed data indicate that the distortions and deflections of the vortex immediately prior to impingement on the surface differ significantly from those computed using two-dimensional potential flow concepts. Author

A90-36256#
TRANSONIC EULER SOLUTIONS ON MUTUALLY INTERFERING FINNED BODIES
LAWRENCE E. LIJEWSKI (USAF, Armament Laboratory, Eglin AFB, FL) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 982-988. Previously cited in issue 09, p. 1275, Accession no. A89-25222. refs
Copyright

A90-36257#
VORTEX GENERATOR JETS - MEANS FOR FLOW SEPARATION CONTROL
JAMES P. JOHNSTON (Stanford University, CA) and MICHIHIRO NISHI (Kyushu Institute of Technology, Kitakyushu, Japan) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 989-994. Research supported by USAF. Previously cited in issue 09, p. 1283, Accession no. A89-25453. refs
Copyright

A90-36258#
LEADING-EDGE VORTICES DUE TO LOW REYNOLDS NUMBER FLOW PAST A PITCHING DELTA WING
RASHEED ATTA (Menia University, Egypt) and DONALD ROCKWELL (Lehigh University, Bethlehem, PA) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 995-1004. Research supported by USAF. refs
Copyright

Flow past a pitching delta wing is examined in a water channel for a range of mean angle of attack. The wing is perturbed sinusoidally over a tenfold range of reduced frequency, in order to determine the nature of the vortex development and breakdown. There occur two basic types of vortex development: at low frequencies, the vortex core develops in the upstream direction towards the apex; at high frequencies, these is ejection of the leading edge of the vortex core from the apex in the downstream direction. Correspondingly, the direction of the dynamic hystersis loop of vortex breakdown location vs angle of attack is determined by the type of vortex development. During unsteady development of the vortex core, the axial velocity on the centerline of the vortex is essentially constant with distance along the core. At the

onset of vortex breakdown, there is abrupt deceleration; the velocity variations in this region exhibit a similar form for a range of angle of attack and reduced frequency. Author

A90-36262#
UNSTEADY AERODYNAMIC GUST RESPONSE INCLUDING STEADY FLOW SEPARATION
SANFORD FLEETER, VINCENT R. CAPECE, and HSIAO-WEI D. CHIANG (Purdue University, West Lafayette, IN) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1024-1031. Research supported by USAF. refs
Copyright

A series of experiments are performed to investigate and quantify the unsteady aerodynamic response of an airfoil to a high reduced frequency gust including the effects of the gust forcing function waveform, airfoil loading, and steady flow separation. This is accomplished by using an axial flow research compressor to experimentally model the high reduced frequency gust forcing function and replacing the last stage stator row with isolated instrumented airfoils. Appropriate data are correlated with predictions from flat plate and cambered airfoil convected gust models. The airfoil surface steady loading is shown to have a large effect on the unsteady aerodynamic response. Also, the steady flow separation has a significant influence on the gust response, particularly upstream of the separation point and in the airfoil trailing-edge region. Author

A90-36279#
TRANSIENT RESPONSE OF LEADING-EDGE VORTICES TO LOCALIZED SUCTION
K. PARMENTER and D. ROCKWELL (Lehigh University, Bethlehem, PA) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1131-1133. Research supported by USAF. refs
Copyright

An effort is made to ascertain the response of the leading-edge vortex of a delta wing to the abrupt onset and cessation of suction, where the suction is applied through a probe located well downstream of the onset of vortex breakdown. Attention is given to the visualization of the vortex core's unsteady evolution, the character of the core development's hysteresis, and the overall response time from the onset of suction to the core's stabilization as a function of suction amplitude and suction probe location. O.C.

A90-36280#
EFFECT OF SURFACE GROOVES ON BASE PRESSURE FOR A BLUNT TRAILING-EDGE AIRFOIL
GREGORY V. SELBY and FARID H. MIANDOAB (Old Dominion University, Norfolk, VA) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1133-1135. refs
(Contract NSF MSM-85-19116)
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An experimental study has been conducted to examine the effect of longitudinal grooves on the base pressure of a flat-plate airfoil with thick trailing edge. The models were tested with groove angles of 10 to 50 deg. It is established that base pressure increases with groove depth and angle; attached flow in the grooves appears to be the mechanism by which higher-momentum fluid is redirected to the base flow region, thereby effecting an increase in base pressure. O.C.

A90-36281#
UNSTEADY TRANSONIC CASCADE FOW WITH IN-PASSAGE SHOCK WAVE
C.-C. LI (Chung Shan Institute of Science and Technology, Tauyuan, Republic of China), A. F. MESSITER, and B. VAN LEER (Michigan, University, Ann Arbor) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1135-1138. refs
Copyright

In the present CFD numerical technique-based scheme for solving the unsteady Euler equations, the unsteady perturbations are allowed to be as large as the steady-flow disturbances, and the shock-wave displacements may be large. While the scheme appears to be successful for the capture of shock waves, it is not capable of adequately resolving vortex sheets. Preliminary calculations for the case of a staggered cascade indicate that the method will be applicable to these geometries as well. O.C.

A90-36282#
SUPPRESSION OF VORTEX ASYMMETRY BEHIND CIRCULAR CONES
WOLFGANG STAHL (DLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1138-1140. Abridged. Research supported by DLR and King Fahd University of Petroleum and Minerals. Previously cited in issue 21, p. 3258, Accession no. A89-49076. refs
Copyright

A90-36413#
RECENT ADVANCEMENT IN HELICOPTER ROTOR WAKE STUDY
WUJIANG LOU and SHICUN WANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, March 1990, p. A113-A119. In Chinese, with abstract in English. refs

Based on a concise review of state-of-the-art of the methodology for analyzing the wake flows behind helicopter rotors, a novel idea for the 'constrained wake model' pertaining to the conventional free wake model is proposed. The constrained wake analysis is conceived in which the wake analysis is performed under the limitation of certain constraints imposed on the wake. The essence of the idea is to lay the free wake analysis on available physical understandings, aiming at a remarkable reduction of computational efforts and a significant improvement on the reliability of the predictions. Author

A90-36415#
MACH NUMBER EFFECTS ON UPSTREAM INFLUENCE IN SWEPT SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTIONS
XUEYING DENG, ZHIZHONG LIU, and JINHUI CUI (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, March 1990, p. A127-A131. In Chinese, with abstract in English. refs

This paper presents an experimental study of shock wave/turbulent boundary layer interactions by swept compression corners. The study uses a supersonic blowdown wind tunnel and 15 models with swept-back angles between 0 and 60 deg and 10 and 30 deg as well as Re = 2.42-2.47 x 10 to the 7th/m and Ma(infinity) = 1.79, 2.04, and 2.50. The results show that the conical or cylindrical upstream influence region appears in the interactions for all models and Mach numbers. The boundary between the conical and cylindrical region varies with Ma(infinity), and can be physically determined by the shape of the inviscid shock wave. C.D.

A90-36419#
SOLUTION OF EULER EQUATIONS FOR FIGHTER FOREBODY-INLET COMBINATION AT HIGH ANGLE OF ATTACK
XIAOQING ZHENG and HUILI SHEN (Northwestern Polytechnical University, Xian People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, March 1990, p. A161-A168. In Chinese, with abstract in English. refs

A computational procedure using three-dimensional Euler equations has been developed to predict inviscid flows over integrated forebody-inlet combinations. A multizone mesh is used to achieve the required geometric flexibility. The whole computational domain is divided into three zones, with the mesh of each zone generated by interpolating the fluxes across the interface between adjacent zones using iterations. A new type of treatment of inlet exit boundary conditions has been developed and tested, and it is applied to forebody-inlet analysis for a range of flight conditions, including subsonic, transonic, and supersonic

flight with various engine mass flows and angles of attack. The steady states of supersonic flight at up to 10 deg angle of attack are obtained for subcritical regimes of the engine. The results are in good agreement with experimental data. C.D.

A90-36465
OSCILLATION OF CIRCULAR SHOCK WAVE
MYEONG KWAN PARK, SHUZO OSHIMA, and RYUICHIRO YAMANE (Tokyo Institute of Technology, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 33, May 1990, p. 208-215. refs
Copyright

Oscillation modes of a circular shock wave in a supersonic radial flow were studied both experimentally and theoretically. The pressure fluctuation was measured in concentric positions to investigate the modes of the circular shock wave in the case of mean radii of 70 and 77 mm, and the A-D converted signals were statistically correlated. A simple model of an oscillating shock wave was proposed. The frequency of the oscillation increased from low to high values with increasing radius. The oscillation mainly consisted of mode 0 superposed by modes of 1, 2 and 4. The mode 1 is considered to be weak. The experimental frequency of each mode agreed well with the theoretical results. Author

A90-36522
TIME-RESOLVED MEASUREMENTS OF TOTAL TEMPERATURE AND PRESSURE IN THE VORTEX STREET BEHIND A CYLINDER
W. F. NG, W. M. CHAKROUN (Virginia Polytechnic Institute and State University, Blacksburg), and M. KUROSAKA (Tennessee, University, Tullahoma) Physics of Fluids A (ISSN 0899-8213), vol. 2, June 1990, p. 971-978. refs
(Contract AF-AFOSR-83-0049)
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The results from the time-accurate measurements of fluctuating total temperature and pressure are presented. The data were obtained by placing a time-resolved aspirating probe in the vortex street behind a cylinder. The free-stream Mach number was 0.4, and the Reynolds number based on the cylinder diameter was 2.3 x 10 to the 5th. The maximum magnitude of the rms fluctuations of total temperature are of the order of 15 K - about 5 percent of the upstream total temperature. Maximum fluctuations in total pressure are approximately 10 percent of the upstream total pressure. Not only are the time traces of the total temperature and pressure taken in the near-wake qualitatively similar, but also quantitatively they agree with the predictions. Author

A90-36524* Stanford Univ., CA.
THE EFFECT OF MACH NUMBER ON THE STABILITY OF A PLANE SUPERSONIC WAKE
JACQUELINE H. CHEN, BRIAN J. CANTWELL (Stanford University, CA), and NAGI N. MANSOUR (NASA, Ames Research Center, Moffett Field, CA) Physics of Fluids A (ISSN 0899-8213), vol. 2, June 1990, p. 984-1004. Previously cited in issue 09, p. 12765, Accession no. A89-25242. refs
(Contract DE-AC04-76DP-P00789)
Copyright

A90-36539#
COMPUTATIONAL METHODS IN DESIGN AERODYNAMICS
IN: Research department fluid mechanics - Scientific report (1988). Cologne, DLR, 1989, p. 10-14.

The activities of the DLR fluid-mechanics department (Forschungsbereich Stroemungsmechanik) in the fields of CFD and aerodynamic design during 1988 are surveyed and illustrated with diagrams and sample computer graphics. Topics addressed include singularity methods for complex configurations, propellers, and rotors; a unified theory of aerodynamics and acoustics; solution methods for the full potential equation; techniques for solving the Euler and Navier-Stokes equations; cooperation with the SUPRENUM supercomputer project; and CFD algorithms for routine use. Particular attention is given to grid generation methods, the CATS and CEVCATS Euler solvers, and a stream-tube curvature method for nacelles with propulsive jets. T.K.

A90-36540#
CONFIGURATION AERODYNAMICS
IN: Research department fluid mechanics - Scientific report (1988). Cologne, DLR, 1989, p. 15-22.

The research activities of the DLR fluid-mechanics department (Forschungsbereich Stroemungsmechanik) in the field of configuration aerodynamics during 1988 are surveyed. Consideration is given to flight tests of a transonic laminar wing for commercial transport aircraft and wind-tunnel testing of (1) a transonic wing model, (2) a subsonic-transport half-model with propfan engine, (3) forward-swept-wing combat aircraft, (4) helicopter-rotor airfoils, and (5) laminar airfoils for general-aviation aircraft (in cooperation with NASA). Also discussed is work on gliders, turbine cascades, and ground vehicles. Extensive diagrams, graphs, and photographs are provided. T.K.

A90-37063*# Ohio State Univ., Columbus.
MEASURED AERODYNAMIC PERFORMANCE OF A SWEPT WING WITH A SIMULATED ICE ACCRETION
A. KHODADOUST and M. B. BRAGG (Ohio State University, Columbus) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan 8-11, 1990. 11 p. Research supported by NASA. refs
(AIAA PAPER 90-0490) Copyright

The effect of a simulated glaze ice accretion on the aerodynamic performance of a three-dimensional swept wing is studied experimentally. A semispan wing of effective aspect ratio four was mounted from a splitter plate in the OSU subsonic wind tunnel. The model uses a NACA 0012 airfoil section on a rectangular planform with interchangeable tip and root pieces to allow for 0- and 30-degree sweep. Surface pressures were measured at 5 semispan locations on the swept-wing model. The section lift data for the 5 semispan locations are presented and compared with theory and zero-sweep model results. In addition, previously unpublished roughness data from the zero-sweep model is presented here. These data show a large drag and maximum lift penalty due to rough simulated glaze ice. The effect of wing-sweep is seen through a decrease in wing lift performance for both the clean and iced wing. Author

A90-37205#
AN EFFICIENT FINITE-DIFFERENCE ALGORITHM FOR COMPUTING AXISYMMETRIC TRANSONIC NACELLE FLOW FIELDS
MINGKE HUANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Jan. 1990, p. A1-A6. In Chinese, with abstract in English. refs

A finite difference method for computing axisymmetric transonic flows over a nacelle is presented. According to an optimum convergence criterion, a new AF scheme is constructed and then applied to solving a conservative full-potential equation for transonic nacelle flow using a body-fitted grid with an exact boundary condition. Computation for several inlets shows a rapid convergence of this scheme and an excellent agreement with experimental results. Author

A90-37209#
A NUMERICAL METHOD IN AEROELASTICITY FOR WINGS WITH SEPARATION AT LARGE ANGLE OF ATTACK
ZHENGYIN YE, LINGCHENG ZHAO, and YONGNIAN YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Jan. 1990, p. A31-A36. In Chinese, with abstract in English.

A numerical method is presented for predicting the static and dynamic aeroelastic characteristics of wings with separation at large angle of attack. The numerical method is used to give the nonlinear aerodynamic loads of wings at large angle of attack in subsonic flow. In the time domain, the governing structural

equations of the system are solved by a numerical method. As an example, a rectangular wing with a side edge separation is considered. Author

A90-37216#
FINITE ELEMENT NUMERICAL ANALYSIS FOR TRANSONIC FLOWS AROUND LIFTING FUSELAGES
GUOFU ZHANG and XIANPIN LI (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Jan. 1990, p. A74-A77. In Chinese, with abstract in English.

A finite element method based on the minimum pressure integral, obtained by a variational principle for full potential equation, is used to calculate transonic flows around lifting fuselages. A system of equations deduced from the finite element discretization is solved by the SLOR procedure, and the density is updated after each SLOR sweep. In order to increase the convergence speed, a successive grid refinement technique is employed, and that reduces the computer time considerably. A number of numerically computed examples are presented and compared with experimental results. Author

A90-37343#
SOLUTION OF EULER EQUATIONS WITH UNSTRUCTURED MESHES
G. D. MORTCHELEWICZ (ONERA, Chatillon, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 6, 1989, p. 1-16. refs
Copyright

RM 2 D is a finite element program that solves two-dimensional unsteady Euler equations, using Richtmyer's scheme. A small displacement hypothesis is used to simulate the motion of the airfoil, which allows us to keep the same mesh. Numerical examples are given. The unstructured mesh is very useful in computing complex geometries. Author

A90-37346#
EXPERIMENTAL STUDY OF INCOMPRESSIBLE FLOW ON THE UPPER SURFACE OF A DELTA WING
J.-L. SOLIGNAC, D. PAGAN, and P. MOLTON (ONERA, Chatillon, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 6, 1989, p. 47-65. refs
Copyright

The flow around a 75 degree sweep angle delta wing is studied to produce reference material for numerical codes. Data at various Reynolds numbers were obtained at three different wind tunnel facilities in France. The flow in one of the tunnels has a laminar boundary layer, while the flow in the other two tunnels has a natural transition on the wing. Upper surface flow visualization experiments were performed and the external flow was probed by three-dimensional LDV and a five-hole pressure probe. The results suggest that the secondary vortex is larger for a laminar boundary layer than for turbulent boundary layer. R.B.

A90-37736#
AN ANALYTIC SOLUTION ON HYPERSONIC FLOW OVER AN ARBITRARY SLENDER BODY WITH NEAR POWER-LAW PROFILE
YAO-SONG CHEN and YONG-ZE CHEN (Beijing University, People's Republic of China) Applied Mathematics and Mechanics (English Edition) (ISSN 0253-4827), vol. 10, Nov. 1989, p. 1063-1080. refs

On the basis of a self-similar solution as well as the assumption of transverse motion, a general linear theory on hypersonic flow over a general slender body is set up. By means of this theory, the problem concerned can be put into a universal system of ordinary differential equations, which can be integrated numerically in advance. Author

A90-37890
A METHOD FOR SOLVING THREE-DIMENSIONAL VISCOUS INCOMPRESSIBLE FLOWS OVER SLENDER BODIES
MOSHE ROSENFELD, MOSHE ISRAELI, and MICHA WOLFSHTEIN (Technion - Israel Institute of Technology, Haifa) Journal of Computational Physics (ISSN 0021-9991), vol. 88, June 1990, p. 255-283. Research supported by the Stiftung Volkswagenwerk and DARPA. refs
(Contract N00014-86-K-0759; N00014-82-C-0451)
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Velocity and pressure are taken to be dependent variables in the present marching iterative method solutions of the three-dimensional incompressible, steady, reduced Navier-Stokes equations in general orthogonal coordinates. Each iteration of the coupled set of the linearized finite-difference continuity and momentum equations consists of spatial marching from the upstream to the downstream boundary. The solution procedure is equivalent to the solution of a single Poisson-type equation by the successive plane-over-relaxation method; several properties of the method are evaluated in light of tests performed on the laminar incompressible flows over prolate spheroids at intermediate incidence. O.C.

A90-37937*# Naval Surface Warfare Center, Silver Spring, MD.
CONDENSATION IN HYPERSONIC NITROGEN WIND TUNNELS
MELISSA A. LEDERER, WILLIAM J. YANTA, WILLIAM C. RAGSDALE (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD), SUSAN T. HUDSON, and WAYLAND C. GRIFFITH (North Carolina State University, Raleigh) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 16 p. refs
(Contract NAGW-1072)
(AIAA PAPER 90-1392)

Experimental observations and a theoretical model for the onset and disappearance of condensation are given for hypersonic flows of pure nitrogen at M = 10, 14 and 18. Measurements include Pitot pressures, static pressures and laser light scattering experiments. These measurements coupled with a theoretical model indicate a substantial non-equilibrium supercooling of the vapor phase beyond the saturation line. Typical results are presented with implications for the design of hypersonic wind tunnel nozzles. Author

A90-37943#
THE CHALLENGING PROCESS OF VALIDATING CFD CODES
A. MARTELLUCCI (Science Applications International Corp., Fort Washington, PA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 13 p. Research sponsored by USAF, SDIO, and U.S. Army. refs
(AIAA PAPER 90-1402) Copyright

Computational fluid dynamics (CFD) has become the principal tool for the aerothermal design of vehicels for supersonic-hypersonic flight. Reliance on CFD for flight prediction is dictated by the inability of ground test facilities to provide the full simultaneous simulation of all pertinent hypersonic flows scaling parameters. While flight test provides the proper simulation, the measurement of key parameters required for CFD validation is difficult to achieve and is also extremely costly. This dictates that the CFD computer code formulations used for vehicle design must be technically sound, practical, and cost effective for use. The validation of these capabilities is a multistep process proceeding from the basic general functioning of the code proceeding to the detailed examination and validation of the key submodules. In principle, validation is a continuous never-ending process. Author

A90-37947#
WALL INTERFERENCE CORRECTION FOR THREE-DIMENSIONAL TRANSONIC FLOWS
W. L. SICKLES and J. C. ERICKSON, JR. (Calspan Corp., Arnold AFB, TN) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 19 p. refs
(AIAA PAPER 90-1408)

Accurate wall interference corrections to experimental lift, drag, and pitching moment are determined for high-subsonic, supercritical three-dimensional flows. To achieve this accuracy, flow-field

computations required simulating viscous effects over the wing and tail. Previous attempts to determine wall interference corrections with inviscid computations had proved unsatisfactory at the same flow conditions. Corrections were determined for two wing/body/tail configurations with a wall interference assessment/correction procedure using measured boundary data and with a pretest predictive procedure using a semiempirical perforated-wall boundary condition. Author

A90-37948*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVALUATION OF EQUILIBRIUM TURBULENCE FOR A NATURALLY DEVELOPING HYPERSONIC BOUNDARY LAYER AT NONADIABATIC WALL CONDITIONS
CINDY W. ALBERTSON (NASA, Langley Research Center, Hampton, VA) and ROBERT L. ASH (Old Dominion University, Norfolk, VA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 10 p. refs
(AIAA PAPER 90-1410) Copyright

Experimental data for defining test conditions necessary for a naturally developing hypersonic equilibrium turbulent boundary layer are presented. The tests were conducted at nominal boundary-layer edge Mach number of 6.2 and 5.0; the adiabatic wall to actual wall temperature ratio was 5.4. The data indicate that a momentum thickness Reynold number of at least 4000 is required for an equilibrium turbulent boundary layer. Based on the above results, a test envelope defining equilibrium flow conditions for an eight-foot high-temperature tunnel in terms of the basic facility operating conditions is given for a Mach-7 nozzle configuration. Representative experimental results for two-dimensional and three-dimensional test articles are assessed, including results of complete and partial adaptation and of residual-interference calculations. V.T.

A90-37951#
EXPERIENCE IN THE USE OF A VISCOUS SIMULATION METHODOLOGY FOR TESTS IN TRANSONIC TUNNELS
A. B. HAINES (Aircraft Research Association, Ltd., Bedford, England) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 12 p. refs
(AIAA PAPER 90-1414) Copyright

The paper describes the basic features of a viscous simulation methodology for the testing of models in transonic tunnels at low or moderate Reynolds numbers and for the extrapolation of the test data to flight Reynolds numbers. Results are presented from some initial experience in which the methodology has been applied to results for a modern two-dimensional aerofoil tested in an 8 ft x 8 ft tunnel. Author

A90-37962*# Boeing Commercial Airplane Co., Seattle, WA.
LAMINAR FLOW TEST INSTALLATION IN THE BOEING RESEARCH WIND TUNNEL
DEZSO GEORGE-FALVY (Boeing Commercial Airplanes, Seattle, WA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 11 p. refs
(Contract NAS1-14630)
(AIAA PAPER 90-1425) Copyright

This paper describes the initial wind tunnels tests in the 5- by 8-ft Boeing Research Wind Tunnel of a near full-scale (20-foot chord) swept wing section having laminar flow control (LFC) by slot suction over its first 30 percent chord. The model and associated test apparatus were developed for use as a testbed for LFC-related experimentation in support of preliminary design studies done under contract with the National Aeronautics and Space Administration. This paper contains the description of the model and associated test apparatus as well as the results of the initial test series in which the proper functioning of the test installation was demonstrated and new data were obtained on the sensitivity of suction-controlled laminar flow to surface protuberances in the presence of crossflow due to sweep. Author

A90-37964#
RESULTS OF WIND TUNNEL GROUND EFFECT MEASUREMENTS ON AIRBUS A320 USING TURBINE POWER SIMULATION AND MOVING TUNNEL FLOOR TECHNIQUES
A. FLAIG (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 10 p.
(AIAA PAPER 90-1427) Copyright

Two wind-tunnel test experiments conducted on an Airbus A320 model in a low-speed wind tunnel are presented. In the first experiment, the general ground testing technique employing a dorsal sting model suspension and a fixed ground plane with a tunnel floor boundary layer removal scoop was used, and engines were simulated by through flow nacelles (TFN). In the second experiment, turbine power simulators (TPS) were utilized, along with a moving ground plane belt. Focus is placed on a horizontal tail and lift, drag, and pitching moment. It is concluded that due to significant differences between TPS and TFN, the TPS technique is recommended over TFN, especially for takeoff configurations; however, for landing configurations, TFN is considered to be sufficient. V.T.

A90-37967#
PNEUMATIC VORTEX FLOW CONTROL ON A 55-DEGREE CROPPED DELTA WING WITH CHINED FOREBODY
SCOTT P. LEMAY and LAWRENCE W. ROGERS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 30 p. refs
(AIAA PAPER 90-1430)

The effects of blowing on the chine/wing vortex interaction on a 0.04-scale generic fighter configuration with a 55-degree cropped delta wing and a slender fuselage forebody with chinelike strakes are studied in a water tunnel. Baseline data reveal a coiling of the wing and chine vortices about each other, promoting vortex breakdown. However, decoupling of the wing and chine vortices and delay of vortex breakdown is observed when blowing is applied. The optimal blowing location is at midchine, with a blowing nozzle angled 35 degrees aft from the forebody normal, and inclined 20 degrees with respect to the wing plane. It is observed that large flow asymmetries are generated using asymmetric blowing, and that normally-mounted and 30-degree cant out tails cause breakdown of the chine and wing vortices occurring farther upstream. V.T.

A90-37968#
FLOW FIELD MEASUREMENTS NEAR A FIGHTER MODEL AT HIGH ANGLES OF ATTACK
N. M. KOMERATH, H. M. MCMAHON, R. J. SCHWARTZ, S. G. LIOU, and J.-J. KIM (Georgia Institute of Technology, Atlanta) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 11 p. Research supported by USAF. refs
(AIAA PAPER 90-1431) Copyright

The low-speed flow environment of a 1/32-scale model of an F-15 fighter aircraft at high angle of attack is studied. Laser sheet flow visualization is used to observe the various sources of vortex generation, along with the evolution of these vortex flows, while surface tufts are used to observe the nature of flow separation on the vertical tails. No concentrated vortex is observed near the vertical tails, and flow separation on the outside surfaces of the vertical tails is complete by 22 degrees angle of attack. The flow on the inside surfaces of the tails is seen to remain largely attached. The flow angularity at the tails varies widely along the tail span, and with angle of attack. The largest velocity fluctuations are seen to be in the separated flow immediately above the wing surfaces. The outer regions of the vortex flow exhibit bi-modal velocity histograms, indicating quasi-periodic intermittency. V.T.

A90-37969#
WIND TUNNEL STUDIES OF F/A-18 TAIL BUFFET
B. H. K. LEE and D. BROWN (National Aeronautical Establishment, Ottawa, Canada) AIAA, Aerodynamic Ground Testing Conference,

16th, Seattle, WA, June 18-20, 1990. 12 p. Research supported by DND. refs
(AIAA PAPER 90-1432) Copyright

A wind tunnel investigation of buffeting on the vertical fin of a rigid 6 percent model of the F/A-18 has been conducted in a 5 ft by 5 ft trisonic-blowdown tunnel. Unsteady pressure measurements on the vertical fin were made by means of 24 fast response transducers on each surface. The vortex flow structure behind the fin was studied with the aid of a 49 pressure-sensor rake mounted on the model sting. In addition to measuring steady pitot pressure values, to deduce pressure contours, unsteady pressure signals were obtained from 13 fast response transducers. Spectral analyses of the pressure fluctuations on the fin and in the vortical flow region behind the fin were performed to detect the presence of dominant oscillations during buffeting. Author

A90-38394#
HYPERSONIC FLOW CALCULATIONS WITH A HYBRID NAVIER-STOKES/MONTE CARLO METHOD
FREDERIK J. DE JONG, JAYANT S. SABNIS, RICHARD C. BUGGELN, and HENRY MCDONALD (Scientific Research Associates, Inc., Glastonbury, CT) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 5th, Seattle, WA, June 18-20, 1990. 15 p. refs
(Contract F08635-87-C-0003; DAAL03-88-C-0028)
(AIAA PAPER 90-1691) Copyright

The axisymmetric hypersonic flow about a blunt-faced cylindrical fore-body has been simulated using a newly developed hybrid Navier-Stokes/Monte Carlo method. This method couples a statistical ('Monte Carlo') treatment of the chemical reactions with a continuum ('Navier-Stokes') description of the gas mixture and the species transport. It facilitates the inclusion of more accurate chemical reaction models, surface catalytic reactions, etc., based on the use of collision/reaction cross-sections (or probabilities), while it retains most of the run-time advantages of a full continuum method. The computed results have been compared with results obtained using a full continuum method and those of a Direct Simulation Monte Carlo method. Author

A90-38416*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF THE LAURA CODE FOR SLENDER-VEHICLE AEROTHERMODYNAMICS
RICHARD A. THOMPSON and PETER A. GNOFFO (NASA, Langley Research Center, Hampton, VA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 5th, Seattle, WA, June 18-20, 1990. 11 p. refs
(AIAA PAPER 90-1714) Copyright

Application of a three-dimensional thin-layer Navier-Stokes code (LAURA) to compute the laminar, perfect gas aerothermodynamics of slender vehicles is demonstrated. Comparison of solutions with experimental data enabled an assessment of the code's aerodynamic heating prediction capabilities. The results show radial grid refinement to a wall cell Reynolds number of 2 to be accurate for predicting aerodynamic heating to a slender cone. Additional comparisons for an 80 deg slab-delta wing and a generic Aero-Space Plane vehicle show the method to be generally accurate using this radial cell spacing. Discrepancies between the predicted and measured heating in a region of crossflow separation on the Aero-Space Plane geometry are noted which indicates the need for further study. While additional applications and comparisons are required to fully test the LAURA program, the results of this study demonstrate the current level of confidence and the engineering utility of this particular code. Author

A90-38468*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THREE DIMENSIONAL DISCRETE PARTICLE SIMULATION ABOUT THE AFE GEOMETRY
WILLIAM J. FEIEREISEN (NASA, Ames Research Center, Moffett Field, CA), JEFFREY D. MCDONALD (Eloret Institute, Palo Alto, CA), and MICHAEL A. FALLAVOLLITA (Stanford University, CA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 5th, Seattle, WA, June 18-20, 1990. 13 p. refs
(AIAA PAPER 90-1778)

The Discrete Particle Simulation method, due to Baganoff, has recently been extended to allow representation of gases composed of multiple species, to general power-law molecular interactions and to permit flows in thermal non-equilibrium. Particular attention has been paid to the implementation of this physics while retaining the efficiency of the original algorithm. Here, the enhanced algorithm is applied to the simulation of the flow field about the Aeroassisted Flight Experiment (AFE) vehicle with the same flight parameters as in a previous paper. The enhancements to the algorithm are introduced and comparisons are made to the previous calculation. Author

A90-38488#
MEASUREMENT OF MEAN AND FLUCTUATING FLOW PROPERTIES IN HYPERSONIC SHEAR LAYERS
J. XERICOS, W. C. ROSE (Rose Engineering and Research, Inc., Incline Village, NV), E. G. RAWLINSON (SY Technology, Inc., Huntsville, AL), and T. B. HARRIS (Science Application International Corp., Fort Washington, PA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 24 p. refs
(Contract DASG60-86-C-0013)
(AIAA PAPER 90-1409) Copyright

A measurement technique was developed to determine the fluctuating density field strength and scales across a turbulent shear layer using measurements of mean flow properties and fluctuating pitot pressures. Basic experimental data on surface static pressure over the sensor window and pitot pressure and total temperature in the shear layer were reduced to derive fluid density profiles. Using high-response fluctuating pitot pressure gauges, the scale lengths for the pitot pressure fluctuations were determined by cross-correlating their high-frequency output. The peak rms density fluctuation levels were determined using the scale lengths which were assumed to be of the same order as those for the density fluctuations. N.B.

A90-38490#
WIND TUNNEL TESTING TECHNIQUES ON AERODYNAMIC EFFECTS WITH SMALL ASYMMETRY
X. Z. HUANG and H. J. CAI (Beijing Institute of Aerodynamics, People's Republic of China) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 8 p. refs
(AIAA PAPER 90-1400) Copyright

Several special test techniques for measuring the aerodynamic effects caused by small asymmetry have been developed. Those techniques include isolating method, relative method, step input response method and pseudorandom input response method. A journal, thrust or three degree of freedom spherical gas bearing was used to support the model according to different test purpose. Some sensors or untouched transducers, such as inductosyn, fiber-optic system etc, were installed to measure the aerodynamic effects. The tests were performed in hypersonic and supersonic wind tunnels at Mach numbers of 3 to 6. The effects of parameters, such as nose tip, mass distribution and trim angle of elevator, are discussed briefly. Author

A90-38495
THE EFFECT OF AN OSCILLATORY FREESTREAM-FLOW ON A NACA-4412 PROFILE AT LARGE RELATIVE AMPLITUDES AND LOW REYNOLDS-NUMBERS
E. KRAUSE and W.-B. SCHWEITZER (Aachen, Rheinisch-Westfaelische Technische Hochschuyle, Federal Republic of Germany) Experiments in Fluids (ISSN 0723-4864), vol. 9, no. 3, May 1990, p. 159-166. refs
Copyright

Results of an experimental investigation of the flow around a NACA-4412 profile in an oscillating freestream are presented. The experiment took place in an Eiffel-type windtunnel at a chord Reynolds-number of Re = 200,000. Measurements of unsteady pressure distributions and boundary-layer profiles as well as flow photographs reveal that even at moderate reduced frequencies

significant changes of the flow field may occur, provided that the relative amplitude of the freestream is sufficiently large. So a periodical separation and reattachment of the flow could be observed while in another case the periodical relaminarization of the boundary-layer could be found. Author

A90-38523
THE INFLUENCE OF INTERACTIONAL AERODYNAMICS OF ROTOR-FUSELAGE-INTERFERENCES ON THE FUSELAGE FLOW
F.-W. MEYER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) Vertica (ISSN 0360-5450), vol. 14, no. 2, 1990, p. 201-215. refs
Copyright

This paper presents a model which enables determination of aerodynamic data and boundary layer effects of the fuselage of a helicopter under the interactional aerodynamics of rotor-fuselage-interferences. The model is based on iterative calculation processes which are combined to a solution procedure. Although there are some complex methods such as panel and integral three-dimensional boundary layer and free wake-methods involved, the solution procedure needs only common computers. The modeling of the fuselage flow consists of a superposition of the influence of free stream velocity, fuselage angle of attack and rotor downwash. The rotor downwash is calculated by blade-element-theory and momentum considerations, the wake is represented by a time-averaged free wake model. The model provides insight to the problem and improves the understanding of the 'secondary' effects of interactional aerodynamics of rotor-fuselage-combinations. Calculations are made by variation of advance ratio, rotor height and fuselage aft section. Author

A90-38608*# High Technology Corp., Hampton, VA.
EFFECTS OF SHOCK ON THE STABILITY OF HYPERSONIC BOUNDARY LAYERS
CHAU-LYAN CHANG, MUJEEB R. MALIK (High Technology Corp., Hampton, VA), and M. YOUSUFF HUSSAINI (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 18 p. refs
(Contract NAS1-18240; NAS1-18605)
(AIAA PAPER 90-1448) Copyright

A set of linearized shock boundary conditions is derived, which is then imposed at the shock to account for the interaction of the shock wave with the boundary/shock layer instability wave; these boundary conditions are used to study the effect of shock on hypersonic boundary layer stability under the assumption of quasi-parallel flow. The result show that the shock has little effect on the boundary layer instability (subsonic first and second mode disturbances) when the shock is located outside the boundary layer edge. When the shock is located near the boundary layer edge, it exerts a stabilizing influence on the first and second modes. The shock also induces unstable supersonic modes with oscillatory structure in the shock layer, but these modes grow slower than the subsonic modes. I.S.

A90-38612#
A NUMERICAL STUDY OF SUPERSONIC FLOW OVER A COMPRESSION CORNER WITH DIFFERENT INCOMING BOUNDARY-LAYER PROFILES
S. C. HOLMES and L. C. SQUIRE (Cambridge, University, England) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 10 p. Research supported by SERC. refs
(AIAA PAPER 90-1453) Copyright

The Reynolds-averaged two-dimensional Navier-Stokes equations are solved for flow with two different incoming boundary-layer profiles over an 11-deg compression corner. The free-stream Mach number is 2.5 and the Reynolds number is 3.8 x 10 to the 7th per meter. The shock/boundary-layer interaction is affected by the fullness of the boundary-layer upstream of the corner. The computed results, using equilibrium and nonequilibrium turbulence models (based on mixing-length and renormalization group theory), are compared with experimental data. The results suggest that nonequilibrium effects should be included in the turbulence modeling, particularly for a nonequilibrium boundary-layer upstream of the interaction. Author

A90-38616*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFECTS OF STREAMWISE VORTICITY INJECTION ON TURBULENT MIXING LAYER DEVELOPMENT
JAMES H. BELL (NASA, Ames Research Center, Moffett Field, CA) and RABINDRA D. MEHTA (Stanford University, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(Contract NCC2-55)
(AIAA PAPER 90-1459) Copyright

This paper investigates the effect of injected strong streamwise vorticity on the structure and development of a plane mixing layer originating from tripped boundary layers. The experiments were conducted in a mixing layer wind tunnel consisting of two separate legs which were driven individually by centrifugal blowers. It was found that, while the vorticity injection increased the growth rate in the near-field, the asymptotic growth rate was reduced by a factor of about two, together with the peak Reynolds stress levels. The result is attributed to the effect of the relatively strong and short wavelength streamwise vorticity in making the spanwise structures more three-dimensional and slowing down their pairing process, thus reducing entrainment, and hence growth. I.S.

A90-38617#
INTERACTION OF A PLANE SHEAR LAYER WITH A DOWNSTREAM FLAT PLATE
PARVIZ MERATI (Western Michigan University, Kalamazoo, MI) and RONALD J. ADRIAN (Illinois, University, Urbana) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. refs
(AIAA PAPER 90-1460) Copyright

The interaction of a plane shear layer with a thin flat plate located downstream in the nonlinear region of the shear layer was investigated in experiments performed in a two-stream plane shear layer wind tunnel, in which the two streams were formed by dividing a single stream with a splitter plate and reducing the speed of the lower stream with fabric which created a pressure drop. It was found that, for different angles of attack of the plate, the mixing layer was deflected toward the slower stream by the high-pressure field of the stagnation region generated by the impingement of the faster stream on the plate. It was also found that the plate dampened the turbulent fluctuations of the shear layer structures. I.S.

A90-38618*# Princeton Univ., NJ.
WALL PRESSURE FLUCTUATIONS IN THE REATTACHMENT REGION OF A SUPERSONIC FREE SHEAR LAYER
ZHEN-HUA SHEN, DOUGLAS R. SMITH, and ALEXANDER J. SMITH (Princeton University, NJ) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 15 p. refs
(Contract NAG1-1072)
(AIAA PAPER 90-1461) Copyright

Results are presented of a study designed to examine the unsteady shock wave interaction formed in the reattachment zone of a separated supersonic flow in which the separation occurred in the absence of a separation shock. Wall pressure fluctuation measurements were conducted in the Princeton University 203 mm-203 mm high-Reynolds number blowdown supersonic wind tunnel at a freestream Mach number of 2.92 and a unit Re number of 6.7 x 10 to the 7th/m. Reattachment accurred on a 20-deg ramp. It was found that, contrary to previous observations of such flow, the reattachment region was highly unsteady and the pressure fluctuations were significant. The overall behavior of the wall pressure loading was similar in scale and magnitude to the unsteadiness of the wall pressure field in compression ramp flows at the same Mach number. I.S.

A90-38619#
NUMERICAL SIMULATION OF CONFINED, SPATIALLY-DEVELOPING MIXING LAYERS - COMPARISON TO THE TEMPORAL SHEAR LAYER
LINDA A. SIGALLA, D. SCOTT EBERHARDT, JEFFREY A. GREENOUGH, JAMES J. RILEY (Washington, University, Seattle), and MOELJO SOETRISNO (Amtec Engineering, Inc., Bellevue, WA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. Research supported by Johns Hopkins University. refs
(Contract N00014-87-K-0174)
(AIAA PAPER 90-1462)

The spatially developing shear layer is investigated using both linear stability theory and numerical simulations. Temporal and spatial linear stability solutions are compared and it is found that the temporal and spatial wavenumbers are equal, the temporal frequency is a function of the spatial frequency, and the temporal and spatial growth rates have a one to one correspondence. Numerical simulations of the Euler equations are performed for the spatially developing shear layer using a linear stability forcing function. Spatially developing simulations of the supersonic/supersonic and supersonic/subsonic acoustic instabilities, and the Kelvin-Helmholtz instability are compared to temporally developing simulations, and found to be in agreement. Author

A90-38621#
STUDY OF COMPRESSIBILITY EFFECTS IN MIXING LAYER BY NUMERICAL SIMULATION
ITARU HATAUE (Tokyo, University, Japan) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 10 p. refs
(AIAA PAPER 90-1464)

Results are presented of an investigation of the compressibility effect in the mixing layer between two parallel high-speed streams of increasing Mach numbers, using numerical simulation. The two- and three-dimensional compressible Navier-Stokes equations were solved using the Harten (1984)-type second-order TVD scheme and the LU-ADI efficient emplicit scheme of Obayashi and Kuwahara (1984). For the two-dimensional incompressible case (for Mach number 0.588), the results clearly show a large-scale coherent structure. The three-dimensional results show the spanwise unsteady fluctuation of the vorticity fields. It is shown that the compressible mixing layer has a large-scale vortical structure and that the growth rate decreases with increasing Mach number. I.S.

A90-38624#
FLOW OVER INCLINED FINITE LENGTH AND WIDTH FLAT PLATES AT LOW AND HIGH REYNOLDS NUMBERS
E. HYTOPOULOS, C. G. RODRIGUEZ, J. A. SCHETZ, and D. T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 15 p. Research supported by the U.S. Navy. refs
(AIAA PAPER 90-1467)

This paper analyzes the laminar incompressible flow over inclined square flat plates for low and high Reynolds numbers, using two numerical methods, the FEM for the low-Re flows and the vortex lattice method (VLM) for high-Re flows. Details are presented for three angles of attack (3, 8, and 15 deg) for a flat plate of aspect ratio 0.5. The full Navier-Stokes equations are solved using a weak Galerkin formulation for the FEM, with the pressure determined by a penalty approach. Results are presented in terms of pressure and normal force coefficients, velocity field predictions, and skin friction. A comparison between the predicted two-dimensional and three-dimensional results shows the influence of the finite width on the flow field. The predictions of FEM and VLM for pressure coefficient and vortex patterns show good agreement. I.S.

A90-38625*# North Carolina State Univ., Raleigh.
AN ABBREVIATED REYNOLDS STRESS TURBULENCE MODEL FOR AIRFOIL FLOWS
R. L. GAFFNEY, JR., H. A. HASSAN (North Carolina State University, Raleigh), and M. D. SALAS (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 10 p. Research supported by USAF and U.S. Navy. refs
(Contract NCC1-22; NAGW-1022; NAGW-1331)
(AIAA PAPER 90-1468)

An abbreviated Reynolds stress turbulence model is presented for solving turbulent flow over airfoils. The model consists of two partial differential equations, one for the Reynolds shear stress and the other for the turbulent kinetic energy. The normal stresses and the dissipation rate of turbulent kinetic energy are computed from algebraic relationships having the correct asymptotic near wall behavior. This allows the model to be integrated all the way to the wall without the use of wall functions. Results for a flat plate at zero angle of attack, a NACA 0012 airfoil and a RAE 2822 airfoil are presented. Author

A90-38626*# Iowa State Univ. of Science and Technology, Ames.
NUMERICAL PREDICTION OF TURBULENT FLOW OVER AIRFOIL SECTIONS WITH A NEW NONEQUILIBRIUM TURBULENCE MODEL
S. AHMED and J. C. TANNEHILL (Iowa State University of Science and Technology, Ames) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 15 p. Research supported by the U.S. Navy. refs
(Contract NAG1-645)
(AIAA PAPER 90-1469)

A new nonequilibrium turbulence closure model has been developed for computing wall bounded two-dimensional turbulent flows. This two-layer eddy viscosity model was motivated by the success of the Johnson-King model in separated flow regions. The influence of history effects are described by an ordinary differential equation developed from the turbulent kinetic energy equation. The performance of the present model has been evaluated by solving the flow around three airfoils using the Reynolds time-averaged Navier-Stokes equations. Excellent results were obtained for both attached and separated turbulent flows about the NACA 0012 airfoil, the RAE 2822 airfoil, and the Integrated Technology A 153W airfoil. Based on the comparison of the numerical solutions with the available experimental data, it is concluded that the new nonequilibrium turbulence model accurately captures the history effects of convection and diffusion on turbulence. Author

A90-38627#
NEWTON SOLUTION OF COUPLED VISCOUS/INVISCID MULTIELEMENT AIRFOIL FLOWS
MARK DRELA (MIT, Cambridge, MA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. Research supported by MIT. refs
(AIAA PAPER 90-1470)

A coupled viscous/inviscid method for calculating multielement airfoil flows is presented. The method is an extension of the computational techniques used in established single element airfoil codes. A streamline-based Euler discretization and a two-equation integral boundary layer formulation are coupled through the displacement thickness and solved simultaneously by a full Newton method. The boundary-layer formulation is extended to a multi-deck form suitable for asymmetric wakes and confluent shear layers. Only the asymmetric wake treatment is currently implemented, and performs well when evaluated with experimental data from a wind tunnel rig. Preliminary results are also presented given for a four-element high-lift airfoil configuration. Excellent predictions are obtained for the pressure distributions and the profile drag. Maximum lift is overpredicted, indicating the need for implementation of the layer confluence model. Author

A90-38628#
FLOW FIELD STUDIES BEHIND A WING AT LOW REYNOLDS NUMBERS
ALLEN E. WINKELMANN (Maryland, University, College Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 19 p. refs
(AIAA PAPER 90-1471) Copyright

Flow visualization and flow field survey studies were conducted on a low aspect ratio plane rectangular wing at low Reynolds numbers. Surface oil flow techniques were used to explore the details of the previously observed mushroom stall cell which occurs on the wing just beyond stall. A hot-wire probe was used to explore the flow field produced by the wing at ultra low Reynolds numbers. The vortex shedding phenomena detected by the hot-wire probe was also observed in smoke flow tests. Author

A90-38629#
PARAMETER EFFECTS ON OSCILLATORY AEROFOIL IN TRANSONIC FLOWS
M. J. SHEU (National Tsing Hua University, Hsinchu, Republic of China) and C. P. CHEN AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 8 p. refs
(AIAA PAPER 90-1473) Copyright

A numerical procedure based on the field integral equation method is developed to calculate the two-dimensional full potential equation for an oscillatory NACA 0012 aerofoil in pitching motion. The numerical solutions of unsteady pressure, lift, pitching moment, and shock location are presented in order to study the significant effects of the parameters, i.e., pitch axis of oscillation, reduced frequency, and amplitude of oscillation on the aerodynamic properties. Author

A90-38637#
THE K-KL TURBULENCE MODEL AND WALL LAYER MODEL FOR COMPRESSIBLE FLOWS
BRIAN R. SMITH (General Dynamics Corp., Fort Worth Div., TX) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. refs
(AIAA PAPER 90-1483) Copyright

The k-kl two equation turbulence model and wall function are presented. The model is derived from a Reynolds stress closure model and modified for compressible flows. A simple function is added which allows the model to be applied in the viscous sublayer. A wall layer model which allows the first computational grid point to be located in the logarithmic region of a turbulent boundary layer is derived from the k-kl turbulence model. The model is implemented in a compressible Navier-Stokes solver. The model is shown to be accurate in applications to transonic, supersonic and hypersonic turbulent flows with shock boundary layer interactions and separation. Both fine grid solutions with the first grid point in the viscous sublayer and coarse grid solutions with the first grid point located in the logarithmic region are compared for each test case. These comparisons show that the wall layer model is consistent with the k-kl model. Author

A90-38639#
VERSATILITY OF AN ALGEBRAIC BACKFLOW TURBULENCE MODEL
S. V. RAMAKRISHNAN and U. C. GOLDBERG (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. refs
(AIAA PAPER 90-1485) Copyright

The versatility of Goldberg's backflow model is demonstrated by comparing computed heat transfer, skin friction, surface pressure distributions and other relevant physical quantities with available experimental results. The flow regimes considered here range from very low subsonic to hypersonic. Results for both internal and external flows are presented. The backflow model is shown to perform equally well in conjunction with three different turbulence models, namely, zero-, one- and two-equation models. This model does not require any user controlled, problem dependent parameters, rendering it a predictive tool. Author

A90-38659#
EXPERIMENTAL INVESTIGATION OF GDL DIFFUSERS
M. G. KTALKHERMAN, V. M. MAL'KOV, and N. A. RUBAN (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 8 p. refs
(AIAA PAPER 90-1512) Copyright

The slowing-down of a supersonic flow in the rectangular channels was investigated. For generalization of the experimental pseudoshock lengths the equivalent diameter - empirical characteristic parameter - was suggested. The dependence of dimensionless pseudoshock length on the running flow Mach number was obtained. The optimal length for different type rectangular diffusers was chosen on this basis. The influence of the inner diffuser geometry and the different way of flow reducing in the throat were investigated. The diffuser performances of different types and lengths were generalized with the help of the offered equivalent diameter. Author

A90-38660#
LIQUID CRYSTAL COATINGS FOR SURFACE SHEAR STRESS VISUALIZATION IN HYPERSONIC FLOWS
D. C. REDA and D. P. AESCHLIMAN (Sandia National Laboratories, Albuquerque, NM) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 7 p. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 90-1513) Copyright
The capabilities of shear-stress-sensitive/temperature-insensitive liquid crystal coatings in hypersonic flows were investigated. Liquid crystal coatings were applied to the surface of a conical modedl exposed to a high-unit-Reynolds-number(2.3 x 10 to the seventh/m) Mach 5 flow. Observation results of the dynamic location of the transition front as a function of model angle of attack were found to be consistent with the published data. It is concluded that, due to the formulation of new compounds and to their sufficiently rapid time response (less or equal to 0.0025 sec), the liquid-crystal-coating technique is a viable diagnostic tool for the use in transient/compressible flow environments. N.B.

A90-38666#
A PRIMITIVE VARIABLE, STRONGLY IMPLICIT CALCULATION PROCEDURE FOR VISCOUS FLOWS AT ALL SPEEDS
K.-H. CHEN and R. H. PLETCHER (Iowa State University of Science and Technology, Ames) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. Research supported by the Iowa State University of Science and Technology. refs
(Contract AF-AFOSR-89-0403)
(AIAA PAPER 90-1521) Copyright

A coupled solution procedure is described for solving the compressible form of the time-dependent, two-dimensional Navier-Stokes equations in body-fitted curviliner coordinates. This approach employs the strong conservative form of the governing equations but uses primitive variables rather than the more traditional conservative variables as unknowns. A coupled modified strongly implicit procedure is used to efficiently solve the Newton-linearized algebraic equations. It appears that this procedure is effective for Mach numbers ranging from the incompressible limit to supersonic. Author

A90-38670#
A LOCALLY IMPLICIT SCHEME FOR 3-D COMPRESSIBLE VISCOUS FLOWS
K. C. REDDY (Tennessee, University, Tullahoma) and J. A. BENEK (Calspan Corp., Arnold Engineering Development Center, Arnold AFB, TN) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers

Conference, 21st, Seattle, WA, June 18-20, 1990. 18 p. refs
(AIAA PAPER 90-1525)

This paper describes a locally implicit method (LIM) for solving three-dimensional compressible Navier-Stokes equations in complex flow domains. The method is based on a point relaxation scheme applied to the nonlinear equations which result from discretization of the flow equations. It does not require linearization of the equations and is completely matrix-free. LIM has the unconditional stability associated with implicit schemes, while retaining the simplicity of the explicit schemes. Complex flow problems are solved by incorporating LIM into the Chimera domain decomposition procedure. Stability, accuracy, and convergence studies are presented and the scheme with computations of a shock/boundary-layer interaction and supersonic flow over a hemisphere-cylinder at an angle of attack is demonstrated. Author

A90-38673#
STABILITY LIMITS FOR THREE-DIMENSIONAL SUPERSONIC BOUNDARY LAYERS
HELEN L. REED, TIMOTHY S. HAYNES, and PONNAMPALAM BALAKUMAR (Arizona State University, Tempe) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. Research supported by McDonnell Douglas Corp. refs
(Contract F49620-88-C-0076)
(AIAA PAPER 90-1528) Copyright

A rotating cone is used as a model of a swept wing in supersonic flow. Linear stability calculations show that the amplification rate of the first mode is increased by a factor of 2 to 4 due to the presence of the crossflow. The most unstable crossflow instability has a nonzero frequency. The second mode in a three-dimensional boundary layer is found to be oblique whereas the second mode in a two-dimensional boundary layer is two-dimensional. The correlation of transition location (N = 9) with various non-dimensional parameters describing the crossflow profile is discussed. Author

A90-38678#
INTERACTIVE AIRFOIL CALCULATIONS WITH HIGHER-ORDER VISCOUS-FLOW EQUATIONS
D. W. ZINGG and G. W. JOHNSTON (Toronto, University, Downsview, Canada) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 17 p. refs
(AIAA PAPER 90-1533) Copyright

A critical examination of the use of higher-order viscous-flow equations in the computation of airfoil flowfields with a viscid-inviscid interaction scheme is presented. Comparisons are made between experimental data and solutions obtained using the boundary-layer equations, the second-order boundary-layer equations, and the Navier-Stokes equations, with corresponding approximations to the viscid-inviscid matching conditions, for flows about symmetric and aftloaded airfoils. Detailed comparisons of computed and experimental results show that normal pressure gradients can be significant in the shear layers near the airfoil trailing edge and that the boundary-layer equations underestimate the boundary-layer growth in this region. The higher-order terms in the viscous-flow equations do not affect the lift and moment predictions but lead to significantly higher predictions of drag. R.E.P.

A90-38679#
A FLOW AROUND AIRFOIL WITH SLAT AND FLAP
YOSHIAKI NAKAMURA, MICHIRU YASUHARA (Nagoya University, Japan), and WEI JIA AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. refs
(AIAA PAPER 90-1535) Copyright

Flows about an airfoil with a slat and a flap are investigated experimentally and numerically to examine the flow pattern and make clear the flow mechanism to produce a high lift. Along with the aerodynamic coefficients, velocity distributions are measured, and the flow fields are visualized experimentally. A numerical procedure is applied to calculate the present flow problem which gives the calculated results to be compared with the experiment. A detailed comparison between experiment and calculation is then made in this study. R.E.P.

A90-38680#
UNSTEADY AERODYNAMIC LOADING PRODUCED BY A SINUSOIDALLY OSCILLATING DELTA WING
STEPHEN A. HUYER, MICHAEL C. ROBINSON, and MARVIN W. LUTTGES (Colorado, University, Boulder) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(Contract F49620-84-C-0065)
(AIAA PAPER 90-1536) Copyright

A range of reduced frequencies, mean angles of attack and pitch axis locations due to the unsteady aerodynamic loading produced by an oscillating delta wing were examined. A three degree of freedom force balance recorded normal and tangential force data. These data were then reduced to provide unsteady normal, tangential, lift, and drag force coefficient data. The resultant aerodynamic loads were found to be highly transient in nature and lift enhancement up to twice that of steady state values were achieved for some cases. The delta wing also experienced lift reduction during portions of the cycle. From these results, it appears that the unsteady motion influences the strength and shedding of the leading edge delta wing vortex. R.E.P.

A90-38681#
NUMERICAL PREDICTION OF TRANSONIC VISCOUS FLOWS AROUND AIRFOILS THROUGH AN EULER/BOUNDARY LAYER INTERACTION METHOD
D. COIRO, M. AMATO, and P. DE MATTEIS (Centro Italiano Ricerche Aerospaziali, Capua, Italy) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(AIAA PAPER 90-1537) Copyright

A semi-inverse viscous/inviscid coupling technique for the calculation of compressible flows is presented. Euler equations in integral form are solved for the inviscid part and integral compressible boundary layer equations in direct and inverse form are solved for the viscous one. Interaction is realized using the equivalent sources approach. The technique has been applied to the calculation of the aerodynamic characteristics of airfoils both in cruise and take-off or landing configurations. In order to treat the complex geometries involved in the latter case a multi-block approach has been employed for the solution of Euler equations. Author

A90-38682#
UNSTEADY NAVIER-STOKES SOLUTIONS FOR A LOW ASPECT RATIO DELTA WING
RAYMOND E. GORDNIER and MIGUEL R. VISBAL (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(AIAA PAPER 90-1538)

A numerical investigation of the flow field about a 76 deg leading edge sweep delta wing at 20.5 deg angle of attack is presented. The computational results are obtained using a Beam-Warming algorithm with a Newton-like subiteration procedure. For freestream Mach number of 0.2 and Re = 900,000 an unsteady flow field is obtained which is shown to be physical in nature. The unsteady behavior is a result of the existence of small scale vortical structures that are associated with a Kelvin-Helmholtz type instability of the shear layer emanating from the leading edge of the delta wing. The computed results show qualitative agreement with other experimental and numerical findings. Author

A90-38683#
DIRECT SIMULATION OF LOW-DENSITY FLOW OVER AIRFOILS
TSZE C. TAI (U.S. Navy, David T. Taylor Naval Ship Research

and Development Center, Bethesda, MD) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 8 p. Research supported by the U.S. Navy. refs
(AIAA PAPER 90-1539)

The transition region, low-density aerodynamics about airfoils is considered using a direct simulation Monte Carlo method. Numerical results are presented for two airfoils (the NACA 00009 and a 9-percent-thick, circular-arc airfoil) traveling at Mach 4 and 5, at an angle of attack of 1.25 degrees and altitudes 56 and 62 miles above sea level. The flow, having a Knudsen number range between 0.47 to 1.15 and a Reynolds number range between 15 and 114, departs considerably from the continuum theory. Results indicate that both lift and drag are very much penalized in the transition region. In contrast with the previous work on slightly rarefied flow with smaller Knudsen numbers (slip flow regime), the effect of rarefaction becomes much more dominant than that due to viscosity. Author

A90-38684*# Flow Analysis, Inc., Tullahoma, TN.
THE FREE-WAKE COMPUTATION OF ROTOR-BODY FLOWS
K. RAMACHANDRAN, J. STEINHOFF (Flow Analysis, Inc., Tullahoma, TN), and F. X. CARADONNA (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(AIAA PAPER 90-1540) Copyright

In this paper a method is described for predicting the compressible, free-wake, flow about a lifting rotor-body configuration. The method is an extension of a unique vorticity embedded full-potential method used to calculate free-wake rotor hover performance. An unusual feature of this method is that it obviates the requirement for multiple grids to treat the rotor-body problem. The approach used to treat the body is similar to that used to include the rotor wake in the full potential calculation. The body is modeled as a structured circulation sheet and the strength of this sheet is determined in an iterative manner. Initially the method is tested to compute the flow past simple isolated bodies like cylinders and spheres. After a comparison of these simple computations with exact solutions this procedure is included into the HELIX-I, free-wake rotor code, to compute the flow around a rotor mounted on a large whirl tower. The effects of the tower on rotor wake geometry and load distribution are presented.
Author

A90-38686#
CALCULATION OF TWO- AND THREE-DIMENSIONAL FLOW IN A TRANSONIC TURBINE CASCADE WITH PARTICULAR REGARD TO THE LOSSES
H. ZIMMERMANN (DLR, Goettingen, Federal Republic of Germany) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 14 p. refs
(AIAA PAPER 90-1542) Copyright

A computer code has been applied to inviscid and viscous flows through a linear turbine cascade operating in the transonic flow regime. The Euler and Navier-Stokes equations are solved by an explicit finite volume time-stepping procedure based on the method of Jameson et al. (1981) for the intetration of the Euler equations and extended to Navier-Stokes equations by Schwamborn (1988). The inviscid and viscous results in two dimensions represent the profile characteristics at midspan position and the three-dimensional, viscous results include sidewall effects. A particular consideration of the flow losses gives a detailed information about secondary flow behavior. The computational results are compared to experimental data for the MTU-T5.1 profile at isentropic outflow Mach numbers of 0.7, 0.9 and 1.1. Author

A90-38687#
INLET RADIAL TEMPERATURE REDISTRIBUTION IN A TRANSONIC TURBINE STAGE
ANDRE P. SAXER and MICHAEL B. GILES (MIT, Cambridge, MA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 13 p. Research supported by Rolls-Royce, PLC. refs
(AIAA PAPER 90-1543) Copyright

This paper presents calculations of a steady stator/rotor interaction in a highly loaded transonic first turbine stage. Of particular interest is the generation of three-dimensional secondary flow in the rotor due to a spanwise non-uniform total temperature variation at the stator inlet. This leads to segregation of hot and cold gas that would significantly affect the heat transfer in the boundary-layer. A key feature of the paper is the use of quasi-three-dimensional non-reflecting boundary conditions that avoids non-physical reflections at the inlet, the outlet, as well as at stator/rotor interfaces. When compared to the standard one-dimensional boundary condition formulation they are shown to be very effective in a turbomachinery environment. Author

A90-38688#
CALCULATION OF UNSTEADY ROTOR/STATOR INTERACTION
C. L. CHEN and S. R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. refs
(AIAA PAPER 90-1544) Copyright

Numerical simulations of unsteady multi-airfoil rotor/stator interactions are examined using the Unified Solution Algorithms (USA) code. The numerical results compare well with experimental data. The capability of the USA code to perform time-accurate calculations with moving grids is shown. Quasi-steady and unsteady solutions are discussed. The quasi-steady solution is shown to be a very good approximation for the first row of blades when the upstream and unsteady effects are small. Consequently, it could be a good initial solution for both supersonic and subsonic rotor/stator interactions. The time-periodicity is also discussed for multi-blade rotor/stator interactions. A pseudo-time marching approach is explored for a time periodic flow. For unsteady flow that involves multiple time scales, the time step limitation for resolving physical scales should be carefully considered. Author

A90-38703#
A GRID GENERATION METHOD FOR AN AFT-FUSELAGE MOUNTED CAPPED-NACELLE/PYLON CONFIGURATION WITH AN ACTUATOR DISK
KIN C. YU and LEE T. CHEN (Douglas Aircraft Co., Long Beach, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 8 p.
(AIAA PAPER 90-1564) Copyright

A hybrid conformal-mapping/transfinite-interpolation grid generation method has been developed to generate three-dimensional body conforming grids about an aft-fuselage mounted capped-nacelle/pylon combination. The C-type mesh generated about the nacelle, pylon, and aft portion of the fuselage offers high grid density at the leading edge of the pylon and the nose of the nacelle. The grid topology is designed to facilitate the implementation of the multigrid scheme in the flow solver, and allows study of upstream boundary effect on flowfields. The same method is also capable of generating C-type mesh about a pylon/nacelle combination with a plane of symmetry for fuselage interference study. Author

A90-38704#
A COMPARISON OF ADAPTIVE-GRID REDISTRIBUTION AND EMBEDDING FOR STEADY TRANSONIC FLOWS
JOHN F. DANNENHOFFER, III (United Technologies Research Center, East Hartford, CT) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 10 p. refs
(AIAA PAPER 90-1565) Copyright

In recent years, numerical analysts have increasingly turned to adaptive grid techniques to efficiently obtain highly-accurate solutions to partial-differential equations. This paper presents a comparison of two distinct grid adaptation approaches, grid-point redistribution and grid-embedding, applied to two-dimensional, steady, inviscid, shocked flows. Grid redistribution is accomplished

through a control function approach applied to the elliptic grid-generator while the embedding approach consists of a fixed global grid and an automatically-chosen number of irregularly-shaped, embedded regions. For both techniques, the Euler flow equations are integrated to steady-state using Ni's Lax-Wendroff-type integrator to predict the flow fields about a variety of isolated airfoil configurations. The application of a common integration scheme as well as a common adaptive control function leads to a direct comparison of the effectiveness of the two adaptation approaches for the types of problems tested. Author

A90-38717#
SUPERSONIC FLOW OVER AN AXISYMMETRIC BACKWARD-FACING STEP
ERIC LOTH, K. KAILASANATH, and RAINALD LOHNER (U.S. Navy, Naval Research Laboratory, Washington, DC) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. refs
(AIAA PAPER 90-1580)

Numerical simulations of supersonic flows over an axisymmetric backward-facing step have been completed using a recently developed axisymmetric version of the Finite Element Method - Flux Corrected Transport algorithm (FEM-FCT). This code also includes adaptive unstructured gridding to resolve flow feature detail and a conservative non-linear scheme to capture compressible flowfield features. Comparisons have been made with available experimental data of flow visualization, base pressure ratio, downstream wall pressure distribution, flow reattachment length for a range of Mach numbers and step height to step radius ratios. In general, good agreement between predictions and measurements was found for pressure values along the backstep and the downstream wall, downstream reattachment lengths, and basic flow features. Effects of axisymmetry were noted in flowfield characteristics such as increased base pressure, curvature of expansion fans, stronger recompression shocks, and higher Mach number levels in the subsonic recirculating region. Author

A90-38718*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL STUDY FOR PASSIVE CONTROL OF SUPERSONIC ASYMMETRIC VORTICAL FLOWS AROUND CONES
C. H. LIU (NASA, Langley Research Center, Hampton, VA), OSAMA A. KANDIL (Old Dominion University, Norfolk, VA), and TIN-CHEE WONG AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(Contract NAS1-18584)
(AIAA PAPER 90-1581)

The unsteady, compressible, double and single thin-layer Navier-Stokes equations are used to numerically study for the passive control of steady and unsteady, supersonic asymmetric flows around circular and noncircular cones. The main computational scheme of the present study is the implicit upwind, flux-difference splitting, finite-volume scheme. Passive control of flow asymmetry is studied by using a vertical fin in the leeward plane of geometric symmetry and side strakes with and without thickness at different orientations. The study is focused on circular-section cones since they are the most potential section-shapes for strong flow asymmetry. Side-strakes passive control has been shown to be more efficient and practical than the vertical-fin passive control. Author

A90-38720*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ENTHALPY DAMPING FOR HIGH MACH NUMBER EULER SOLUTIONS
ANUTOSH MOITRA (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 8 p.
(AIAA PAPER 90-1585) Copyright

An improvement on the enthalpy damping procedure currently in use in solving supersonic flow fields is described. A correction based on entropy values is shown to produce a very efficient scheme for simulation of high Mach number three-dimensional flows. Substantial improvements in convergence rates have been achieved by incorporating this enthalpy damping scheme in a finite-volume Runge-Kutta method for solving the Euler equations. Results obtained for blended wing-body geometries at very high Mach numbers are presented. Author

A90-38721#
AN INTERACTIVE SCHEME FOR TRANSONIC WING/BODY FLOWS BASED ON EULER AND INVERSE BOUNDARY-LAYER EQUATIONS
L. T. CHEN and M. N. BUI (Douglas Aircraft Co., Long Beach, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(AIAA PAPER 90-1586) Copyright

A viscous/inviscid interactive scheme based on Euler and inverse boundary-layer equations has been developed for computing transonic flows over wings and wing/bodies. The Euler method has been modified to use three types of grid systems of different topologies, and incorporated with an inverse boundary layer (IBL) methods by means of a surface blowing approach. Solutions have been obtained for various wing and wing/body configurations and are compared with test data and full-potential/IBL solutions. Author

A90-38723*# McDonnell-Douglas Helicopter Co., Mesa, AZ.
EULER SOLUTIONS FOR SELF-GENERATED ROTOR BLADE-VORTEX INTERACTIONS
A. A. HASSAN (McDonnell Douglas Helicopter Co., Mesa, AZ), C. TUNG (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 16 p. Research supported by McDonnell Douglas Helicopter Co. refs
(AIAA PAPER 90-1588) Copyright

A finite-difference procedure was developed, on the basis of the conservation form of the unsteady three-dimensional Euler equations, for the prediction of rotor blade-vortex interactions (BVIs). Numerical solution procedures were obtained for the analysis of the model parallel BVIs and the more realistic helicopter self-generated-rotor BVIs. It was found that, for self-generated subcritical interactions, the accuracy of the predicted leading edge pressures relied heavily on the user-specified vortex core radius and on the CAMRAD-code-predicted geometry of the interaction vortex elements and their relative orientation with respect to the blade. It was also found that the free-wake model used in CAMRAD to predict the tip vortex trajectory for use in the Euler solution yields lower streamwise and higher axial wake convective velocities than those inferred from the experimental data. I.S.

A90-38727*# High Technology Corp., Hampton, VA.
ADVANCED MACH 3.5 AXISYMMETRIC QUIET NOZZLE
FANG-JENQ CHEN, MUJEEB R. MALIK (High Technology Corp., Hampton, VA), and IVAN E. BECKWITH (NASA, Langley Research Center; George Washington University, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(Contract NAS1-18240)
(AIAA PAPER 90-1592) Copyright

To advance boundary-layer stability and transition research and to ultimately provide reliable predictions of transition for supersonic flight vehicles, a wind tunnel is required with very low stream disturbance levels comparable to free flight conditions. Experimental and theoretical research to develop a low-disturbance supersonic wind tunnel has achieved a breakthrough. A new concept for nozzle design is presented which promises a large increase in the length of the quiet test core. The Advanced Mach 3.5 Axisymmetric Quiet Nozzle is the first prototype built to prove the new design concept. Experimental results from this new nozzle on the extent of laminar wall boundary layers are compared with data from other nozzles and with theoretical predictions based on

linear stability theory. The Reynolds numbers based on the measured length of the quiet test core for this new nozzle are in excellent agreement with the theoretical predictions. The effect of surface finish on the nozzle performance is also discussed. Author

A90-38729*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC AIRCRAFT DRAG REDUCTION
D. M. BUSHNELL (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 25 p. refs
(AIAA PAPER 90-1596) Copyright

This paper reviews aerodynamic drag reduction for friction, wave and vortex drag associated with supersonic cruise aircraft and suggests approaches and research directions. Suction laminar flow control may also enable improved low-speed, high-lift systems, improved lift-to-drag ratio for subsonic cruise, reduced parasitic viscous drag for favorable interference wave drag reduction approaches, and turbulent skin friction reduction via slot injection. Flow separation control at cruise proffers opportunities for increased leading-edge thrust, increased lift increment from upper surface, increased fuselage lift/camber for wave drag-due-to-lift reduction, improved performance of various favorable interference wave drag reduction schemes, as well as possibly better low-speed, high-lift systems and wing cruise performance. Author

A90-38731#
FLOW AND ACOUSTIC FEATURES OF A SUPERSONIC TAPERED NOZZLE
E. GUTMARK, H. L. BOWMAN, and K. C. SCHADOW (U.S. Navy, Naval Weapons Center, China Lake, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 10 p. refs
(AIAA PAPER 90-1599)

The acoustic and flow characteristics of a supersonic tapered jet were measured for free and shrouded flow configurations. The supersonic tapered jet is issued from a converging-diverging nozzle with a 3:1 rectangular slotted throat and a conical diverging section leading to a circular exit. The jet was compared to circular and rectangular supersonic jets operating at identical conditions. The distinct feature of the jet is the absence of screech tones in the entire range of operation. The free jet's spreading rate is nearly constant and similar to the rectangular jet. Author

A90-38732#
WIDE ANGLE DIFFUSERS WITH PASSIVE BOUNDARY-LAYER CONTROL
S. RAGHUNATHANA, S. T. MCILWAIN (Belfast, Queen's University, Northern Ireland), and D. G. MABEY (Royal Aerospace Establishment, Bedford, England) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. Research supported by the Department of Education of Northern Ireland and Queen's University. refs
(AIAA PAPER 90-1600) Copyright

Experiments were made on a two-dimensional low speed diffuser with passive control. The passive control consisted of porous surfaces made of holes/slots connected by a breather passage. Passive control postpones the stall and reduces buffet levels in the diffuser. This test confirms that passive controls for flow separation are not restricted to transonic speeds. Author

A90-38734*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TWO AND THREE DIMENSIONAL GRID GENERATION BY AN ALGEBRAIC HOMOTOPY PROCEDURE
ANUTOSH MOITRA (NASA, Langley Research Center; High Technology Corp., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. refs
(AIAA PAPER 90-1603) Copyright

An algebraic method for generating two- and three-dimensional grid systems for aerospace vehicles is presented. The method is based on algebraic procedures derived from homotopic relations for blending between inner and outer boundaries of any given configuration. Stable properties of homotopic maps have been exploited to provide near-orthogonality and specified constant spacing at the inner boundary. The method has been successfully applied to analytically generated blended wing-body configurations as well as discretely defined geometries such as the High-Speed Civil Transport Aircraft. Grid examples representative of the capabilities of the method are presented. Author

A90-38736#
AN ALGEBRAIC ADAPTIVE-GRID TECHNIQUE FOR THE SOLUTION OF NAVIER-STOKES EQUATIONS
WILLIAM C. CONNETT, ALAN L. SCHWARTZ (Missouri, University, Saint Louis), RAMESH K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO), and JOYCE A. WHEELER (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. Research supported by the McDonnell Douglas Independent Research and Development Program and University of Missouri. refs
(AIAA PAPER 90-1605) Copyright

The algebraic adaptive grid-generation scheme is extended to produce adaptive grids about complex geometries with large curvature. The straightforward application of the original algorithm to an initial grid around a nonconvex body (for example, an airfoil or a blunt body) caused some of the grid points to move inside the body when the initial grid was adapted to the flow. This difficulty has been overcome in the present paper by defining adaption as a two-step process; first, an adaption to the geometry of the configuration, and second, adaption to the requirements of the flow. Excellent grids and flow solutions have been obtained for transonic viscous flow about airfoils and launch vehicles. Author

A90-38737#
A GENERAL DECOMPOSITION ALGORITHM APPLIED TO MULTI-ELEMENT AIRFOIL GRIDS
MARK E. M. STEWART (Princeton University, NJ) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. Research supported by NSERC. refs
(AIAA PAPER 90-1606) Copyright

Multiblock grids are generated and used to solve the Euler equations for multiple element airfoil sections. The grids are generated using a novel algorithm which automates several stages in the decomposition of arbitrary, two-dimensional domains into non-overlapping, topologically rectangular regions. Because the grids are constructed so that coordinate lines are continuous across block interfaces, local accuracy estimates may be found analytically, and they indicate local second-order accuracy. The results show that multiblock grids are an effective approach to generating grids in complex two-dimensional geometries and demonstrate steps toward full automation of the domain decomposition process. Author

A90-38751#
EXPERIMENTAL INVESTIGATION OF COANNULAR JET FLOW WITH SWIRL ALONG A CENTERBODY
M. O. FREY and F. B. GESSNER (Washington, University, Seattle) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. refs
(Contract AF-AFOSR-85-0273)
(AIAA PAPER 90-1622) Copyright

An experimental study was conducted in order to investigate the nature of incompressible coannular jet flow with swirl along an unconfined centerbody. Swirl was imparted to the inner stream upstream of the nozzle exit, and the ratio of the outer-to-inner stream mass flow rate ratio was fixed at unity. The results indicate that the flow is dominated by coherent structures in the form of vortices which are shed periodically from the lips of the nozzle. These vortices cause large departures from local equilibrium to the extent that the sign of the turbulent shear stress does not always follow the sign of the local mean rate of strain. This behavior

causes the axial eddy viscosity component to vary widely throughout the flow and be negative in the inner region of the mixing layer. Vortex-induced turbulence amplification also causes turbulence kinetic energy levels to be elevated in regions of the flow where turbulence kinetic energy production rates have diminished. Analysis of the data shows that closure at the full Reynolds stress transport equation level is required if the main features of the flow are to be predicted with reasonable accuracy. Author

A90-38753*# High Technology Corp., Hampton, VA.
A COMPUTATIONAL STUDY OF THE TAXONOMY OF VORTEX BREAKDOWN
ROBERT E. SPALL (High Technology Corp., Hampton, VA) and THOMAS B. GATSKI (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. refs
(AIAA PAPER 90-1624) Copyright

The results of a fully three-dimensional numerical simulation of vortex breakdown using the unsteady, incompressible Navier-Stokes equations are presented. The solutions show that the freestream axial velocity distribution has a significant effect on the position and type of vortex breakdown. Common features between bubble-type and spiral-type breakdown are identified and the role of flow stagnation and the critical state are discussed as complimentary ideas describing the initiation of breakdown. Author

A90-38754*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE ORGANIZED NATURE OF A TURBULENT TRAILING VORTEX
PROMODE R. BANDYOPADHYAY (NASA, Langley Research Center, Hampton, VA), ROBERT L. ASH (Old Dominion University, Norfolk, VA), and DANIEL J. STEAD AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. refs
(Contract NAS1-18599; NAG1-530)
(AIAA PAPER 90-1625) Copyright

The turbulence structure of a trailing vortex produced at the juncture of a flow aligned cylinder and a pair of oppositely loaded airfoils is analyzed. The freestream turbulence intensity in this study varies from 0.32 to 1.48 percent, the vortex Reynold number varies from 15000 to 25000, and the Rossby number varies from 0.65 to 0.81. Within this parameter range, it is shown that the screens, but not the freestream turbulence level, are able to produce significant variations in the turbulence structure of the vortex, and that the turbulent structure is determined by the Rossby number and not the vortex Reynolds number. It is noted that the core is dynamic and an organized exchange of momentum takes place between the outer flow and the core region of the vortex. The vortex structure in the trailing vortex having the lowest Rossby number is considered. V.T.

A90-38755*# Tennessee Univ., Tullahoma.
APPLICATION OF VORTEX EMBEDDING TO AIRCRAFT FLOWS
JOHN STEINHOFF, HEINRICH SENGE, and FRIEDHELM DECKER (Tennessee, University, Tullahoma) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 15 p. Research supported by the University of Tennesse and Rheinisch-Westfaelische Technische Hochschule. refs
(Contract NAG1-898)
(AIAA PAPER 90-1626) Copyright

A combined Eulerian/Lagrangian 'vortex embedding' method was applied to two cases. The first case involved compressible flow over a realistic fighter aircraft (X-29 fighter) at low angle of attack, for both subsonic and transonic speeds, with shock. Good agreement was obtained for computed wing surface pressures when compared to flight test data. The second case involved incompressible flow over a delta wing with round leading edges at moderate angles of attack. Strong, concentrated vortices were shown to be shed from the leading edge. The vortex embedding method appears to be an efficient solution procedure for cases where well-defined vortex sheets are shed from surfaces. N.B.

A90-38756*# Old Dominion Univ., Norfolk, VA.
A DEVICE FOR INTRODUCING HELICAL PERTURBATIONS INTO A TRAILING LINE VORTEX
ROBERT L. ASH (Old Dominion University, Norfolk, VA) and JOHN E. RIESTER, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 10 p. refs
(Contract NAS1-18599; NAG1-530)
(AIAA PAPER 90-1627) Copyright

A perturbation generator has been designed which can be attached to the centerbody of a matched airfoil type vortex generator. The device was desired to enable the introduction of helical-wave, velocity perturbations into a vortex core to permit experimental verification of theoretical vortex stability predictions. Evaluation of the perturbation generator performance, prior to vortex stability studies, has been reported here. Controlled perturbations with frequencies above 200 hz have been produced, but visual observations were insufficient to confirm their helical character. Hot wire velocity spectrum data have confirmed the device's ability to introduce controlled frequency fluctuations. In addition, other flow oscillations have been discussed which can influence the controllability of vortex perturbations. Author

A90-38757#
NAVIER-STOKES COMPUTATIONS OF VORTICAL FLOWS
G. B. DENG, J. PIQUET, and P. QUEUTEY (Ecole Nationale Superieure de Mecanique, Nantes, France) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(Contract DRET-86-104)
(AIAA PAPER 90-1628) Copyright

A generally fully elliptic numerical mehthod for the solution of the Reynolds-averaged Navier-Stokes equations was developed and applied to flows where significant vortical effects are present; i.e., the flow around a wing-body junction and a lifting flow past a prolate spheroid. It is found that, due to the increased grid resolution needed by the eviction of the wall function approach and the increased stiffness of the pressure matrix, LU-reconditioned conjugate gradient methods improve the convergence of the pressure solver by an order of magnitude over standard relaxation techniques. The results in respect to the modeling of flow characteristics are considered satisfactory if the grid problem was resolved; in respect to the numerical methodology, the accuracy of convection-diffusion scheme appears to present a problem due to the convergence difficulties and to the fact that the optimization of the location of grid points over the flow domain remains unsatisfactory. N.B.

A90-38759*# Washington Univ., Seattle.
A NUMERICAL STUDY OF LONGITUDINAL VORTEX INTERACTION WITH A BOUNDARY LAYER
D. A. RUSSELL (Washington, University, Seattle) and L. SANKARAN AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. Research supported by the University of Washington. refs
(Contract NAG2-283)
(AIAA PAPER 90-1630) Copyright

A numerical study of vortex generator aerodynamics has been carried out with a reduced set of Navier-Stokes equations. These are used to model the physical process of longitudinal vortex interaction with a turbulent boundary layer on a flat plate in incompressible flow. Comparison with experimental data is used to validate the approach, and detailed predictions are made. Results show an increase in skin friction and a decrease in integral layer thicknesses where the flow is toward the wall, and the reverse where the flow is away from the wall. The major controlling parameters of vortex strength, spacing and height are each found to have optimum values for which the efficiency of boundary-layer

thinning is maximized. Vortex core spreading and secondary vorticity produced in the layer are observed and studied, as well as circulation decay and other features of the flow. Author

A90-38762#
UNSTEADY LIFT DEVELOPMENT ON A CONSTANTLY ACCELERATED RECTANGULAR WING
R. STEVEN SAWYER and JOHN P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 10 p. refs
(AIAA PAPER 90-1633) Copyright

Lift response of a rectangular wing at a fixed angle of attack has been measured while undergoing constant acceleration from rest. When non-dimensionalized appropriately, results for different accelerations agree as expected. A von Karman and Sears analysis was modified to incorporate finite geometry and steady state, low Reynolds number performance of the wing. This prediction was much lower than the measured response. Under steady state conditions, lift data and flow visualization confirmed that at the test Reynolds numbers, the wing exhibited an upper surface laminar separation. However, flow visualization of the accelerating wing reveals that attached flow is maintained for substantial times before separation occurs. Further, a prediction of the wing response using the high Reynolds number wing performance matched the experimental results for low times before under-predicting the response at higher times. This latter effect was tentatively attributed to lift augmentation by vortical structures shed after separation, similar to that encountered in 'dynamic stall' tests. Author

A90-38772#
STRUCTURE OF SWEPT SHOCK WAVE/BOUNDARY-LAYER INTERACTIONS USING CONICAL SHADOWGRAPHY
F. S. ALVI and G. S. SETTLES (Pennsylvania State University, University Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. refs
(Contract AF-AFOSR-89-0315)
(AIAA PAPER 90-1644) Copyright

A flow-visualization study of swept shock wave/turbulent boundary layer interactions generated by sharp fins is presented. By taking advantage of the natural nearly-conical symmetry of these interactions, conical shadowgraphy has been used to image the structure of the flowfield with very high resolution. A parametric study over the Mach number range of 2.5 to 4 and with fin angles-of-attack up to 25 degrees reveals the evolution of the flowfield structure. Weak, unseparated flows at one end of the spectrum become strongly separated with increasing shock-wave strength. While primarily qualitative, this study has provided a number of new and valuable insights as well as specific conclusions into the behavior and structure of such flows. R.E.P.

A90-38773*# Texas Univ., Austin.
DYNAMICS OF THE OUTGOING TURBULENT BOUNDARY LAYER IN A MACH 5 UNSWEPT COMPRESSION RAMP INTERACTION
RICHARD A. GRAMANN and DAVID S. DOLLING (Texas, University, Austin) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 15 p. Research supported by the U.S. Army. refs
(Contract AF-AFOSR-86-0112; NAGW-964)
(AIAA PAPER 90-1645) Copyright

Wall pressure fluctuations have been measured under the unsteady separation shock and on the ramp face in an unswept Mach 5 compression ramp interaction. The freestream Reynolds number was 51.0 x 10 to the 6th/m, and the incoming turbulent boundary layer developed on the tunnel floor under approximately adiabatic wall temperature conditions. Standard data-acquisition methods, as well as real-time and posttest conditional sampling techniques were used. The results show that the mean and rms pressure levels are strong functions of separation shock position. At all stations on the ramp, from the corner to where the pressure reaches the theoretical inviscid value, the pressure signals have two dominant components: a low frequency component characteristic of the global unsteadiness, which correlates with the separation shock motion, and a higher frequency component associated with turbulence. The former is the major contributor to the overall signal variance. Author

A90-38774#
CORRELATION OF SEPARATION SHOCK MOTION IN A COMPRESSION RAMP INTERACTION WITH PRESSURE FLUCTUATIONS IN THE INCOMING BOUNDARY LAYER
M. E. ERENGIL and D. S. DOLLING (Texas, University, Austin) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 16 p. refs
(Contract AF-AFOSR-86-0112)
(AIAA PAPER 90-1646) Copyright

Simultaneous fluctuating wall pressure measurements have been made under the unsteady separation shock and incoming undisturbed turbulent boundary layer in a Mach 5 compression ramp interaction. The freestream unit Reynolds number was 49.6 x 10 to the 6th/m and the turbulent boundary layer developed on the tunnel floor under approximately adiabatic wall temperature conditions. Conditional sampling algorithms, a 'variable-window' ensemble averaging technique and the VITA technique have been used to examine the correlation between pressure fluctuations in the incoming flow and the separation shock wave motion. The results show some evidence of a correlation between pressure fluctuations in the incoming flow and large-scale downstream sweeps of the shock wave. No correlation is evident for large-scale upstream sweeps. In contrast, there is a distinct correlation between pressure fluctuations in the incoming flow and changes in the direction of the motion of the shock wave. Author

A90-38777*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THREE-DIMENSIONAL FLUX-SPLIT EULER SCHEMES INVOLVING UNSTRUCTURED DYNAMIC MESHES
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 8 p. refs
(AIAA PAPER 90-1649) Copyright

Improved algorithms for the solution of the three-dimensional time-dependent Euler equations are presented for aerodynamic analysis involving unstructured dynamic meshes. The improvements have been developed recently to the spatial and temporal discretizations used by unstructured grid flow solvers. The spatial discretization involves a flux-split approach which is naturally dissipative and captures shock waves sharply with at most one grid point within the shock structure. The temporal discretization involves either an explicit time-integration scheme using a multi-stage Runge-Kutta procedure or an implicit time-integration scheme using a Gauss-Seidel relaxation procedure which is computationally efficient for either steady or unsteady flow problems. With the implicit Gauss-Seidel procedure, very large time steps may be used for rapid convergence to steady state, and the step size for unsteady cases may be selected for temporal accuracy rather than for numerical stability. Steady flow results are presented for both the NACA 0012 airfoil and the ONERA M6 wing to demonstrate applications of the new Euler solvers. The paper presents a description of the Euler solvers along with results and comparisons which assess the capability. Author

A90-38778*# Purdue Univ., West Lafayette, IN.
TEMPORAL-ADAPTIVE EULER/NAVIER-STOKES ALGORITHM FOR UNSTEADY AERODYNAMIC ANALYSIS OF AIRFOILS USING UNSTRUCTURED DYNAMIC MESHES
WILLIAM L. KLEB, MARC H. WILLIAMS (Purdue University, West Lafayette, IN), and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. refs
(Contract NAG1-372)
(AIAA PAPER 90-1650)

A temporal adaptive algorithm for the time-integration of the

two-dimensional Euler or Navier-Stokes equations is presented. The flow solver involves an upwind flux-split spatial discretization for the convective terms and central differencing for the shear-stress and heat flux terms on an unstructured mesh of triangles. The temporal adaptive algorithm is a time-accurate integration procedure which allows flows with high spatial and temporal gradients to be computed efficiently by advancing each grid cell near its maximum allowable time step. Results indicate that an appreciable computational savings can be achieved for both inviscid and viscous unsteady airfoil problems using unstructured meshes without degrading spatial or temporal accuracy. Author

A90-38780#
A THREE-DIMENSIONAL FINITE ELEMENT NAVIER-STOKES SOLVER WITH K-EPSILON TURBULENCE MODEL FOR UNSTRUCTURED GRIDS
D. L. MARCUM and R. K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 16 p. refs
(AIAA PAPER 90-1652) Copyright

A three-dimensional finite element Navier-Stokes solver has been developed for calculating transonic viscous flow on unstructured grids about complex aerodynamic configurations. The solver employs a second-order-accurate space discretization of the Navier-Stokes equations obtained from a Galerkin weighted-residual approximation. Time discretization is obtained using either an explicit two-step Lax-Wendroff scheme, or an explicit multistep Runge-Kutta scheme. The overall solution procedure has been initially validated by calculating two- and three-dimensional inviscid and viscous transonic flows. Author

A90-38782#
FORMATION OF SHOCKS WITHIN AXISYMMETRIC NOZZLES
ERIC LOTH, JOSEPH D. BAUM, and RAINALD LOHNER (U.S. Navy, Naval Research Laboratory, Washington, DC) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 8 p. refs
(AIAA PAPER 90-1655)

Numerical simulations of axisymmetric supersonic internal and external nozzle flow were completed using an axisymmetric version of the FEM/flux-corrected-transport (FCT) algorithm. Shock formation predicted by the adaptive unstructured gridding and the conservative nonlinear FCT scheme appears to agree with experimental data. Shocks for two given nozzle configurations were observed to form just downstream from the throat due to overexpansion. Axisymmetric effects resulted in increased strength of shocks as they approached the center line, as well as curvature of compression and expansion waves. An additional shock near the exit plane, caused by the interaction of the strong cross-stream pressure gradient and the overexpansion near the corner, was predicted for the second nozzle configuration. Measured and predicted radial pressure distributions supporting the presence of this shock are in good agreement. N.B.

A90-38784*# Ohio State Univ., Columbus.
A COMPUTATIONAL STUDY OF THE IMPINGEMENT REGION OF AN UNSTEADY SUBSONIC JET
ZAKARIA A. JALAMANI, SHOICHIRO NAKAMURA (Ohio State University, Columbus), and WILLIAM R. VAN DALSEM (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 20 p. refs
(Contract NCA2-298)
(AIAA PAPER 90-1657)

Vertical/Short Take-Off and Landing (V/STOL) aircraft may encounter operating difficulties while hovering near the ground. Lift loss, hot gas and debris ingestion, and landing surface damage are some of the potential problems which can result from the interaction of the propulsive jets with the airframe and ground. The purpose of the present work is to develop a detailed understanding of a flowfield, a jet exiting from a flat plate impacting a ground plane, that contains much of the essential physics of the complex flows encountered by V/STOL aircraft in hover. To achieve this, a high-resolution time-accurate numerical simulation of the impinging jet flow was performed. The numerical simulation is based on the solution of the laminar compressible Navier-Stokes equations using the Beam-Warming algorithm. Complex start-up and periodic jet and jet-induced vortex structures were captured, including the formation of primary and secondary jet-induced vortices and wall-jet separation. The formation and development of these phenomena are supported by experimental measurements and smoke visualization. Results are compared with appropriate experiments. Author

N90-21726# National Aerospace Lab., Tokyo (Japan).
NUMERICAL SIMULATION OF HYPERSONIC FLOW AROUND A SPACE PLANE. PART 2: APPLICATION TO HIGH ANGLES OF ATTACK FLOW
YUKIMITSU YAMAMOTO Feb. 1989 22 p
(NAL-TR-1011T; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

A flux-split upwind TVD (Total Variation Diminishing) scheme was applied to the hypersonic flow around a space plane proposed by the National Aerospace Laboratory (NAL). Thin-layer Navier-Stokes equations in a finite volume formulation are solved by the National Aerospace Laboratory (NAL). Thin-layer Navier-Stokes equations in a finite volume formulation are solved Mach number of 7.0 and Reynolds number of 4.4 x 10(exp 6) at angles of attack up to 50 degrees. Numerical results are compared with experimental data obtained from the hypersonic wind tunnel tests at NAL. Through these comparisons, it is demonstrated that the present TVD Navier-Stokes code has excellent capabilities for evaluating total aerodynamic performance and investigating aerodynamic heating, and which are of great significance in the design of a space plane configuration. Author

N90-21727*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SWEPT WING ICE ACCRETION MODELING
MARK G. POTAPCZUK and COLIN S. BIDWELL 1990 26 p
Presented at the 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990; sponsored by AIAA
(NASA-TM-103114; E-5238; NAS 1.15:103114; AIAA-90-0756)
Avail: NTIS HC A03/MF A01 CSCL 01A

An effort to develop a three-dimensional modeling method was initiated. This first step towards creation of a complete aircraft icing simulation code builds on previously developed methods for calculating three-dimensional flow fields and particle trajectories combined with a two-dimensional ice accretion calculation along coordinate locations corresponding to streamlines. This work is a demonstration of the types of calculations necessary to predict a three-dimensional ice accretion. Results of calculations using the 3-D method for a MS-317 swept wing geometry are projected onto a 2-D plane normal to the wing leading edge and compared to 2-D results for the same geometry. It is anticipated that many modifications will be made to this approach, however, this effort will lay the groundwork for future modeling efforts. Results indicate that the flow field over the surface and the particle trajectories differed for the two calculations. This led to lower collection efficiencies, convective heat transfer coefficients, freezing fractions, and ultimately ice accumulation for the 3-D calculation. Author

N90-21731 Georgia Inst. of Tech., Atlanta.
DEVELOPMENT AND APPLICATION OF A GENERALIZED DYNAMIC WAKE THEORY FOR LIFTING ROTORS Ph.D. Thesis
CHENGJIAN HE 1989 214 p
Avail: Univ. Microfilms Order No. DA9005480

Rotorcraft aeroelasticity and aeromechanics analysis requires a consistent mathematical model that has an appropriate combination of structural dynamics and unsteady aerodynamics. To provide rotorcraft dynamists with an efficient unsteady wake model, an intermediate level unsteady induced-flow theory suitable for rotorcraft aeroelastic stability, vibration control, and aeroelastic tailoring studies is being developed. The unsteady wake theory is

developed for lifting rotors based on an acceleration potential for an actuator disk. The induced inflow at the rotor disk is expressed in terms of a Fourier series azimuthally and a polynomial distribution radially. A system of first-order, ordinary differential equations in the time domain, formulated from first principles, describes the flow. The pressure at the rotor disk is discretized at each motor blade to allow for the effect of finite number of blades. This formulation is well fitted to rotor aeroelastic analysis. The research has resulted in closed-form, analytical expressions for the induced-flow influence coefficients, one of the most critical parts in the development of the theory in forward flight. Encouragingly, the results show an overall good correlation with recent measurement data, both time-averaged and time-dependent, with the Army's Langley facility. The theory correctly predicts such essential characteristics as fore-to-aft induced-flow gradient, dissymmetric side-to-side induced-flow distribution in forward flight, and saw-tooth, triangular wave form of unsteady inflow associated with the passage of rotor blades. The theory also reveals the significant distance between the time-averaged induced flow at points fixed in space and instantaneous induced flow in the blade-fixed rotating system. Dissert. Abstr.

N90-21732 Virginia Polytechnic Inst. and State Univ., Blacksburg.

EFFECTIVE METHODS OF CONTROLLING A JUNCTION VORTEX SYSTEM IN AN INCOMPRESSIBLE, THREE-DIMENSIONAL, TURBULENT FLOW Ph.D. Thesis

JAIWON SHIN 1989 685 p

Avail: Univ. Microfilms Order No. DA9003609

An experimental investigation was conducted to find effective methods of controlling a junction vortex system around and in the wake of a NACA 0020 body with a 1.5:1 elliptical nose mounted normal to the flat surface. Control of the junction vortex system was investigated using more slender noses and leading edge fillets. The study includes surface flow visualizations, and extensive mean flow measurements. The mean flow measurements consist of velocity, total pressure, and static pressure distributions. The results of the mean flow measurements around and in the wake of a NACA 0020 body with a 1.5:1 elliptical nose show the presence of a large, dominant vortex, or a primary horseshoe vortex, in the junction between the body and the flat surface. A smaller, co-rotating vortex relative to the primary horseshoe vortex was observed at the 100 percent chord position, which is believed to be identified with the corner separation at the junction near the trailing edge. Mean flow measurements of the flow field around and in the wake of a NACA 0020 body with more slender noses were acquired. The results indicate that the more slender nose generated a weaker primary horseshoe vortex. The results also suggest that the weak primary horseshoe vortex developed by the more slender nose was dissipated alongside the body to the point where it had a very small effect on the flow field at the 100 percent chord position. The results of the mean flow measurements around and in the wake of a NACA 0020 body with a 1.5:1 elliptical nose with leading edge fillets indicate that the leading edge fillets were very effective in reducing the strength and size of the primary horseshoe vortex. The vorticity identified with the corner separation vortex was observed in the wake for both leading edge shape changes and fillets. The results show that the corner separation vortex dominates the flow in the wake due to the weak effects of the primary horseshoe vortex. Dissert. Abstr.

N90-21733*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CONTROL OF FLOW SEPARATION AND MIXING BY AERODYNAMIC EXCITATION

EDWARD J. RICE and JOHN M. ABBOTT 1990 13 p Proposed for presentation at the 17th Congress of the International Council of the Aeronautical Sciences, Stockholm, Sweden, 9-14 Sep. 1990; sponsored by AIAA

(NASA-TM-103131; E-5462; NAS 1.15:103131) Avail: NTIS HC A03/MF A01 CSCL 01A

The recent research in the control of shear flows using unsteady aerodynamic excitation conducted at the NASA Lewis Research Center is reviewed. The program is of a fundamental nature, concentrating on the physics of the unsteady aerodynamic processes. This field of research is a fairly new development with great promise in the areas of enhanced mixing and flow separation control. Enhanced mixing research includes influence of core turbulence, forced pairing of coherent structures, and saturation of mixing enhancement. Separation flow control studies included are for a two-dimensional diffuser, conical diffusers, and single airfoils. Ultimate applications include aircraft engine inlet flow control at high angle of attack, wide angle diffusers, highly loaded airfoils as in turbomachinery, and ejector/suppressor nozzles for the supersonic transport. An argument involving the Coanda Effect is made that all of the above mentioned application areas really only involve forms of shear layer mixing enhancement. The program also includes the development of practical excitation devices which might be used in aircraft applications. Author

N90-21734*# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.

PREDICTION OF FORCES AND MOMENTS FOR FLIGHT VEHICLE CONTROL EFFECTORS. PART 1: VALIDATION OF METHODS FOR PREDICTING HYPERSONIC VEHICLE CONTROLS FORCES AND MOMENTS Final Report

MARK D. MAUGHMER, L. OZOROSKI, T. OZOROSKI, and D. STRAUSSFOGEL May 1990 140 p

(Contract NAG1-849)

(NASA-CR-186571; NAS 1.26:186571) Avail: NTIS HC A07/MF A01 CSCL 01A

Many types of hypersonic aircraft configurations are currently being studied for feasibility of future development. Since the control of the hypersonic configurations throughout the speed range has a major impact on acceptable designs, it must be considered in the conceptual design stage. The ability of the aerodynamic analysis methods contained in an industry standard conceptual design system, APAS II, to estimate the forces and moments generated through control surface deflections from low subsonic to high hypersonic speeds is considered. Predicted control forces and moments generated by various control effectors are compared with previously published wind tunnel and flight test data for three configurations: the North American X-15, the Space Shuttle Orbiter, and a hypersonic research airplane concept. Qualitative summaries of the results are given for each longitudinal force and moment and each control derivative in the various speed ranges. Results show that all predictions of longitudinal stability and control derivatives are acceptable for use at the conceptual design stage. Results for most lateral/directional control derivatives are acceptable for conceptual design purposes; however, predictions at supersonic Mach numbers for the change in yawing moment due to aileron deflection and the change in rolling moment due to rudder deflection are found to be unacceptable. Including shielding effects in the analysis is shown to have little effect on lift and pitching moment predictions while improving drag predictions. Author

N90-21735*# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.

PREDICTION OF FORCES AND MOMENTS FOR FLIGHT VEHICLE CONTROL EFFECTORS. PART 2: AN ANALYSIS OF DELTA WING AERODYNAMIC CONTROL EFFECTIVENESS IN GROUND EFFECT Final Report

MARK D. MAUGHMER, L. OZOROSKI, T. OZOROSKI, and D. STRAUSSFOGEL May 1990 116 p

(Contract NAG1-849)

(NASA-CR-186572; NAS 1.26:186572) Avail: NTIS HC A06/MF A01 CSCL 01A

Many types of hypersonic aircraft configurations are currently being studied for feasibility of future development. Since the control of the hypersonic configurations throughout the speed range has a major impact on acceptable designs, it must be considered in the conceptual design stage. Here, an investigation of the aerodynamic control effectiveness of highly swept delta planforms operating in ground effect is presented. A vortex-lattice computer program incorporating a free wake is developed as a tool to

calculate aerodynamic stability and control derivatives. Data generated using this program are compared to experimental data and to data from other vortex-lattice programs. Results show that an elevon deflection produces greater increments in C sub L and C sub M in ground effect than the same deflection produces out of ground effect and that the free wake is indeed necessary for good predictions near the ground. Author

N90-21736*# Eloret Corp., Sunnyvale, CA.
MODELING OF VORTEX-INDUCED OSCILLATIONS BASED ON INDICIAL RESPONSE APPROACH Final Technical Report, 1 May 1989 - 30 Apr. 1990
KHIEM VAN TRUONG 15 May 1990 32 p
(Contract NCC2-634)
(NASA-CR-186560; NAS 1.26:186560) Avail: NTIS HC A03/MF A01 CSCL 01A

The indicial response approach, a modeling approach originally used for studying nonlinear problems in flight dynamics is applied to the study of vortex-induced oscillations phenomena. The indicial response of the velocity field is derived for the problem studied with emphasis on physical postulates involved. A full account of fluid dynamics effects is taken by considering the incompressible Navier-Stokes equations. The theory is applied to the particular case of flow past a cylinder in periodically forced motion to derive some salient features. The indicial response approach is shown to be equivalent to a currently popular approach based on the use of the amplitude equation. Jump and hysteresis phenomena that experiments indicate occur within the lock-in regime (where the velocity field oscillates at the forcing frequency) are captured by the approach. Author

N90-21737# Sandia National Labs., Albuquerque, NM.
SLOTTED-WALL RESEARCH WITH DISK AND PARACHUTE MODELS IN A LOW-SPEED WIND TUNNEL
J. M. MACHA, R. J. BUFFINGTON, J. F. HENFLING, D. VANEVERY, and J. L. HARRIS (DSMA International, Inc., Mississauga, Ontario) 1990 20 p Presented at the 16th AIAA Aerodynamic Ground Testng Conference, Seattle, WA, 18-20 Jun. 1990
(Contract DE-AC04-76DP-00789)
(DE90-002989; SAND-89-2666C; CONF-900672-1) Avail: NTIS HC A03/MF A01

An experimental investigation of slotted-wall blockage interference was conducted using disk and parachute models in a low speed wind tunnel. Test section open area ratio, model geometric blockage ratio, and model location along the length of the test section were systematically varied. Resulting drag coefficients were compared to each other and to interference-free measurements obtained in a much larger wind tunnel where the geometric blockage ratio was less than 0.0025. DOE

N90-21738*# Johnson Aeronautics, Palo Alto, CA.
AIRLOADS, WAKES, AND AEROELASTICITY
WAYNE JOHNSON Apr. 1990 54 p Presented at AGARD Special Course on Aerodynamics of Rotorcraft, Brussels, Belgium, 2-5 Apr. 1990; Ankara, Turkey, 9-11 Apr. 1990; and Moffett Field, CA, 14-17 May 1990 Sponsored by Army Aviation Systems Command, Saint Louis, MO
(Contract NAS2-11555)
(NASA-CR-177551; A-90165; NAS 1.26:177551; USAAVSCOM-TM-90-A-005) Avail: NTIS HC A04/MF A01 CSCL 01A

Fundamental considerations regarding the theory of modeling of rotary wing airloads, wakes, and aeroelasticity are presented. The topics covered are: airloads and wakes, including lifting-line theory, wake models and nonuniform inflow, free wake geometry, and blade-vortex interaction; aerodynamic and wake models for aeroelasticity, including two-dimensional unsteady aerodynamics and dynamic inflow; and airloads and structural dynamics, including comprehensive airload prediction programs. Results of calculations and correlations are presented. Author

N90-21739*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EXTENSION OF A STREAMWISE UPWIND ALGORITHM TO A MOVING GRID SYSTEM
SHIGERU OBAYASHI (MCAT Inst., San Jose, CA.), PETER M. GOORJIAN, and GURU P. GURUSWAMY Apr. 1990 22 p
(NASA-TM-102800; A-90101; NAS 1.15:102800) Avail: NTIS HC A03/MF A01 CSCL 01A

A new streamwise upwind algorithm was derived to compute unsteady flow fields with the use of a moving-grid system. The temporally nonconservative LU-ADI (lower-upper-factored, alternating-direction-implicit) method was applied for time marching computations. A comparison of the temporally nonconservative method with a time-conservative implicit upwind method indicates that the solutions are insensitive to the conservative properties of the implicit solvers when practical time steps are used. Using this new method, computations were made for an oscillating wing at a transonic Mach number. The computed results confirm that the present upwind scheme captures the shock motion better than the central-difference scheme based on the beam-warming algorithm. The new upwind option of the code allows larger time-steps and thus is more efficient, even though it requires slightly more computational time per time step than the central-difference option. Author

N90-21740# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
A COMPUTER PROGRAM FOR THE PREDICTION OF NOZZLE-PROPELLER PERFORMANCE
IVAN S. GIBSON Feb. 1989 60 p
(LR-578; ETN-90-96342) Avail: NTIS HC A04/MF A01

A programmers guide and users manual for a FORTRAN program called IDUK are presented. The program allows for the calculation of the hydrodynamic performance of single and multi-element nozzles with either fixed or controllable pitch marine propellers of known geometry. Each program input option is fully described. The corresponding computer output is presented and examined. A listing of the program and all subroutines is presented. ESA

N90-21741# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
THEORY AND NUMERICAL ANALYSIS OF SINGLE AND MULTI-ELEMENT NOZZLE PROPELLERS
IVAN S. GIBSON Feb. 1989 67 p
(LR-579; ETN-90-96343) Avail: NTIS HC A04/MF A01

Theoretical and numerical analysis methods developed to predict the operating performance of nozzle or ducted propellers in axisymmetric flow are described. Surface vorticity techniques are used to model the nozzle and hub. A lifting line theory for both three dimensional and finite blade effects is described. Radial variation of axial inflow velocity are accommodated for in the theory, to allow for systematic calculations of device performance in the wakefield behind a ship's after body. Recommendations for further study are presented. ESA

N90-21742# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
RECENT IMPROVEMENTS IN THE SCOPE AND ACCURACY OF THE PERFORMANCE PREDICTION OF NOZZLE PROPELLERS
IVAN S. GIBSON Jul. 1989 38 p
(LR-598; ETN-90-96353) Avail: NTIS HC A03/MF A01

Updated theoretical analysis developed to predict the operating performance of a nozzle or ducted propeller in axisymmetric flow is presented. Improvements in the calculation of the cavitation number at the propeller blade sections are described. Research results on which future development of the theoretical model might be built are discussed. The sequence that must be followed in order to achieve successful nozzle-propeller configuration design is outlined. A one-shot method which helps to avoid adverse boundary layer separation effects on the nozzle thrust is described. ESA

N90-21746*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYTICAL STUDY OF THE ORIGIN AND BEHAVIOR OF ASYMMETRIC VORTICES
MURRAY TOBAK, DAVID DEGANI (Technion - Israel Inst. of Tech., Haifa.), and GREGORY G. ZILLIAC Apr. 1990 19 p
(NASA-TM-102796; A-90089; NAS 1.15:102796) Avail: NTIS HC A03/MF A01 CSCL 01A

An hypothesis advanced originally to explain computational observations is supported by theoretical considerations: The asymmetric mean flow observed on bodies of revolution at moderate to high angles of attack is the result of a convective instability of an originally symmetric flow to a time-invariant space-fixed disturbance. Additionally, the time-dependent fluctuations characteristic of the flow at higher angles of attack (up to 90 deg) are the result of an absolute instability of an originally steady flow to a small temporal disturbance of finite duration. Within a common domain, the instability mechanisms may coexist. The experimentally confirmed existence of bistable states, wherein the side-force variation with nose roll angle approaches a square-wave distribution, is attributed to the dominant influence of a pair of trailing vortices from the ogival forebody. Their existence is made possible by the appearance of foci of separation in the skin-friction line pattern beyond a critical angle of attack. The extreme sensitivity of the asymmetric flow orientation to nose geometry, demonstrated experimentally, is attributed to the presence of an indeterminate phase in the family of possible solutions for the three-dimensional wave system. Author

N90-21985# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Military Aircraft Div.
GRID PATCHING APPROACHES FOR COMPLEX THREE-DIMENSIONAL CONFIGURATIONS
W. SCHWARZ, G. HARTMANN, and M. A. SCHMATZ *In* AGARD, Applications of Mesh Generation to Complex 3-D Configurations 14 p Mar. 1990
Copyright Avail: NTIS HC A14/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Three examples of different grid generation procedures are reported. The first one is based on a single-block approach but nevertheless it is able to handle very complex aircraft configurations and requires only a minimum of user input. This system was the base for the development of the following patched grid method. The next example shows the application of the patched grid technique for the zonal solution of Euler, boundary-layer and Navier-Stokes equations and demonstrates the ability of this method to achieve the necessary local grid refinement for viscous calculations. Finally an application of a patched grid method for an Euler code with a shock fitting approach for supersonic calculations is presented. The grid near the body surface is fixed while the grid in the outer region is moved so that it can be adapted to the location of the bow shock. Author

N90-22531*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DYNAMIC GROUND-EFFECT MEASUREMENTS ON THE F-15 STOL AND MANEUVER TECHNOLOGY DEMONSTRATOR (S/MTD) CONFIGURATION
GUY T. KEMMERLY Washington Jun. 1990 31 p
(NASA-TP-3000; L-16555; NAS 1.60:3000) Avail: NTIS HC A03/MF A01 CSCL 01/1

A moving-model ground-effect testing method was used to study the influence of rate-of-descent on the aerodynamic characteristics for the F-15 STOL and Maneuver Technology Demonstrator (S/MTD) configuration for both the approach and roll-out phases of landing. The approach phase was modeled for three rates of descent, and the results were compared to the predictions from the F-15 S/MTD simulation data base (prediction based on data obtained in a wind tunnel with zero rate of descent). This comparison showed significant differences due both to the rate of descent in the moving-model test and to the presence of the ground boundary layer in the wind tunnel test. Relative to the simulation data base predictions, the moving-model test showed substantially less lift increase in ground effect, less nose-down pitching moment, and less increase in drag. These differences became more prominent at the larger thrust vector angles. Over the small range of rates of descent tested using the moving-model technique, the effect of rate of descent on longitudinal aerodynamics was relatively constant. The results of this investigation indicate no safety-of-flight problems with the lower jets vectored up to 80 deg on approach. The results also indicate that this configuration could employ a nozzle concept using lower reverser vector angles up to 110 deg on approach if a no-flare approach procedure were adopted and if inlet reingestion does not pose a problem. Author

N90-22532*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
WATER-TUNNEL STUDY RESULTS OF A TF/A-18 AND F/A-18 CANOPY FLOW VISUALIZATION
STEVEN A. JOHNSON and DAVID F. FISHER Mar. 1990 29 p Original contains color illustrations
(NASA-TM-101705; H-1570; NAS 1.15:101705) Avail: NTIS HC A03/MF A01; 13 functional color pages CSCL 01/1

A water tunnel study examining the influence of canopy shape on canopy and leading edge extension flow patterns was initiated. The F/A-18 single-place canopy model and the TF/A-18 two place canopy model were the study subjects. Plan view and side view photographs showing the flow patterns created by injected colored dye are presented for 0 deg and 5 deg sideslip angles. Photographs taken at angle of attack and sideslip conditions correspond to test departure points found in flight test. Flight experience has shown that the TF/A-18 airplane departs in regions where the F/A-18 airplane is departure-resistant. The study results provide insight into the differences in flow patterns which may influence the resulting aerodynamics of the TF/A-18 and F/A-18 aircraft. It was found that at 0 deg sideslip, the TF/A-18 model has more downward flow on the sides of the canopy than the F/A-18 model. This could be indicative of flow from the leading edge extension (LEX) vortexes impinging on the sides of the wider TF/A-18 canopy. In addition, the TF/A-18 model has larger areas of asymmetric separated and unsteady flow on the LEXs and fuselage, possibly indicating a lateral and directional destabilizing effect at the conditions studied. Author

N90-22536 Purdue Univ., West Lafayette, IN.
FORCING FUNCTION EFFECTS ON ROTOR ROW UNSTEADY AERODYNAMIC RESPONSE IN A MULTISTAGE COMPRESSOR Ph.D. Thesis
STEVEN R. MANWARING 1989 282 p
Avail: Univ. Microfilms Order No. DA9008662

The fundamental flow physics of wake and distortion generated periodic rotor blade row unsteady aerodynamics were experimentally investigated. In particular, this was accomplished through a series of experiments performed in an extensively instrumented axial flow research compressor. The effects of aerodynamic forcing functions of different reduced frequency, interblade phase angle, waveform, and amplitude on rotor blade row periodic unsteady aerodynamic response while operating over a range of operating conditions in multistage subresonant and superresonant acoustic resonant environments were investigated. On the rotor blade low camber pressure surface, the unsteady pressure nondimensionalization compressed the magnitude data with mean flow incidence except in the accelerating flow field of the front chord region at negative mean flow incidence. However, for the high camber suction surface, gust interactions with the mean flow field affected the unsteady pressure response over the entire blade surface. The harmonic analysis of blade row unsteady aerodynamic response to complex waveform forcing functions was experimentally demonstrated. Subresonant and superresonant acoustic environments were established, with the magnitude data predictions correlation being very good in the subresonant flow regime and the correlation of these data in the superresonant flow regime only fair. In both acoustic environments, the correlation

of the phase data were poor, both in value and trend.
Dissert. Abstr.

N90-22538*# Scientific Research Associates, Inc., Glastonbury, CT.
EXTENSION OF A THREE-DIMENSIONAL VISCOUS WING FLOW ANALYSIS USER'S MANUAL: VISTA 3-D CODE
BERNARD C. WEINBERG, SHYI-YAUNG CHEN, STEPHEN J. THOREN, and STEPHEN J. SHAMROTH May 1990 106 p
(Contract NAS1-18140)
(NASA-CR-182024; NAS 1.26:182024; SRA-900049-UM) Avail: NTIS HC A06/MF A01 CSCL 01/1

Three-dimensional unsteady viscous effects can significantly influence the performance of fixed and rotary wing aircraft. These effects are important in both flows about helicopter rotors in forward flight and flows about three-dimensional (swept and tapered) supercritical wings. A computational procedure for calculating such flow field was developed. The procedure is based upon an alternating direction technique employing the Linearized Block Implicit method for solving three-dimensional viscous flow problems. In order to demonstrate the viability of this method, two- and three-dimensional problems are computed. These include the flow over a two-dimensional NACA 0012 airfoil under steady and oscillating conditions, and the steady, skewed, three-dimensional flow on a flat plate. Although actual three-dimensional flows over wings were not obtained, the ground work was laid for considering such flows. In this report a description of the computer code is given. Author

03

AIR TRANSPORTATION AND SAFETY

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

A90-35353
TESTS OF AUTOMATIC DEPENDENT SURVEILLANCE (ADS) IN WESTERN EUROPE - POSSIBLE FUTURE DEVELOPMENTS [EXPERIMENTATIONS DE LA SURVEILLANCE DEPENDANTE AUTOMATIQUE /ADS/ EN EUROPE OCCIDENTAL ET DEVELOPPEMENTS POSSIBLES DANS L'AVENIR]
M. E. COX (Eurocontrol, Brussels, Belgium), G. A. COOKE (Civil Aviation Authority, London, England), E. ESTEBAN (Direccion General de Aviacion Civil, Madrid, Spain), and E. MEYENBERG (Eurocontrol, Bretigny, France) (Royal Institute of Navigation, NAV 89 - Symposium on Satellite Navigation, London, England, Oct. 17-19, 1989) Navigation (Paris) (ISSN 0028-1530), vol. 38, April 1990, p. 228-245. In French.
Copyright

Air traffic service communication (ATSC) aspects of the ESA Prodat project are reviewed, summarizing the results of simulation and operational tests conducted by the UK CAA, Eurocontrol, and the Spanish DGAC. Prodat aims to improve land-mobile, maritime,and aeronautical communication by using a low-bit-rate satellite data link. The ATSC component comprises automatic data reporting (ADR), including automatic dependent surveillance (ADS), and ATC communication; ADR encompasses the acquisition of data via the data link from both aircraft avionics units and a ground data base. The tests involved both an experimental aircraft (the RAE BAC-111) and a commercial B747-200, and evaluated :(1) the operation of the ADR/ADS hardware (in polling, end-to-end, and request/response modes); (2) the availability and utilization of the data; and (3) and the performance of the ADS system in tactical ATSC. Also considered are the requirements for global ADS network and plans for further experiments. R.E.P.

A90-35758#
LOW-LEVEL WINDSHEAR ALERT SYSTEMS AND DOPPLER RADAR IN AIRCRAFT TERMINAL OPERATIONS
EDWIN KESSLER (Oklahoma, University, Norman) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 423-428. Previously cited in issue 09, p. 1289, Accession no. A89-25545. refs
Copyright

A90-35767*# National Oceanic and Atmospheric Administration, Norman, OK.
CLOUD-TO-GROUND STRIKES TO THE NASA F-106 AIRPLANE
VLADISLAV MAZUR (NOAA, National Severe Storms Laboratory, Norman, OK) and BRUCE D. FISHER (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 466-468. Previously cited in issue 07, p. 944, Accession no. A88-22288. refs
Copyright

A90-38535#
AV-8B SHIPBOARD SKI JUMP EVALUATION
T. C. LEA, III and A. L. NALLS (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 8 p.

Flight tests conducted aboard a ship designed with a 12-degree ski jump to the improve takeoff performance of Harrier-type aircraft are discussed. Test objectives were to define operating procedures and limitations and document performance gains over conventional flat-deck short takeoffs (STO). The following performance gains over flat-deck launches are noted: (1) required wind-over-deck (WOD) reduced by approximately 30 kt; (2) required deck run (ground roll) reduced by approximately 350 ft; and (3) up to 53 percent increase in takeoff payload capability. In addition, reduced pilot workload and improved safety are observed. It is noted that reduction in required deck run improves the Harrier/helicopter interoperability, allowing aircraft to use the forward half of the flight deck concurrently with helicopters using the aft portion, while reduction in WOD requirements means fuel savings and flight operations having less impact on ship's speed and heading. V.T.

N90-21747*# Rice Univ., Houston, TX. Aero-Astronautics Group.
OPTIMIZATION AND GUIDANCE OF FLIGHT TRAJECTORIES IN THE PRESENCE OF WINDSHEAR Final Report, 1984 - 1989
A. MIELE 1989 73 p Sponsored by Boeing Commercial Airplane Co. and Air Line Pilots Association
(Contract NAG1-516)
(NASA-CR-186163; NAS 1.26:186163; AAR-244) Avail: NTIS HC A04/MF A01 CSCL 01C

Research on the optimization and guidance of flight trajectories in the presence of windshear performed in the period 1984 to 1989 is discussed. The research concerns windshear recovery systems and covers two major areas of investigation: optimal trajectories for takeoff, abort landing, and penetration landing; and guidance schemes for takeoff, abort landing, and penetration landing. Author

N90-21748# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORT, UNITED AIRLINES FLIGHT 811, BOEING 747-122, N4713U, HONOLULU, HAWAII, FEBRUARY 24, 1989
16 Apr. 1990 75 p
(PB90-910401; NTSB/AAR-90/01) Avail: NTIS HC A04/MF A01 CSCL 01C

Factual information related to the sudden opening of an improperly latched cargo door in flight on United Airlines flight 811 near Honolulu, Hawaii, on 24 Feb. 1989 are presented. The safety issues discussed include the design and certification of the Boeing 747 cargo doors; the operation and maintenance of the cargo doors; portable emergency oxygen bottles; storage compartments over emergency exit doors; flight attendant communications during an emergency; life preservers; and aircraft

rescue and firefighting. Recommendations addressing these issues were made to the Federal Aviation Administration, the State of Hawaii, and the U.S. Department of Defense. Author

N90-22544 Civil Aviation Authority, London (England).
UK AIRMISSES INVOLVING COMMERCIAL AIR TRANSPORT, JANUARY - APRIL 1989
Dec. 1989 40 p
(ISSN-0951-6301; ETN-90-96445) Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, England

Copies of the completed airmiss reports involving commercial air transport aircraft in a four month period are presented. The purpose and the investigation of the airmiss reports are explained. The categorization of airmisses, relating to the degree of risk inherent in each report, is described. The number of incidents, the actual number of commercial air transport aircrafts involved and the airmisses related to flying hours, which took place Jan. to Apr. 1989 are given. ESA

N90-22545# Simula, Inc., Phoenix, AZ.
AIRCRAFT CRASH SURVIVAL DESIGN GUIDE. VOLUME 1: DESIGN CRITERIA AND CHECKLISTS Final Report, Sep. 1986 - Aug. 1989
RICHARD E. ZIMMERMAN and NORMAN A. MERRITT Dec. 1989 217 p Revised
(Contract DAAJ02-86-C-0028)
(AD-A218434; USAAVSCOM-TR-89-D-22A-VOL-1) Avail: NTIS HC A10/MF A02 CSCL 01/3

This five-volume publication was compiled to assist design engineers in understanding the design considerations associated with the development of crash-resistant U.S. Army aircraft. A collection of available information and data pertinent to aircraft crash resistance is presented, along with suggested design conditions and criteria. The five volumes of the Aircraft Crash Survival Design Guide cover the following topics: Design Criteria and Checklists; Aircraft Design Crash Impact Conditions and Human Tolerance; Aircraft Structural Crash Resistance; Aircraft Seats, Restraints, Litters and Cockpit/Cabin Delethalization; and Aircraft Postcrash Survival. This volume (Volume 1) contains concise criteria drawn from Volumes 2 through 5, supplemented by checklists intended to assist designers in implementing the criteria. GRA

N90-22546# Simula, Inc., Phoenix, AZ.
AIRCRAFT CRASH SURVIVAL DESIGN GUIDE. VOLUME 2: AIRCRAFT DESIGN CRASH IMPACT CONDITIONS AND HUMAN TOLERANCE Final Report, Sep. 1986 - Aug. 1989
J. W. COLTMAN, C. V. INGEN, N. B. JOHNSON, and RICHARD E. ZIMMERMAN Dec. 1989 132 p Revised
(Contract DAAJ02-86-C-0028)
(AD-A218435; USAAVSCOM-TR-89-D-22B-VOL-2) Avail: NTIS HC A07/MF A01 CSCL 01/3

This five-volume publication was compiled to assist design engineers in understanding the design considerations associated with the development of crash-resistant U.S. Army aircraft. A collection of available information and data pertinent to aircraft crash resistance is presented, along with suggested design conditions and criteria. The five volumes of the Aircraft Crash Survival Design guide cover the following topics: Design Criteria and Checklists; Aircraft Design Crash Impact Conditions and Human Tolerance; Aircraft Structural Crash Resistance; Aircraft Seats, Restraints, Litters and Cockpit/Cabin Delethalization; and Aircraft Postcrash Survival. This volume (Volume 2) contains information on the aircraft crash environment, human tolerance to impact, occupant motion during a crash, human anthropometry, and crash test dummies, all of which serves as background for the design information presented in the other volumes. GRA

N90-22547# Simula, Inc., Phoenix, AZ.
AIRCRAFT CRASH SURVIVAL DESIGN GUIDE. VOLUME 3: AIRCRAFT STRUCTURAL CRASH RESISTANCE Final Report, Sep. 1986 - Aug. 1989
RICHARD E. ZIMMERMAN, JAMES C. WARRICK, ALAN D. LANE, NORMAN A. MERRITT, and AKIF O. BOLUKBASI Dec. 1989 265 p Revised
(Contract DAAJ02-86-C-0028)
(AD-A218436; USAAVSCOM-TR-89-D-22C-VOL-3) Avail: NTIS HC A12/MF A02 CSCL 01/3

This five volume publication was compiled to assist design engineers in understanding the design considerations associated with the development of crash resistant U.S. Army aircraft. A collection of available information and data pertinent to aircraft crash resistance is presented, along with suggested design conditions and criteria. The five volumes of the Aircraft Crash Survival Design Guide cover the following topics: Design Criteria and Checklists; Aircraft Design Crash Impact Conditions and Human Tolerance; Aircraft Structural Crash Resistance; Aircraft Seats, Restraints, Litters and Cockpit/Cabin Delethalization; and Aircraft Postcrash Survival. This volume (Volume 3) contains information on the design of aircraft structures and structural elements for improved crash survivability. Current requirements for structural design of U.S. Army aircraft pertaining to crash resistance are discussed. Principles for crash-resistant design are presented in detail for the landing gear and fuselage subject to a range of crash conditions, including impacts that are primarily longitudinal, vertical or lateral in nature and those that involve more complicated dynamic conditions, such as rollover. Analytical methods for evaluating structural crash resistance are described. GRA

N90-22548# Simula, Inc., Phoenix, AZ.
AIRCRAFT CRASH SURVIVAL DESIGN GUIDE. VOLUME 4: AIRCRAFT SEATS, RESTRAINTS, LITTERS, AND COCKPIT/CABIN DELETHALIZATION Final Report, Sep. 1986 - Aug. 1989
S. P. DESJARDINS, RICHARD E. ZIMMERMAN, AKIF O. BOLUKBASI, and NORMAN A. MERRITT Dec. 1989 271 p Revised
(Contract DAAJ02-86-C-0028)
(AD-A218437; USAAVSCOM-TR-89-D-22D-VOL-4) Avail: NTIS HC A12/MF A02 CSCL 01/3

This five-volume publication was compiled to assist design engineers in understanding the design considerations associated with the development of crash-resistant U.S. Army aircraft. A collection of available information and data pertinent to aircraft crash resistance is presented, along with suggested design conditions and criteria. The five volumes of the Aircraft Crash Survival Design Guide cover the following topics: Design Criteria and Checklists; Aircraft Design Crash Impact Conditions and Human Tolerance; Aircraft Structural Crash Resistance; Aircraft Seats, Restraints, Litters and Cockpit/Cabin Delethalization; and Aircraft Postcrash Survival. This Volume (4) contains information on aircraft seats, litters, personnel restraint systems, and hazards on the occupant's immediate environment. Requirements for design of seats, litters, and restraints systems are discussed, as well as design principles for meeting these requirements and testing for verification that the systems perform as desired. Energy-absorbing devices for use in seats are described, as are various types of cushions. Delethalization of cockpit and cabin interiors is discussed, including the use of protective padding and the design of controls for prevention of injury. Finally, computerized methods of analysis for evaluation of seats, restraints, and the occupant's immediate environment are presented. GRA

N90-22549# Simula, Inc., Phoenix, AZ.
AIRCRAFT CRASH SURVIVAL DESIGN GUIDE. VOLUME 5: AIRCRAFT POSTCRASH SURVIVAL Final Report, Sep. 1986 - Aug. 1989
N. B. JOHNSON, S. H. ROBERTSON, and D. S. HALL Dec. 1989 219 p Revised
(Contract DAAJ02-86-C-0028)
(AD-A218438; USAAVSCOM-TR-89-D-22E-VOL-5) Avail: NTIS HC A10/MF A02 CSCL 01/3

This five-volume publication was compiled to assist design engineers in understanding the design considerations associated with the development of crash-resistant U.S. Army aircraft. A

collection of available information and data pertinent to aircraft crash resistance is presented, along with suggested design conditions and criteria. The five volumes of the Aircraft Crash Survival Design Guide cover the following topics: Design Criteria and Checklists; Aircraft Design Crash Impact Conditions and Human Tolerance; Aircraft Structural Crash Resistance; Aircraft Seats, Restraints, Litters and Cockpit/Cabin Delethalization; and Aircraft Postcrash Survival. This volume (Volume 5) contains information on the aircraft postcrash environment and design techniques that can be used to reduce postcrash hazards. Topics include the postcrash fire environment, crashworthy fuel systems, ignition source control, fire behavior of interior materials, ditching survival, emergency escape, and crash locator beacons. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A90-35351
ELECTRONIC CARTOGRAPHY - A NEW NEED FOR COMMERCIAL AIRCRAFT [CARTOGRAPHIE ELECTRONIQUE - UN BESOIN NOUVEAU POUR LES AVIONS DE LIGNE]
RENOUARD (Union de Transports Aeriens, Paris, France) Navigation (Paris) (ISSN 0028-1530), vol. 38, April 1990, p. 175-182. In French.
Copyright

The utilization of digital maps to further improve commercial airline operations, profitability, flight safety, and passenger interest is presented. Specifically, the onboard installation of digital displays can reduce aircraft operating gross weight by eliminating some 100 kg of documentation, implement an advanced ground collision avoidance system, and at the same time offer passengers a progressive in-flight path map. The need for such a system to conform with International Standard Organization norms is discussed. R.E.P.

A90-35684
MODE S - A DATA LINK FOR FUTURE AIR TRAFFIC CONTROL
M. C. STEVENS (Cossor Electronics, Ltd., ATC Systems Div., Harlow, England) and R. H. KAHANE (Thomson-CSF, Division Systemes Defense et Controle, Bagneux, France) ICAO Bulletin (ISSN 0018-8778), vol. 44, Dec. 1989, p. 9-12.
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Consideration is given to the performance and implementation of SSR Mode S. The features of Mode S are compared with those of SSR and monopulse SSR, emphasizing the benefits of Mode S. Tests performed at Mode S experimntal stations are reviewed and the installation of Mode S at several airports, including London Gatwick and Paris Orly. The manufacture of Mode S transponders for airlines in the UK and France and the comprehensive plan for implementing Mode S in Europe are discussed. Also, the use of the Mode S data link by the Airborne Collision Avoidance System is noted. R.B.

A90-35709
PASSIVE LOCATION AND TRACKING USING DOA AND TOA MEASUREMENTS OF SINGLE NONMANEUVERING OBSERVER
ZHONGKANG SUN and MING ZHANG (National University of Defense Technology, Changsha, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 3, Feb. 1990, p. 34-41.
Copyright

Passive location and tracking (PLAT) of a moving emitter can be implemented by multisited observers or by single maneuvering observer using DOA (direction of arrival) measurements only. The principle and method of passive location and tracking of a moving emitter by a single nonmaneuvering observer using DOA and TOA (time of arrival) measurements are described. Computer simulation of PLAT of a moving emitter in two-dimensional plane was implemented. It is shown that convergent and accurate tracking data can be obtained. Author

A90-36115
OPTIMIZATION OF COMPLEX DATA PROCESSING ALGORITHMS IN MULTICHANNEL RADIO DIRECTION FINDING [OPTIMIZATSIIA ALGORITMOV KOMPLEKSNOI OBRABOTKI INFORMATSII PRI MNOGOKANAL'NOM RADIOPELENGOVANII]
A. S. BOGACHEV and A. V. OCHNEV Radiotekhnika (ISSN 0033-8486), Jan. 1990, p. 8-12. In Russian. refs
Copyright

The Markov theory of optimal nonlinear continuous filtering is used together with the principle of data distribution to synthesize algorithms for the spatial-temporal processing of radio signals and output signals of measuring devices monitoring the aircraft motion parameters during multichannel radio direction finding. The algorithms obtained here can be used for solving a wide variety of practical problems in the synthesis of multichannel radio direction finding systems in the case of a priori indeterminacy of infomation process models. V.L.

A90-36916#
THE CASE FOR BOTH RAIM AND GIC WORKING TOGETHER - THE ULTIMATE SOLUTION TO THE GPS INTEGRITY PROBLEM
R. GROVER BROWN (Iowa State University of Science and Technology, Ames) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 53-55. Research supported by FAA.

It is demonstrated that Receiver Autonomous Integrity Monitoring (RAIM) and GPS Integrity Channel (GIC) can work together, each helping the other, with the resulting combination providing the ultimate solution to the GPS integrity problem. In order to accomplish this, it is necessary that ranging capability be designed into the GIC system. This method enhances RAIM availability, and RAIM can then help GIC by providing an independent integrity check. This, in turn, makes it feasible to introduce the GIC range corrections into the navigation solution without the penalty for mixing the navigation and integrity functions. The improved navigation solution should make it possible to do 100-m nonprecision approaches without an excessive alarm rate. V.T.

A90-36917#
ASHTECH XII - A NEW GPS TECHNOLOGY
JAVAD ASHJAEE and JAMES COLLINS (Ashtech, Inc., Sunnyvale, CA) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 113-115.

A new-generation GPS receiver designed to track the maximum number of Block I and Block II satellites that may be in view during a kinematic survey session is described. Among the issues discussed are a number of channels, portability, low power consumption, and size. All equipment needed to perform kinematic surveying (including batteries) can be carried by one person along the kinematic survey route, and logging of point occupation numbers is done automatically. Software required for the internal procedure is outlined, as well as post-processing software. Navigation ability and compatibility with other GPS receivers are covered. V.T.

A90-36918#
EQUIPMENT AND CAPABILITY TRENDS IN LORAN-C RNAV
WALTER N. DEAN (ARNAV Systems, Inc., Portland, OR) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 117-121.

The paper concentrates on the rapid development of microprocessors and EPROMs with large capacity employed in aircraft loran receivers. Emphasis is placed on database storage of information on 6173 airports plus 1284 VORs and 1902 NDBs, in addition to 8530 enroute waypoints, on a set of EPROMs which can be mounted on a 'credit card' updated every 26 days. The ability to manipulate such large databases enables new navigation receivers to present much information usually consigned to charts and manuals, and make it available to the pilot in a dynamic manner to enhance his ability to navigate safely. Among such information covered are location of the nearest airport, the minimum safe altitude, minimum enroute safe altitude, and the Terminal Control Area alert. Simulation of a typical flight employing a loran receiver is presented. V.T.

A90-36921#
DATABASE MANAGEMENT CONSIDERATIONS FOR IFR CERTIFIED EARTH-REFERENCED NAVIGATION SYSTEMS
DALE E. JOHNSON (II Morrow, Inc., Salem, OR) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 153-158.

Proper management of the high volume of data in a complete air navigation database for cockpit use being developed is considered, along with its operational issues. Database content is discussed, including runway surface and lighting, frequency data, and precise runway end coordinates. Special-use airspace boundaries and associated controlling agency frequencies for terminal control areas, airport radar service areas, terminal radar service areas, prohibited areas, restricted areas, warning areas, military operations areas, and alert areas should be available in the database for convenient use by pilots flying VFR. Database certification issues are covered, with emphasis on a list of minimum IFR navigation data items and on different levels of criticality. V.T.

A90-36922#
A SURVEILLANCE 360 DEG TELEVISION ORIENTATION AND RANGING SYSTEM AS AN AID TO COLLISION AVOIDANCE
SIDNEY FELDMAN (RD Services, Inc., Riverdale, NY) and GEORGE G. BARTON (Bismarc, Inc., Harkers Island, NC) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 161-167. refs

It is suggested that radar, assisted with a supplemental navigational aid with day and night imaging capability, such as provided by a 360-deg television imaging system, may help in reducing the number of sea and air collisions. A nonmechanical nonrotating 360-deg television imaging system coupled with standard TV and photographic cameras is described. The system consists of a first-surface reflective conical mirror with computer-programmed aspheric surfaces and it operates with conventional narrow-field-of-view cameras and objective lenses. The real-time 360-deg TV imaging display is processed electronically to produce display of azimuth and elevation data of all objects in the 360-deg scene assisting radar with additional close-up information for the optimum maneuver to avoid collision. V.T.

A90-36924#
MULTISENSOR INTEGRATED NAVIGATION SYSTEM
JOE N. PORTNEY and RAY W. BRESLAU (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 181-194.

The conceptual aspects of the Multisensor Integrated Navigation System (MINS) are presented, and a specific application to which the MINS concept has been successfully applied is discussed. The basic concept of MINS is the utilization of a medium-accuracy Inertial Navigation System (INS) in conjunction with one or more secondary sensors which act as error bounding sources. Within the INS, a Kalman filter is implemented which accepts the bounding source (secondary sensor) inputs and provides the best estimate of the vehicle position velocity, heading, and attitudes, as well as estimates of the modeled error sources. The result is a synergistic self-calibrating navigation system capable of providing enhanced accuracy performance. Estimates of performance derived from simulations for various sensor input configurations are assessed. V.T.

A90-36926#
PROTOTYPE TESTING OF AN INTEGRATED DOPPLER/GPS NAVIGATION SYSTEM
JAMES L. MAIDA (Teledyne Ryan Electronics, San Diego, CA) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 205-213.

Developing a GPS receiver that could be embedded in an existing Doppler navigation system meeting the requirements of medium dynamic aircraft is described. The major development objectives for the final system version (production configuration) are listed, and system configuration and operation are covered. A prototype/developmental demonstrator used as a proof of concept system is presented, with emphasis on feasibility and performance verification as the major demonstration objectives. This includes the ability to track satellites during dynamic maneuvers and during temporary outages caused by terrain or vehicle masking. Test results demonstrate that an overall position accuracy in the range of 20 meters SEP (Spherical Error Probable) and velocity accuracy on the order of one meter/second can be achieved with the prototype system. V.T.

A90-36927#
OMEGA-GPS INTEROPERABILITY FOR THE LONG HAUL
HENRY SCHLACHTA (Canadian Marconi Co., Montreal, Canada) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 215-220.

A conceptual approach to the interoperation of the worldwide radio navigation system Omega and GPS is presented. First, integration of Omega and GPS is discussed, and several examples of such integration are assessed. It is noted that Omega has its weaknesses such as less than optimum signal coverage in some areas; however, advances in Omega signal receivers and signal processing software, coupled with the use of the U.S. Navy VLF Communication signals, have largely eliminated this difficulty. While GPS coverage is useful only for experimental purposes at this time, as the full constellation is progressively implemented over the next few years, updating of Omega systems by the use of a GPS receiver is considered to be offering greater overall flight accuracy; at the same time through the synergistic process of interoperation a more accurate and navigationally reliable radio navigation system can be produced. V.T.

A90-36929#
LOW COST QUBIK IMU FOR INTEGRATION WITH GPS, OMEGA, LORAN-C, AND SDI SYSTEMS
MELVIN MARK MORRISON (Qubik Consultants, Canoga Park, CA) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 233-242.

Inertial Measurement Unit (IMU) technologies offering superior accuracy over other forms of guidance systems for short-term time periods are considered. It is noted that long-term high-accuracy GPS, Loran-C, and Omega system integrated with an IMU can improve their short-term model. A working IMU model containing a breadboard sensor weighing less than 25 grams is described. For hybrid applications, the basic sensor cube and associated electronics can be packaged on a printed circuit board. Preliminary testing of the model, limited to a laboratory bench, is discussed, showing that the IMU has a minimum dynamic range of 10 to the 4th power. Finally, production design considerations are presented, and cost of ownership is assessed. V.T.

A90-36931#
THE MULTI-FUNCTION RLG SYSTEM COMES OF AGE - A TECHNICAL UPDATE
MICHAEL HADFIELD and ED WHEELER (Honeywell, Inc., Military Avionics Div., Clearwater, FL) IN: Institute of Navigation, National Technical Meeting, San Mateo, CA, Jan. 23-26, 1989, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 257-266. refs

The paper deals with expanding the functional capabilities of ring laser gyroscope (RLG) inertial systems beyond basic position and velocity outputs, into the more dynamic area of other sensor stabilization/motion compensation (radars, electro-optical sensors and weapons) and integrated navigation/flight control applications. The capability of current RLG system technology to meet the more dynamic output requirements is assessed, and the information related to quantifying these parameters in terms of both the ranges and reasons for the requirements is presented. The actual results being achieved both in inertial system tests and in the end application are discussed, along with flight test results with synthetic aperture radar in the F-15 Eagle. V.T.

A90-37211#
MODIFIED FAULT TOLERANT INERTIAL NAVIGATION SYSTEM
HANGUO ZHANG and HONGYUE ZHANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Jan. 1990, p. A46-A52. In Chinese, with abstract in English.

The performance of a failure detection and isolation (FDI) algorithm applied to a redundant strapdown measurement unit is limited by sensor errors, such as input misalignment, scale factor errors, and biases. A separated-bias estimation method is applied to obtain estimates of those combinations of sensor errors that affect the parity vector. The estimates are used to form a compensated parity vector which does not include the effects of sensor errors. The compensated parity vector is then used in place of the uncompensated parity vector to make FDI decision for improving FDI performance. The problem of noise compensation for FDI systems is also presented. Author

N90-21751# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
FIRST-ORDER WEIGHT CORRECTIONS FOR REAL-TIME FLIGHT PATH MANAGEMENT
H. G. VISSER Feb. 1989 35 p
(LR-580; ETN-90-96344) Avail: NTIS HC A03/MF A01

The usefulness of singular perturbation methods in developing real time automatic flight trajectory synthesis algorithms is investigated. Using the minimum principle of optimal control theory, approximate feedback type solutions are developed. It is concluded that the approximations are not practical for onboard applications in commercial jet transports. Singular perturbation analysis does provide valuable insight into the solution behavior, which may eventually help in the development of simplified algorithms. Numerical experiments are suggested to validate the concept and serve as a basis for quantitative comparison. ESA

N90-21752# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
AN APPROACH TO ON-BOARD OPTIMIZATION OF CRUISE AT CONSTANT ALTITUDE
H. G. VISSER Dec. 1989 52 p
(LR-581; ETN-90-96345) Avail: NTIS HC A04/MF A01

The derivation and evaluation of an automatic flight trajectory synthesis algorithm is described. The algorithm can generate both time-free and time-fixed fuel-optimal cruise trajectories. The algorithm is based on a regularly perturbed optimal control formulation of cruise at constant altitude. Complicating effects such as winds aloft, off nominal ambient temperatures and engine losses are embedded in the dynamic model using a regular perturbation approach. It is shown that by including the weight dynamics in the system formulation, the performance of the algorithm is improved. ESA

N90-22232*# Georgia Inst. of Tech., Atlanta.
PASSIVE NAVIGATION USING IMAGE IRRADIANCE TRACKING
P. K. A. MENON (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.) *In* NASA, Ames Research Center, Vision Science and Technology at NASA: Results of a Workshop p 38 Feb. 1990
(Contract NAG2-463)
Avail: NTIS HC A04/MF A01 CSCL 17G

Rotorcraft operating at low altitudes require navigational schemes for detecting terrain and obstacles. Due to the nature of the missions to be accomplished and available power onboard, a passive navigation scheme is desirable in this situation. The development of a passive navigation scheme using optical image sequences and vehicle motion variables from an onboard inertial navigation scheme is described. This approach combines the geometric properties of perspective projection and a feedback irradiance tracking scheme at each pixel in the image to determine the range to various objects within the field-of-view. Derivation of the numerical algorithm and simulation results are given. Due to the feedback nature of the implementation, the computational scheme is robust. Other applications of the proposed approach include navigation for autonomous planetary rovers and telerobots. Author

N90-22238*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
KALMAN FILTER BASED RANGE ESTIMATION FOR AUTONOMOUS NAVIGATION USING IMAGING SENSORS
BANAVAR SRIDHAR *In its* Vision Science and Technology at NASA: Results of a Workshop p 47-48 Feb. 1990
Avail: NTIS HC A04/MF A01 CSCL 17G

Rotorcraft operating in high-threat environments fly close to the surface of the earth to utilize surrounding terrain, vegetation, or man-made objects to minimize the risk of being detected by the enemy. Two basic requirements for obstacle avoidance are detection and range estimation of the object from the current rotorcraft position. There are many approaches to the estimation of range using a sequence of images. The approach used in this analysis differes from previous methods in two significant ways: an attempt is not made to estimate the rotorcraft's motion from the images; and the interest lies in recursive algorithms. The rotorcraft parameters are assumed to be computed using an onboard inertial navigation system. Given a sequence of images, using image-object differential equations, a Kalman filter (Sridhar and Phatak, 1988) can be used to estimate both the relative coordinates and the earth coordinates of the objects on the ground. The Kalman filter can also be used in a predictive mode to track features in the images, leading to a significant reduction of search effort in the feature extraction step of the algorithm. The purpose is to summarize early results obtained in extending the Kalman filter for use with actual image sequences. The experience gained from the application of this algorithm to real images is very valuable *and is a necessary step before proceeding to the estimation of* range during low-altitude curvilinear flight. A simple recursive method is presented to estimate range to objects using a sequence of images. The method produces good range estimates using real images in a laboratory set up and needs to be evaluated further using several different image sequences to test its robustness. The feature generation part of the algorithm requires further refinement on the strategies to limit the number of features (Sridhar and Phatak, 1989). The extension of the work reported here to curvilinear flight may require the use of the extended Kalman filter. Author

N90-22554# Carnegie-Mellon Univ., Pittsburgh, PA. Software Engineering Inst.
INERTIAL NAVIGATION SYSTEM SIMULATOR: BEHAVIORAL SPECIFICATION, REVISION Final Report
STEFAN F. LANDHERR and MARK H. KLEIN Aug. 1989 39 p
(Contract F19628-85-C-0003)
(AD-A219294; CMU/SEI-89-TR-35-REV; ESD-TR-89-46-REV)
Avail: NTIS HC A03/MF A01 CSCL 17/7

The Real-Time Embedded Systems Testbed (REST) Project at the Software Engineering Institute is specifying and developing a representative real-time application. An original set of specifications written by a Navy affiliate is augmented. The purpose of this behavioral specification is to clarify and augment the original.
GRA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A90-35300#
AGILITY AS A CONTRIBUTION TO DESIGN BALANCE
ANDREW M. SKOW (Eidetics International, Inc., Torrance, CA) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 20 p. refs
(AIAA PAPER 90-1305) Copyright

This paper defines agility as a contribution to a balanced design, and relates this concept to conventional measures of merit. The characteristics of three famous examples of the balanced design are discussed, with special consideration given to the agility features of the Spitfire, the P-51 Mustang, and the F-16 fighter aircraft. An evaluation of the operational value attributable to various types of agility enhancements is presented. It is shown that the agility methodology used to compare existing fighters has a potential to extract valuable information about the agility characteristics of competitive aircraft. I.S.

A90-35761*# Southwest Research Inst., San Antonio, TX.
INSTALLATION EFFECTS ON PROPELLER WAKE/VORTEX-INDUCED STRUCTURE-BORNE NOISE TRANSMISSIONS
J. F. UNRUH (Southwest Research Institute, San Antonio, TX) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 444-448. Previously cited in issue 13, p. 1943, Accession no. A89-33717. refs
(Contract NAS1-17921)
Copyright

A90-35762#
REDUCED-ORDER AEROELASTIC MODELS VIA DYNAMIC RESIDUALIZATION
M. KARPEL (Technion - Israel Institute of Technology, Haifa) (European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings, p. 633-642) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 449-455. Previously cited in issue 14, p.2130, Accession no. A90-33412. refs
Copyright

A90-35774
EH101 ADVANCE TECHNOLOGY ROTORCRAFT LOW DETECTABILITY/GOOD NEIGHBOR DESIGN
JOHN W. LEVERTON (E. H. Industries, Inc., Arlington, VA) Vertiflite (ISSN 0042-4455), vol. 36, May-June 1990, p. 44-48.
Copyright

During initial design of the EH101 helicopter, community noise standards, low detectability, and overall noise characteristics were considered equally important factors among anticipated certification requirements. It was established by various studies that the detailed noise characteristics of a helicopter, as well as their overall dB level, influence the likelihood of detection or annoyance. Noise abatement/minimum noise procedures have also been developed to further reduce noise levels in normal operations; the EH101's superior climb rate will in particular be used to rapidly build up distance from airports. O.C.

A90-35846
WATER BORNE AGAIN
ALLAN WINN Flight International (ISSN 0015-3710), vol. 137, May 9, 1990, p. 48-52.
Copyright

A brief history of the resurgence and rapid decline of amphibians and floatplanes after World War II is presented. In recent years, small amphibians have had some popularity, but only Canadair's rugged and specialized CL-215 water bomber has achieved worldwide success. Nevertheless, a completely new amphibian aircraft has been designed, flown, and is now awaiting flight testing and certification. Named the Seastar CD2, it is an all-composite, unpressurized, 12-passenger amphibian with tandem tractor/pusher turboprop engines installed above a strut-mounted wing. Island-hopping passenger and cargo services are a prime market for this aircraft. Additional technical details and a cutaway diagram are provided. R.E.P.

A90-35848
YAKOVLEV STRIKES BACK
ALAN POSTLETHWAITE Flight International (ISSN 0015-3710), vol. 137, May 9, 1990, p. 61, 62, 65, 66.
Copyright

Propfan and other high-technology derivatives of the Yak-42 airliner are planned. This airliner was designed to Soviet airworthiness regulations and does not meet all aspects of U.S. FAR part 25. However, it is still produced and deliveries have been made to Italy, India and China. The Yak-42M derivative is a substantially new aircraft built around the basic fuselage stretched by four meters to accommodate 156 passengers in a typical layout or up to 168 passengers in a higher-density configuration. Some of the advanced design concepts incorporated include a supercritical airfoil section, winglets, fly-by-wire controls, and a two-man flight crew. The powerplant has an enlarged fan and delivers an additional 1000 pounds of thrust over the present engine. This improved engine and the advanced airframe aerodynamics mean the Yak 42M will be 35-40 percent more fuel-efficient than the present model. R.E.P.

A90-36026#
FLIGHT TESTING OF THE LOW ALTITUDE/AIRSPEED UNMANNED RESEARCH AIRCRAFT (LAURA)
RICHARD J. FOCH and PEGGY L. TOOT (U.S. Navy, Naval Research Laboratory, Washington, DC) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 17 p. Research supported by the U.S. Navy. refs
(AIAA PAPER 90-1262)

The NAVY's LAURA program utilizes a set of instrumented, high performance, remotely piloted vehicles for in-flight aerodynamic research. This research focusses on demonstrating that high L/D values at high lift coefficients can be achieved with practical designs, despite detrimental low Reynolds number (LRN) aerodynamic effects due to the combination of low airspeed and small vehicle size. In addition such aircraft must also exhibit sufficient control response to negotiate low altitude gusts and ship's turbulence when launching from and recovering aboard ship. These aircraft utilize advanced composite technology to achieve light weight structures while maintaining the highly accurate airfoil shapes required for high performance flight under LRN conditions. R.E.P.

A90-36027*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT TESTS OF A HELMET-MOUNTED DISPLAY SYNTHETIC VISIBILITY SYSTEM
KENNETH R. YENNI (NASA, Langley Research Center, Hampton, VA) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 5 p.
(AIAA PAPER 90-1279) Copyright

A short flight test program was conducted using the NASA Langley Research Center's B737 Advanced Transport Operating Systems (ATOPS) research airplane to determine if pilots could land a transport category airplane under visual meteorological

conditions (VMC) by reference to a synthetic visibility system. No external guidance was to be used. The program was undertaken jointly by NASA and the McDonnel-Douglas Corporation. The airplane was fitted with forward-looking television cameras fixed in the nose. Inputs from the television cameras were mixed with internally generated symbology and displayed to the pilot on helmet-mounted eyepieces. The pilot task was to execute a visual approach and landing. Two NASA and two McDonnel-Douglas engineering test pilots participated in the program completing over 200 landings in a 32-hour test program. Landings accomplished with the helmet-mounted display (HMD) were compared with visual landings for each pilot. Author

A90-36029*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPACT OF EMERGING TECHNOLOGIES ON FUTURE COMBAT AIRCRAFT AGILITY
LUAT T. NGUYEN and WILLIAM P. GILERT (NASA, Langley Research Center, Hampton, VA) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 19 p. refs
(AIAA PAPER 90-1304) Copyright

The foreseeable character of future within-visual-range air combat entails a degree of agility which calls for the integration of high-alpha aerodynamics, thrust vectoring, intimate pilot/vehicle interfaces, and advanced weapons/avionics suites, in prospective configurations. The primary technology-development programs currently contributing to these goals are presently discussed; they encompass the F-15 Short Takeoff and Landing/Maneuver Technology Demonstrator Program, the Enhanced Fighter Maneuverability Program, the High Angle-of-Attack Technology Program, and the X-29 Technology Demonstrator Program. O.C.

A90-36031#
SOME ASPECTS OF THE CONTROL SYSTEM AND POWER UNIT LEAD TESTS USING IN-FLIGHT SIMULATOR SYSTEMS AND FLYING TEST-BEDS
I. I. ZAITSEV, B. B. KOROVIN, and L. G. KHARAZIAN (Flight Research Institute, USSR) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 5 p.
(AIAA PAPER 90-1323) Copyright

Methods for improving flight test effectiveness as part of the state-of-the-art aviation design process are presented. It is shown that flying test beds are an effective instrument for solving difficult problems of helicopter flight control system research tests, as well as for engine climatic tests. It is also demonstrated that in some cases engine climatic tests may be successfully carried out without transporting the flying test bed to remote climatic zones due to the use of physical simulation methods. R.E.P.

A90-36273*# Maryland Univ., College Park.
STABILITY SENSITIVITY ANALYSIS OF A HELICOPTER ROTOR
JOON W. LIM and INDERJIT CHOPRA (Maryland, University, College Park) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2, p. 813-824) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1089-1097. Previously cited in issue 12, p. 1826, Accession no. A88-32258. refs
(Contract NAG1-739)
Copyright

A90-36423#
A STUDY ON MECHANICAL MODEL OF THE HELICOPTER 'GROUND RESONANCE'
ZHONGQUAN GU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, March 1990, p. A188-A193. In Chinese, with abstract in English.

In order to study the influences of rotating multiblade rotor on the degrees of freedom and on the flap 'ground resonance' of a helicopter, it is necessary to consider not only the lag degrees of freedom but also the flap degrees of freedom. Using the Lagrangian equation, a dynamic equation of the space model for the helicopter 'ground resonance' is deduced for the first time. Some computational results are reported which show that the mechanical model including both lag DOF and flap DOF are more reasonable. C.D.

A90-36438#
ANALYSIS OF SERIOUS MECHANICAL TROUBLE IN A RETRACTABLE MAIN LANDING GEAR OF A JET FIGHTER
ZHENWEI HUANG (Chengdu Aircraft Corp., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, April 1990, p. B192-B194. In Chinese, with abstract in English.

A90-36850
WHAT'S BEST TO TILT - THE ROTOR OR THE WING?
R. W. PROUTY Rotor and Wing International (ISSN 0191-6408), vol. 24, June 1990, p. 40-43.
Copyright

A reanalysis is conducted of the development history of the VTOL configurational family that encompasses both tilt-rotor and tilt-wing aircraft, in view of the emerging debate among designers as to their relative advantages. Attention is given to the tradeoff between the superior aerodynamics of tilt wings in hover and the superior structural efficiency of the tilt-rotor's fixed wings, as well as to the development status of a Japanese, twin-turboshaft, V-22-scaled VTOL aircraft which employs the tilt-wing principle; this design is optimized for greater horizontal flight efficiency than the V-22 tilt-rotor, and accordingly employs smaller-diameter rotors that will be less efficient in hover. O.C.

A90-37217#
AEROELASTIC TAILORING OF COMPOSITE WING STRUCTURES
CHUANQI HUANG and XIN QIAO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Jan. 1990, p. A78-A82. In Chinese, with abstract in English.

This paper deals with aeroelastic tailoring of composite wing surfaces. The objective function is structural weight. Multi-constraints, such as displacements, flutter speed, and gauge requirements, are taken into consideration. The finite element method is used in the static analysis. Natural vibration modes are obtained by the spectral transformation Lanczos method. The subsonic doublet lattice method is used to obtain the unsteady aerodynamics. The critical flutter speed is generated by the V-g method. The optimal problem is solved by the feasible direction method. Author

A90-37241#
ANALYSIS AND IMPROVEMENT OF CABIN TEMPERATURE CONTROL SYSTEM
MINSHENG ZHAO (Civil Aeronautics Institute of China, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Feb. 1990, p. B101-B106. In Chinese, with abstract in English.

A linearized mathematical model of the delayed negative feedback oscillation is derived. In order to improve the stability and disturbance rejection of the cabin temperature control system, a new approach to the design of a presensing bridge circuit is presented. The presensing bridge so designed can realize a lead-correction with a time constant as high as a few thousand seconds. Besides, by employing the existing engine control system installations, without any additional parts, a feed-forward control method for rejecting disturbance can be achieved. Author

A90-38028
A STATUS REVIEW OF NON-HELICOPTER V/STOL AIRCRAFT DEVELOPMENT. II
B. LINDENBAUM (Aerial Mobility, Inc., Dayton, OH) Vertiflite (ISSN 0042-4455), vol. 36, May-June 1990, p. 54-60.
Copyright

A comparative study is presented of the distinctive design features and anticipated performance characteristics of numerous innovative V/STOL aircraft configurations, some of which are compatible with supersonic flight and accordingly applicable to military aircraft. Among the propulsion/airframe configurational types evaluated are foldable-blade tilt-rotors, tilt-nacelle turbofans, vectoring-exhaust turbofans, thrust-augmentor wing-surfaced turbojets, plenum chamber-burning fan exhaust turbofans, tandem fans with vectorable exhausts, and tilt-wing turboprops. O.C.

A90-38525
THE U.S. ARMY HELICOPTER STRUCTURAL INTEGRITY PROGRAM - 1989 EUROPEAN ROTORCRAFT FORUM
FREDERICK H. IMMEN (U.S. Army, Aviation Systems Command, Saint Louis, MO) Vertica (ISSN 0360-5450), vol. 14, no. 2, 1990, p. 241-253. refs
Copyright

This paper discusses the issues addressed by the U.S. Army Helicopter Structural Integrity Program (HSIP). The influence of HSIP on the steps of structural design criteria is examined, and the initial design is described together with the design substantiation (qualification), the fabrication processes, and the field maintenance of structural integrity. Special consideration is given to the unique aspects of metals vs resin matrix fibrous composites in the structural integrity issue and to the organization and documentation of the HSIP. I.S.

A90-38529#
V-22 DEVELOPMENTAL STATUS
STANLEY MARTIN, JR. and RICHARD OSTLUND (Bell Boeing Joint Program Office, Arlington, VA) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 12 p.

The status of the full-scale development of a tiltrotor is summarized, with emphasis placed on its digital flight controls, composite structure, and drive system. Triplex digital electronic flight controls mixing and scheduling helicopter and fixed-wing control functions are discussed. It is shown how the design of the wing illustrates the advantages of composites, not only in saving weight, but also in permitting the designer to tailor the stiffness of the structure to aeroelastic stability and vibration design criteria. The development of the drive system operating through a wide range of attitudes and speeds is described, along with variable-attitude bench test rigs and a ground static test article. The structural flight envelope of the aircraft is presented along with the principal envelope expansion flights. V.T.

A90-38536#
LOW SPEED MANEUVERABILITY AND AGILITY DESIGN CONSIDERATIONS FOR V/STOL AIRCRAFT
DANIEL P. SCHRAGE, MARK WASIKOWSKI, CLIFFORD M. MCKEITHAN (Georgia Institute of Technology, Atlanta), and FREDERICK STELLAR IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 22 p. refs

V/STOL aircraft concepts are reviewed across the spectrum from helicopter to vectored thrust aircraft. Low speed maneuverability and agility design considerations for military V/STOL aircraft and the sensitivity of several design parameters are discussed. Effects of installed power on rotary-wing and fixed-wing aircraft are considered, along with decreased blade loading or wind loading improving maneuverability at the low speed range of the flight envelope for both fixed-wing and rotary-wing aircraft. It is concluded that the demands for survivability and enhanced mission effectiveness on future battlefields are requiring the capability to look across the spectrum of V/STOL aircraft and technologies. V.T.

A90-38538#
V-22 ENGINE INSTALLATION AND REMOVAL TOOL - DESIGNING SUPPORT EQUIPMENT WITH THE AIRCRAFT, NOT AFTER
THOMAS G. REILLY (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 8 p.

The V-22 engine installation and removal tool conceptualized and designed simultaneously with the V-22 airframe is described. The airframe design team, powerplant group, reliability and maintainability engineers, logistics specialists, and support equipment designers collaborated on studies of tradeoffs between airframe configurations and support elements. The initial concept, detail layout with proof-of-concept, and detail design are discussed. It is noted that designing support equipment with the aircraft can keep added weight and size out, while keeping supportability in; interface points can be incorporated into the designs; line routing and component placement can be designed with maintainability and functional goals in mind. V.T.

A90-38540*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DEVELOPMENT OF THE XV-15 TILTROTOR RESEARCH AIRCRAFT - LESSONS LEARNED
LAUREL G. SCHROERS (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 48 p.

The initial ground rules that guided the decision process during the initial stages of the XV-15 tiltrotor aircraft development are reviewed and reevaluated. A full flight-envelope nonlinear simulation mathematical model is outlined, along with the advantages of a multiaircraft program. Direct involvement of government engineers in all aspects of the program is considered to be beneficial, while the ejection-seat test requirement is not. Utilization of existing components - a rotor, transmissions, and engines - is analyzed, and emphasis is placed on integrated system test plans responsible for producing two reliable aircraft through a complete checkout of the aircraft subsystems before the start of the fligth program. Wind-tunnel and fatigue test requirements are presented, and the decision to go with an all mechanical control system design is addressed. V.T.

N90-21753*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
A COMPARISON OF TIME-OPTIMAL INTERCEPTION TRAJECTORIES FOR THE F-8 AND F-15 Final Technical Report
ANTHONY J. CALISE and JAMES B. PETTENGILL Jan. 1990 30 p
(Contract NCC2-506)
(NASA-CR-186300; NAS 1.26:186300) Avail: NTIS HC A03/MF A01 CSCL 01C

The simulation results of a real time control algorithm for onboard computation of time-optimal intercept trajectories for the F-8 and F-15 aircraft are given. Due to the inherent aerodynamic and propulsion differences in the aircraft, there are major differences in their optimal trajectories. The significant difference in the two aircrafts are their flight envelopes. The F-8's optimal cruise velocity is thrust limited, while the F-15's optimal cruise velocity is at the intersection of the Mach and dynamic pressure constraint boundaries. This inherent difference necessitated the development of a proportional thrust controller for use as the F-15 approaches it's optimal cruise energy. Documented here is the application of singular perturbation theory to the trajectory optimization problem, along with a summary of the control algorithms. Numerical results for the two aircraft are compared to illustrate the performance of the minimum time algorithm, and to compute the resulting flight paths. Author

N90-21755*# North American Aircraft Operations, Los Angeles, CA.
CONCEPTUAL DESIGN OPTIMIZATION STUDY Final Report, Aug. 1987 - Nov. 1988
S. J. HOLLOWELL, E. R. BEEMAN, II, and R. M. HIYAMA Washington NASA May 1990 118 p
(Contract NAS1-18015)
(NASA-CR-4298; NAS 1.26:4298; NA-88-1877) Avail: NTIS HC A06/MF A01 CSCL 01C

The feasibility of applying multilevel functional decomposition and optimization techniques to conceptual design of advanced fighter aircraft was investigated. Applying the functional decomposition techniques to the conceptual design phase appears to be feasible. The initial implementation of the modified design process will optimize wing design variables. A hybrid approach, combining functional decomposition techniques for generation of aerodynamic and mass properties linear sensitivity derivatives with existing techniques for sizing mission performance and optimization, is proposed. Author

N90-21756*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IDENTIFICATION OF XV-15 AEROELASTIC MODES USING FREQUENCY-DOMAIN METHODS
CECIL W. ACREE, JR. and MARK B. TISCHLER Feb. 1989 28 p Previously announced in IAA as A89-41092 Prepared in cooperation with Army Aviation Research and Development Command, Moffett Field, CA
(NASA-TM-101021; A-88268; NAS 1.15:101021; USAAVSCOM-CP-89-A-001) Avail: NTIS HC A03/MF A01 CSCL 01C

The XV-15 Tilt-Rotor wing has six major aeroelastic modes that are close in frequency. To precisely excite individual modes during flight test, dual flaperon exciters with automatic frequency-sweep controls were installed. The resulting structural data were analyzed in the frequency domain (Fourier transformed) with cross spectral and transfer function methods. Modal frequencies and damping were determined by performing curve fits to transfer function magnitude and phase data and to cross spectral magnitude data. Results are given for the XV-15 with its original metal rotor blades. Frequency and damping values are also compared with earlier predictions. Author

N90-21758*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
QUIET MODE FOR NONLINEAR ROTOR MODELS
R. E. MCFARLAND Apr. 1990 38 p
(NASA-TM-102236; A-89247; NAS 1.15:102236) Avail: NTIS HC A03/MF A01 CSCL 01C

High frequency harmonics are generated by helicopter rotor systems, and nonlinear blade-element models of these systems create the same harmonics. In discrete real-time rotorcraft simulation, however, especially for handling qualities research, they are more of a nuisance than a benefit. The cycle times required to adequately represent them are rarely obtainable. The result is that distinct frequencies alias into the pilot and simulator bandwidths, thereby decreasing simulation fidelity. However, use of an interpolation procedure permits the observation of harmonics at their proper frequency locations, and an accompanying notch filter may then be used to attenuate the harmonics prior to decimation. Rotorcraft simulations using these techniques are not contaminated with the spurious frequencies that create variable trim points, produce erroneous stability and control derivative data, and obscure time histories. Author

N90-21984# National Aerospace Lab., Amsterdam (Netherlands).
DESIGN AND TESTING OF A MULTIBLOCK GRID-GENERATION PROCEDURE FOR AIRCRAFT DESIGN AND RESEARCH
J. W. BOERSTOEL, J. M. J. W. JACOBS, A. KASSIES, A. AMENDOLA, R. TOGNACCINI, and P. L. VITAGLIANO (Aeritalia S.p.A., Pomigliano D'Arco, Italy) *In* AGARD, Applications of Mesh Generation to Complex 3-D Configurations 16 p Mar. 1990
Copyright Avail: NTIS HC A14/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A multiblock grid-generation procedure embedded in a numerical flow simulation system is described. Major features of the grids are: suitable for complex aerodynamic configurations; grid lines continuous, in particular, over block faces; grid lines not slope-continuous over block faces, topology and geometry of block decomposition first specified, and then grid-point distributions; application of transfinite interpolation and elliptic techniques. It is possible to construct multiblock grids around complex configurations with 250 to 1000 blocks, and to compute (Euler) flows on such grids. New technical concepts are proposed, to improve the accuracy of the flow simulation results, and to reduce manhour investments in the construction of multiblock grids. These concepts concern the use of compound faces and edges; the application of grid refinement per block and per coordinate direction, to remove the constraining effect of grid-line continuity on grid-point-density control; the use of new techniques for analytic aerodynamic geometry modeling, to reduce the dependence on non-CFD geometry software packages; the control of grid quality and acceptability with weight functions in the independent variables of the 3D vector functions defining the geometrical shape of edges, faces and blocks; and use of hyperblocks to speed up the block decomposition. Author

N90-21986# British Aerospace Public Ltd. Co., Hatfield (England). Airlines Div.
MULTIBLOCK TOPOLOGY SPECIFICATION AND GRID GENERATION FOR COMPLETE AIRCRAFT CONFIGURATIONS
STEVE ALLWRIGHT *In* AGARD, Applications of Mesh Generation to Complex 3-D Configurations 11 p Mar. 1990
Copyright Avail: NTIS HC A14/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The ability to calculate the flow around complex geometries is fundamentally controlled by the ability to generate grids of suitable structure and quality around the configurations of interest. The approach to Multiblock topology specification and grid generation pursued within British Aerospace, targeted to make Multiblock flow prediction methods available for use at all stages of the aerodynamic design process is discussed. The grids and computed flow solutions for a number of complex geometries are shown, and the capability for rapid systematic analysis of similar configuration geometries is illustrated. Author

N90-22555*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EXPERIMENTAL STUDY OF TIP SHAPE EFFECTS ON THE FLUTTER OF AFT-SWEPT, FLAT-PLATE WINGS
BRYAN E. DANSBERRY, JOSE A. RIVERA, JR., and MOSES G. FARMER Washington Jun. 1990 22 p
(NASA-TM-4180; L-16638; NAS 1.15:4180) Avail: NTIS HC A03/MF A01 CSCL 01/3

The effects of tip chord orientation on wing flutter are investigated experimentally using six cantilever-mounted, flat-plate wing models. Experimentally determined flutter characteristics of the six models are presented covering both the subsonic and transonic Mach number ranges. While all models have a 60 degree leading edge sweep, a 40.97 degree trailing edge sweep, and a root chord of 34.75 inches, they are subdivided into two series characterized by a higher aspect ratio and a lower aspect ratio. Each series is made up of three models with tip chord orientations which are parallel to the free-stream flow, perpendicular to the model mid-chord line, and perpendicular to the free-stream flow. Although planform characteristics within each series of models are held constant, structural characteristics such as mode shapes and natural frequencies are allowed to vary. Author

N90-22556 Georgia Inst. of Tech., Atlanta.
APPLICATION OF A DYNAMIC STALL MODEL TO ROTOR TRIM AND AEROELASTIC RESPONSE Ph.D. Thesis
MNAOUAR CHOUCHANE 1989 205 p
Avail: Univ. Microfilms Order No. DA9005475

A unified aerodynamic lift model including stall is used to describe the aerodynamic environment of a rotor blade. The model is successfully used in conjunction with an elastic blade formulation to predict the aerodynamic forces on the helicopter blade and the flap-lag-torsional response before and after stall occurs. The control settings are assumed to be initially unknown and are computed as a part of the solution by an auto-pilot controller. A solution method based on a modified Galerkin's method is used to separate the time and space variables in the differential equations. The numerical solution is obtained by a time marching method for solving systems of first-order differential equations. The structural model consists mainly of flap, lag, and torsion equations. These equations can be reduced to rigid blade equations by using a single mode for each degree of freedom. The fast rate of convergence of the elastic solution shows that the orthogonal polynomials used in this work represented a good choice for the comparison functions. The unified-aerodynamic model is an extension of the model developed by the Office National d'Etudes et de Recherches Aerospaciales and includes plunge, unsteady free stream, and large angles of attack. The model is used to predict both the unsteady nonlinear lift and pitching. Dynamic response was conducted for a variety of thrust coefficients and advance ratios with both rigid and elastic blade assumptions and at several torsional frequencies. The correlation of the results with flight test data from the SA349/2 helicopter has generally resulted in a good prediction of the vehicle control settings.
Dissert. Abstr.

N90-22557*# Lockheed Engineering and Sciences Co., Hampton, VA.
MULTILEVEL DECOMPOSITION APPROACH TO THE PRELIMINARY SIZING OF A TRANSPORT AIRCRAFT WING
GREGORY A. WRENN and AUGUSTINE R. DOVI Washington NASA 1990 31 p
(Contract NAS1-19000)
(NASA-CR-4296; NAS 1.26:4296) Avail: NTIS HC A01/MF A01 CSCL 01/3

A multilevel/multidisciplinary optimization scheme for sizing an aircraft wing structure is described. A methodology using nonlinear programming in application to a very large engineering problem is presented. This capability is due to the decomposition approach. Over 1300 design variables are considered for this nonlinear optimization task. In addition, a mathematical link is established coupling the detail of structural sizing to the overall system performance objective, such as fuel consumption. The scheme is implemented as a three level system analyzing aircraft mission performance at the top level, the total aircraft structure as the middle level, and individual stiffened wing skin cover panels at the bottom level. Numerical show effectiveness of the method and its good convergence characteristics. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A90-37088
PERFORMANCE ASSESSMENT FOR AIRBORNE SURVEILLANCE SYSTEMS INCORPORATING SENSOR FUSION
D. E. IVERSON (Boeing Aerospace, Seattle, WA), K. C. CHANG, and C. Y. CHONG (Advanced Decision Systems, Inc., Mountain View, CA) IN: Signal and data processing of small targets 1989; Proceedings of the Meeting, Orlando, FL, Mar. 27-29, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 269-283. refs
(Contract F19628-87-C-0268)
Copyright

Proposed surveillance systems must not only satisfy certain technical requirements on fusion performance but must examine many other performance issues as well, ultimately culminating in an estimate of life cycle cost to meet a specified mission objective. The decomposition of the performance assessment problem and the resultant implications in terms of component modeling and interfaces are discussed. This discussion begins at the surveillance requirement stage, then looks successively at sensor suite optimization; sensor modeling (both in terms of measurement capability and operational utilization); sensor fusion (employing a multiple hypothesis approach with adaptive resource allocation); surveillance effectiveness evaluation; and finally life cycle costing. Author

A90-38441*# University of Western Michigan, Kalamazoo.
THERMAL MANAGEMENT OF CLOSED COMPUTER MODULES UTILIZING HIGH DENSITY CIRCUITRY
A. W. HOADLEY and A. J. PORTER (Western Michigan University, Kalamazoo, MI) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 5th, Seattle, WA, June 18-20, 1990. 9 p.
(Contract NCC2-493)
(AIAA PAPER 90-1748) Copyright

This paper presents data on a preliminary analysis of the thermal dynamic characteristics of the Airborne Information Management System (AIMS), which is a continuing design project at NASA Dryden. The analysis established the methods which will be applied to the actual AIMS boards as they become available. The paper also describes the AIMS liquid cooling system design and presents a thermodynamic computer model of the AIMS cooling system, together with an experimental validation of this model. I.S.

N90-21759# Federal Aviation Administration, Atlantic City, NJ.
ENHANCED LOW LEVEL WIND SHEAR (LLWAS) 6-SENSOR IMPROVEMENT USER'S MANUAL FOR DATA PROCESSING OF FIELD DATA
ERIC J. HOOVER May 1990 30 p
(DOT/FAA/CT-TN90/8) Avail: NTIS HC A03/MF A01

The Low Level Wind Shear Alert System (LLWAS) data collection includes only those Fairchild/Weston 6 and N Sensor sites qualified to copy data to TK50 magnetic tape cartridges. The data is prescribed to be collected on a 90-day schedule for 6-Sensor airports, and a 60-day schedule for N-Sensor airports. The data is copied onto the TK50 cartridge and then mailed to FAATC, ANC-230, Atlantic City International Airport, Atlantic City, New Jersey. Information is provided for the processing of the LLWAS-recorded wind data at the Federal Aviation Administration Technical Center Data Analysis Facility. Author

N90-22563# Charles River Analytics, Inc., Cambridge, MA.
MODEL-BASED METHOD FOR TERRAIN-FOLLOWING DISPLAY DESIGN Final Report, 15 Jan. - 5 Jun. 1989
PAUL G. GONSALVES, EDWARD W. KNELLER, GREG L. ZACHARIAS, RALPH J. ST.JOHN, and BRADLEY D. PURVIS 15 Jun. 1989 124 p
(Contract F33615-86-C-0551)
(AD-A219302; AAMRL-TR-89-039) Avail: NTIS HC A06/MF A01 CSCL 17/7

A model-based method for terrain following display design and evaluation is described. The basic approach centers on the use of a pilot/vehicle/display model based on the optimal control model (OCM), which combines general knowledge of human perception and performance, with specific knowledge of terrain following aircraft and avionics capabilities. A real-time terrain following simulation facility was developed, implemented, and exercised to provide an experimental basis for validating model-based display designs, and to serve as a tool for developing and testing displays. Two basic display configurations were studied: a nominal vertical situation display (VSD) along with several enhancements, and a pictorial guidance display (PGD).

Model-based analysis of the real-time simulator data demonstrated the ability to closely match performance and frequency response trends across the range of display configurations studied, accounting for both general performance trends and fine-grained pilot dynamic response strategy in the measured data. GRA

07

AIRCRAFT PROPULSION AND POWER

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

A90-35174
AEROELASTIC INSTABILITIES IN AIRCRAFT ENGINES - APPLICATION TO A SNECMA FAN STAGE [INSTABILITE AEROELASTIQUE DANS LES MOTEURS D'AVIONS APPLICATION A UN ETAGE DE SOUFFLANTE S.N.E.C.M.A.]
R. HENRY and B. VINCENT (Lyon, Institut National des Sciences Appliquees, Villeurbanne, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 1, 1990, p. 23-32. Research supported by SNECMA. refs
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Requirements for competition and earning capacity lead designers to operating their engines under ever more stringent conditions. Consequently, it is a necessity to complete data from test facilities with a reliable software analysis. A method for predicting analytically the aeroelastic flutter of aircraft engine blades, especially suited to axial compressors, has been developed. Following a short survey of the method for modeling the mechanical structure as well as the internal flow, a description is given of the procedure for coupling these models and for testing instabilities (flutter). This procedure is applied to a SNECMA fan stage and prospects for improvements of the present aeroelastic modeling procedures are investigated. Author

A90-35228#
NUMERICAL CALCULATION OF THE JET-INTERACTION INDUCED SEPARATION WITH RESPECT TO THRUST VECTOR CONTROL
W. WAIDMANN (DLR, Institut fuer chemische Antriebe und Verfahrenstechnik, Hardhausen am Kocher, Federal Republic of Germany) IN: Symposium on Turbulent Shear Flows, 7th, Stanford, CA, Aug. 21-23, 1989, Proceedings. Volume 1. University Park, PA, Pennsylvania State University, 1989, p. 13.2.1-13.2.5.

An experimental and theoretical study of the interaction of a gaseous secondary jet into a supersonic flow field was conducted, and the results are reported. The jet-interaction phenomenon was studied using detailed surface pressure distributions measured before and behind the secondary jet conjunction with comprehensive shadowgraph coverage of the interaction flow field. The induced thrust was measured. Good agreement is obtained between the numerically calculated and experimentally observed configurations of the recirculation zones, the jet penetration height, the pressure distribution at the nozzle wall, and the side thrust. C.D.

A90-35229#
DEVELOPMENT OF A NEW LOW-REYNOLDS-NUMBER TYPE REYNOLDS STRESS MODEL AND ITS APPLICATION TO A LOBE MIXER FLOW
MAKOTO YAMAMOTO (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan), CHUICHI ARAKAWA (Tokyo, University, Japan), and TETSUO TAGORI (Tsukuba, University, Japan) IN: Symposium on Turbulent Shear Flows, 7th, Stanford, CA, Aug. 21-23, 1989, Proceedings. Volume 1. University Park, PA, Pennsylvania State University, 1989, p. 13.3.1-13.3.6. refs

A new low-Reynolds-number type Reynolds stress model (RSM) is proposed, which incorporates an extended Launder, Reece, and Rodi (LRR) model. Four modifications were introduced into the LRR model, taking into account the behavior of Reynolds stresses near the wall. Results of the tuning of unknown constants and the model verification for two-dimensional channel flow are found to be satisfactory. The model was also applied to a lobe mixer flow with three-dimensional characteristics. The results are shown to be qualitatively reasonable, although the model is unable to predict with high accuracy the Reynolds stress behavior near the wall. N.B.

A90-35230#
VELOCITY AND TURBULENCE CHARACTERISTICS OF ISOTHERMAL LOBED MIXER FLOWS
P. KOUTMOS and J. J. MCGUIRK (Imperial College of Science, Technology, and Medicine, London, England) IN: Symposium on Turbulent Shear Flows, 7th, Stanford, CA, Aug. 21-23, 1989, Proceedings. Volume 1. University Park, PA, Pennsylvania State University, 1989, p. 13.5.1-13.5.6. Research supported by Rolls-Royce, PLC. refs

An experimental and computational investigation of three-dimensional isothermal flow in model multilobed forced mixers is presented. In the experiment, laser-Doppler anemometry was used to obtain the three velocity components and corresponding turbulence intensities in the downstream mixing duct. The flow development in the near field was quantified by measuring the cross-plane velocities. Measurements of the spatial uniformity in the mean and turbulence fields that indicate a rapid mixing is achievable in these systems. The computational investigation of the coplanar configuration used a non-aligned mesh to solve the steady state three-dimensional elliptic equations which describe the flow within the lobes. Comparison between measurements and calculations, using a standard high Reynolds number k-epsilon model, shows a very good qualitative agreement with maximum disagreement in the radial flows of about 20 percent in positions of peak velocities. N.B.

A90-35513
GAS TURBINE ENGINES FOR COMBAT AVIATION - CURRENT REALITIES AND PERSPECTIVES FOR THE NEAR FUTURE [LOS TURBORREACTORES PARA LA AVIACION DE COMBATE - REALIDADES DEL PRESENTE Y PERSPECTIVAS PARA UN PROXIMO FUTURO]
MARTIN CUESTA ALVAREZ Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Mar.-Apr. 1990, p. 14-26. In Spanish.
Copyright

A current development status evaluation and a prospective design evolution and performance enhancement assessment are presented for the both afterburnerless and afterburner-incorporating low bypass turbofans used by such advanced tactical aircraft as the Mirage 2000, F/A-18, Gripen, F-15, F-16, Rafale, and EFA. Typical of the state-of-the-art, the F-404/RM 12's thrust/weight ratio on afterburner is 7.83:1; the next-generation Eurojet 200, which is to power EFA, will have a thrust/weight of 8.1:1 without, and fully 10:1 with, afterburner. O.C.

A90-35600
WIDE CHORD FAN CLUB
GUY NORRIS Flight International (ISSN 0015-3710), vol. 137, May 29, 1990, p. 34-36, 38.
Copyright

The major commercial aeroengine manufacturers of the world are being pressed to develop turbofan engines of greater thrust (85000 lbs) to power the proposed aircraft of the next generation. Shroudless wide-chord fan technology appears to be the approach taken by most engine companies at this time. Both hollow, shroudless, titanium wide-chord fan blades and those using composite materials are under study. Impact resistance is a key factor for this technology where tip speeds are relatively low. Pressure ratio that can be generated by the fan tip is limited by the pressure gradient through the gaps between the blades. By increasing the chord the fan tip can be designed to produce more pressure at the limiting pressure gradient, so raising the surge

line and increasing the surge margin. Some initial wide-chord fan testing has demonstrated bypass efficiency improvements ranging from 2 percent at low thrust to more than 9 percent at high thrust compared with the narrow-chord fan with snubbers. R.E.P.

A90-35673
A STUDY OF THE INFLUENCE OF PREDEFORMATIONS ON THE VIBRATIONS OF BLADES
A. ROSEN, R. G. LOEWY, and M. B. MATHEW (Rensselaer Polytechnic Institute, Troy, NY) Journal of Sound and Vibration (ISSN 0022-460X), vol. 138, April 22, 1990, p. 285-304. refs
(Contract DAAG29-82-K-0093; DAAL03-88-C-0004)
Copyright

The influence of flapwise predeformations on the natural frequencies and mode shapes of rotating and non-rotating blades is studied, by using a new method presented recently. The method combines a principal curvature transformation, a velocity component transformation and the generalized co-ordinates approach. In the present paper it is used to analyze the small free vibrations of a blade superimposed on predeformations of finite magnitude. The influence of such parameters as the magnitude and shape of the predeformation, the presence of a root torsional spring representing control system flexibility and changes in structural properties are addressed and discussed. It appears that the influence of predeformations on the free vibrations of blades may be more difficult to anticipate than appears at first glance. The influence is sensitive to various parameters and, therefore, use of detailed numerical calculations will often be required to predict these influences correctly. Blades with predeformations will generally have substantial coupling among out-of-plane and in-plane bending and torsion. It is shown that use of mode identification criteria, such as the strain energy criterion, can be misleading for rotating, predeformed blades.
Author

A90-35708
SIMULATION RESEARCH ON THE AFTERBURNING DYNAMIC CHARACTERISTICS OF ENGINE CONTROL SYSTEM
KEJIU MAO and XU WANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 3, Feb. 1990, p. 23-33.
Copyright

Static and dynamic mathematical models for a new type of engine and its actual hydraulic control system are proposed. A nonlinear mathematical model is used for the engine and afterburner fuel control system. With programs formed on the basis of these models, the static and dynamic close loop characteristics of this engine control system under afterburning conditions have been analyzed in detail. The results are useful for solving many practical problems of the engine control system. Author

A90-35753#
FINITE ELEMENT SIMULATION OF COMPLEX JETS IN A CROSSFLOW FOR V/STOL APPLICATIONS
TAE S. OH and JOSEPH A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 389-399. Previously cited in issue 18, p. 3005, Accession no. A88-44814. refs
Copyright

A90-35764#
TAKEOFF CHARACTERISTICS OF TURBOFAN ENGINES
YOUNG B. SUH (Texas A & M University, College Station) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 458-461.
Copyright

The present derivation of reliable formulas for the takeoff characteristics of turbofan-powered aircraft, encompassing ground-roll distance and time, fuel consumption, etc, incorporates ground effect-induced drag reduction. This drag reduction factor is varied according to type of aircraft; the turbofans in question may be of high-bypass transport-aircraft type or of low bypass and afterburner-employing configuration, as is typically the case in military aircraft. It is shown that bypass ratio variations have little influence on takeoff ground-rolling distance. O.C.

A90-35773
THE T800-LHT-800 ENGINE - DESIGNED FOR SUPPORTABILITY
LARRY R. DEMOTT (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) and KENNETH R. BULT (Allied-Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ) Vertiflite (ISSN 0042-4455), vol. 36, May-June 1990, p. 22-26.
Copyright

The U.S. Army's Reliability and Maintainability, Integrated Logistics Support, and 'MANPRINT' Manpower/Personnel Integration programs have generated requirements which have resulted in the unprecedented supportability characteristics of the T-800-LHT-800 turboshaft engine, whose simple, rugged construction enhances durability without compromising performance. The engine's designers were initially surprised to learn that consideration of soldiers' mental and physical capabilities in battlefield situations were to furnish significant constraints on component and system designs. Attention is given to the characteristics of an interactive, video disk-based training course developed to teach maintenance skills for this engine. O.C.

A90-36786#
THE EXPERIMENTAL STUDY ON THE COAXIAL DUMP COMBUSTOR WITH INNER SWIRL INLET UNDER THE COMBUSTION CONDITION
MENGJUE HU, QIANG YU, SHAOBO LIU, and XINYU QIU (MAS, 31st Research Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), June 1990, p. 20-24. In Chinese, with abstract in English.

In this paper an experiment on a coaxial dump combustor with inner swirl inlet under combustion conditions was carried out. High combustion efficiency was obtained within a wide range of alpha and accompanied with low pressure loss. The embedded structure of recirculation zones is available to improve the combustion efficiency. Author

A90-36787#
EXPERIMENTAL INVESTIGATION OF EXTERNAL HEAT TRANSFER COEFFICIENTS ON FILM-COOLED TURBINE BLADE LEADING EDGE
ZUKAI KONG and JIRUI ZHENG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), June 1990, p. 25-30. In Chinese, with abstract in English.

A semicylinder nose is used in test models to simulate a turbine-blade leading edge with film cooling. Four models with ejection holes at different angles and positions for film cooling are used. The external heat-transfer-coefficient (HTC) distributions along the leading-edge region with and without film cooling are measured separately. It is observed that the mainstream boundary layer is damaged due to the existence of film jets, resulting in an enhancement of external HTCs, especially in the vicinity of film holes. The effect of film cooling on external HTCs increases with the blowing ratios of film jets. Author

A90-37210#
MAIN CHARACTERISTIC PARAMETER MODEL FOR JET ENGINE FAULT DIAGNOSIS
ZUOMIN FAN, CHUNLIN SUN, and ZHAOFU LIN (Civil Aviation Institute of China, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Jan. 1990, p. A37-A45. In Chinese, with abstract in English.

A main characteristics parameter model (MCPM) is presented. The optimum solutions of thermodynamic relationships describing an engine component matching operation are obtained by an optimization method for every possible fault combination, and reasonable optimum solutions are selected according to applicable and reasonable criteria. The MCPM can be used to diagnose primary engine faults, with the number of possible fault parameters exceeding that of measurable parameters. Author

A90-37230#
THE DESIGN OF THE SERIES OF BLADE FLUTTER ROTOR AND THE EXPERIMENTAL INVESTIGATION OF FLOW-INDUCED VIBRATION
ZHAOHONG SONG, YUWEI WANG, and REILIAN KONG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Feb. 1990, p. B31-B39. In Chinese, with abstract in English. refs

The design of a series of blade flutter rotors and several kinds of flow-induced vibration phenomena which occurred in the experiment are introduced. The methods of measurement used in the experiment are also presented, and the blade stall flutter phenomena are analyzed. Author

A90-37239#
STUDY ON PROCESS CONTROL OF AEROENGINE USING MICROCOMPUTER
DING FAN and CHIHUA WU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Feb. 1990, p. B93-B97. In Chinese, with abstract in English.

The start-up of an aeroengine controlled by a microcomputer was studied. The start-up fuel supply was controlled according to the relation between the corrective start-up fuel supply and the corrective speed for automatic regulation of the fuel supply under different climatic conditions. In order to guarantee the safety and reliability of the aeroengine, several parameters of the engine were monitored. The hybrid simulation test for the whole start-up process was carried out, and satisfactory results were obtained. Author

A90-37562*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PERFORMANCE CHARACTERISTICS OF A ONE-THIRD-SCALE, VECTORABLE VENTRAL NOZZLE FOR SSTOVL AIRCRAFT
BARBARA S. ESKER and JACK G. MCARDLE (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 11 p. Previously announced in STAR as N90-21725.
(AIAA PAPER 90-2271) Copyright

Several proposed configurations for supersonic short takeoff, vertical landing aircraft will require one or more ventral nozzles for lift and pitch control. The swivel nozzle is one possible ventral nozzle configuration. A swivel nozzle (approximately one-third scale) was built and tested on a generic model tailpipe. This nozzle was capable of vectoring the flow up to + or - 23 deg from the vertical position. Steady-state performance data were obtained at pressure ratios to 4.5, and pitot-pressure surveys of the nozzle exit plane were made. Two configurations were tested: the swivel nozzle with a square contour of the leading edge of the ventral duct inlet, and the same nozzle with a round leading edge contour. The swivel nozzle showed good performance overall, and the round-leading-edge configuration showed an improvement in performance over the square-leading-edge configuration. Author

A90-38129
ELECTRICAL POWER SYSTEMS FOR HIGH MACH VEHICLES
I. S. MEHDI and E. J. WOODS (Boeing Co., Seattle, WA) IN: IECEC-89; Proceedings of the Twenty-fourth Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug. 6-11, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1989, p. 625-630. refs
Copyright

Recent electrical power system investigations for Mach 3 to 25 aircraft are described. Several electrical power system voltage and frequency combinations are considered. A reliability and failure analysis was performed on each of several architectures to determine its suitability for supplying electrical power to the aircraft. It was found that a system architecture having three separate generating sources provided good reliability and enough redundancy so that the aircraft would still fly after the failure of two generating channels, and the mission could be completed after the failure of one generating channel. I.E.

A90-38130
CONTROL OF A SWITCHED-RELUCTANCE AIRCRAFT ENGINE STARTER-GENERATOR OVER A VERY WIDE SPEED RANGE
STEPHEN R. MACMINN (General Electric Co., Schenectady, NY) and JAMES W. SEMBER (GE Drive Systems, Salem, VA) IN: IECEC-89; Proceedings of the Twenty-fourth Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug. 6-11, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1989, p. 631-638. refs
Copyright

An electric direct-drive gearless starter-generator has been designed and built for an aircraft-engine application. The system is based on a switched reluctance motor, which was chosen for its simplicity, ruggedness, high-speed capability, and efficiency. A description is given of motor control system algorithms and hardware, which are used to control the motor over its operating speed range from standstill to 48,000 rpm in both monitoring and generating modes. Novel features of the starter-generator control system are a closed-loop regulator which controls the amount of firing angle advance to maintain optimum torque production at high speed, and a hardware-based digital commutation controller which generates phase firing pulses for the inverter on the basis of machine rotor angle, pulse width, and pulse advance. I.E.

A90-38186
ACCELERATING HYPERSONIC AIRPLANES WITH GROUND-POWER
HENRY OMAN (Boeing Aerospace, Seattle, WA) IN: IECEC-89; Proceedings of the Twenty-fourth Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug. 6-11, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1989, p. 1131-1136.
Copyright

The possible benefits of using ground power to accelerate the hypersonic airplane on a launch ramp are quantified. A passenger-carrying hypersonic airplane leaving its loading ramp carries fuel for acceleration, cruise, and landing. A ramp for launching a 150-metric-ton vehicle to Mach 5 with 4-g acceleration would be 38-km long and require up to 10 GW of power. In the final second, 2.8 MWh of energy would be consumed along 1720 m of ramp. Possible scenarios and acceleration mechanisms are evaluated. I.E.

A90-38472#
HEAT TRANSFER IN A SOLID FUEL RAMJET COMBUSTOR
F. M. VINNEMEIER (DLR, Institut fuer chemische Antriebe und Verfahrenstechnik, Hardthausen am Kocher, Federal Republic of Germany) and J. P. DE WILDE (Delft, Technische Universiteit, Netherlands) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 5th, Seattle, WA, June 18-20, 1990. 10 p. Research supported by the Stichting voor de Technische Wetenschapen. refs
(AIAA PAPER 90-1783) Copyright

A new approach has been used to determine the convective heat transfer from a flow of air toward the surface of a cylindrical channel with an abrupt expansion. Temperature histories measured at various depths under the surface of the fuel grain are compared with theoretically determined histories using a computer model. By fitting the predicted temperature histories to the measured ones, the value for the convective heat transfer coefficient can be determined. Author

A90-38531#
TECHNOLOGY UPDATE OF EARLY GAS TURBINE DESIGNS
ALAN RHODES (Rolls-Royce, PLC, Bristol, England) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 11 p.

The topic of the paper is the Harrier/AV8 'jump jet' and, more

specifically, its powerplant the Pegasus gas turbine. It is shown that the engine redesign is responsible for an orderly arrangement of nine modules which offer maximum flexibility at minimum labor cost for both intermediate and depot support levels. The main changes for the LP compressor, HP compressor, combustor, LP turbine, HP turbine, and exhaust unit are discussed. Emphasis is placed on a full-authority digital engine control system and aircraft costs and maintenance. It is concluded that the design changes to the core engine offer reduction in the cost of ownership which together with the associated with improvements in maintainability lead to the bottom line requirement of enhanced aircraft availability at operational level. V.T.

A90-38532#
PROGRESS IN CERTIFYING F402-RR-408 - THE IMPROVED PEGASUS ENGINE FOR AV-8B AND HARRIER II PLUS
DAVID J. MARTIN (Rolls-Royce, PLC, Bristol, England) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 9 p. Research supported by Ministry of Defence of England and Rolls-Royce, PLC.

A demonstrator-engine program for improved performance of the Harrier/AV8 family of aircraft is described. The main objectives and characteristics of the program, including installation, lift thrust, combat thrust, surge margin, limitation on weight increase, and service life, are outlined. Demonstrator-engine features are covered, with focus placed on turbine blade materials and cooling techniques, combustor and turbine designs, and a fan rig. Demonstrator results are analyzed, and it is noted that a required action to improve is the tendency for the fan to surge during a slam deceleration, that the introduction of 'T' vaporizers leads to a significant reduction in the combustion chamber outlet temperature distribution factor, and that the maximum blade temperature can be reduced by 160 C and 80 C for the first and second stages, respectively. A modularized, weight-reduced, and bird-proofed production design is also presented, and the demonstrator program status is assessed. V.T.

A90-38534#
TILT ROTOR REQUIREMENTS ON ENGINE DESIGN AND QUALIFICATION
STEVE MURRAY and CRAIG HEATHCO (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 12 p.

The design constraints imposed on gas turbine engines by tilt rotor installations are discussed, and the development testing conducted to verify design concepts is addressed. Emphasis is placed on the design of the lubrication and vent system of the engine, in particular, its functions which are taxed by the wide variations in attitude - scavenging, oil pickup, tank venting, and oil retention. Two stages of the development testing are presented: component rigs used to insure that critical design parameters are met, and an attitude test facility where full engine evaluations are performed. V.T.

A90-38539#
POWER TRANSFER DEVICES FOR V/STOL CONVERTIBLE ENGINE SYSTEMS
D. A. WAGNER, T. F. MCKAIN, and R. J. SCHOOLCRAFT (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 9 p.

Power-transfer mechanisms for V/STOL convertible engines capable of dual thrust and shaft modes of operation are discussed, with emphasis placed on a clutch and torque converter approach. Automotive wet and dry disk clutches are considered, and heat rejection as a key design parameter is examined. Clutch installations in aircraft are covered, including convertible-engine clutch design characteristics. Torque converters considered for use in convertible engines as a means of coupling and decoupling the fan with the engine power turbine are also covered, and torque-converter size relationships as a function of speed and power are outlined. It is noted that convertible-engine clutches are expected to operate at higher energy levels than current automotive limits, while significant converter performance benefits are expected for convertible engine applications by optimizing for 1:1 speed ratio operation. V.T.

A90-38596#
AN APPLICATION OF EXPERT SYSTEM TO JET ENGINE DIAGNOSTIC PROCEDURES
HIROSHI ISHIZAWA, KOJIRO UMENE, and TOSHIHARU WAGURI Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 30, March 1990, p. 95-99. In Japanese, with abstract in English.

Functional and performance checks (including engine control trims) are required for jet engine test runs followed by engine production or overhaul in order to verify acceptability of the engines. Diagnostic procedure resulting from engine trouble during test runs has been brought forth by experts who have many years of experience and differing backgrounds of specialized knowledge. Diagnostic procedure is the result of proper judgements based on experience and knowledge using quite a lot of data and a rapid treatment. This paper deals with an application of expert system for jet engine diagnostic procedure including knowledge acquisition, knowledge base construction, inference mechanism, applications and so forth. Author

A90-38597#
EXPERT DIAGNOSIS SYSTEM FOR FJR ENGINE TROUBLES
KUNIYASU YAMANAKA, HIDEO KOBAYASHI, TOSHIAKI MORIMOTO, and HIROSHI FUJIYAMA Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 30, March 1990, p. 100-105. In Japanese, with abstract in English.

The expert diagnosis system has been developed for the FJR710/600S engine installed for the quiet STOL research aircraft 'ASUKA'. This expert system has been designed with conventional expert program on the small-sized personal computer, not only from the economical point of view but also from the viewpoint of operational convenience. The main objects of this system are to compile and integrate the knowledge of engine touble-shooting and to verify the ability of diagnosis by small-scale expert system. This present paper describes the outline and the estimation of the system. Author

A90-38761*# Virginia Univ., Charlottesville.
INJECTANT MOLE FRACTION MEASUREMENTS OF TRANSVERSE INJECTION IN CONSTANT AREA SUPERSONIC DUCTS
STEVEN D. HOLLO, ROY J. HARTFIELD, JR., and JAMES C. MCDANIEL (Virginia, University, Charlottesville) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 14 p. refs
(Contract NAG1-795)
(AIAA PAPER 90-1632) Copyright

Planar measurements of the injectant mole fraction distribution in a nonreacting model SCRAMJET combustor have been made using a nonintrusive optical technique, laser-induced iodine fluorescence. The combustor geometry investigated in this work was staged, transverse sonic injection of air into Mach 2 and Mach 2.9 freestreams. Accurate three-dimensional surveys of the injectant mole fraction distribution for both freestream Mach numbers have been generated. These experimental measurements provide valuable insight into the fluid mechanics of the mixing process. The existence of streamwise vortices is shown to dominate the mixing in the injector nearfield while shock wave interactions with the injectant plume are seen to significantly enhance mixing downstream of the injectors. The effect of combustor Mach number on injectant mixing is found to be small for this geometry. These measurements provide an accurate data set for the validation of computational fluid dynamics codes being developed for the calculation of highly three-dimensional nonreacting supersonic combustor flow fields. Author

N90-21760*# McDonnell Aircraft Co., Saint Louis, MO.
EXHAUST ENVIRONMENT MEASUREMENTS OF A TURBOFAN ENGINE EQUIPPED WITH AN AFTERBURNER AND 2D NOZZLE Final Report
L. O. BRASE Washington May 1990 59 p Sponsored in part by Air Force Wright Research and Development Center and Pratt and Whitney
(NASA-CR-4289; E-5302; NAS 1.26:4289) Avail: NTIS HC A04/MF A01 CSCL 21E

A test to measure the acoustic noise and static pressure environment on a structure exposed to engine exhaust flow was conducted at the NASA Lewis Research Center Propulsion Systems Laboratory by using an F100 derivative engine with a two-dimensional convergent-divergent (2D/CD) non-flight-weight demonstrator nozzle. A highly instrumented, water cooled flat panel was placed behind the 2D/CD nozzle, and tests were conducted at simulated Mach/altitude flight conditions with the engine at military or maximum-afterburner power setting. The panel instrumentation consisted of acoustic pressure microphones, thermocouples, and static-pressure pickups. Measurements indicated that the exhaust environment may excite structural resonances up to 10,000 HZ and that overall sound pressure levels decrease with increasing altitude. Author

N90-21761*# Pratt and Whitney Aircraft, West Palm Beach, FL.
ASSESSMENT OF HIGH TEMPERATURE SUPERCONDUCTING (HTS) ELECTRIC MOTORS FOR ROTORCRAFT PROPULSION Final Report
JAY DOERNBACH Apr. 1990 49 p
(Contract NAS3-25117)
(NASA-CR-185222; NAS 1.26:185222; PW-FR-20668) Avail: NTIS HC A03/MF A01 CSCL 21E

The successful development of high temperature superconductors (HTS) could have a major impact on future aeronautical propulsion and aeronautical flight vehicle systems. Applications of high temperature superconductors have been envisioned for several classes of aeronautical systems, including subsonic and supersonic transports, hypersonic aircraft, V/STOL aircraft, rotorcraft and solar powered aircraft. The potential of HTS electric motors and generators for providing primary shaft power for rotorcraft propulsion is examined. Three different sized production helicopters were investigated; namely, the Bell Jet Ranger, the Sikorsky Black Hawk and the Sikorsky Super Stallion. These rotorcraft have nominal horsepower ratings of 500, 3600, and 13400 respectively. Preliminary results indicated that an all-electric HTS drive system produces an improvement in rotorcraft Takeoff Gross Weight (TOGW) for those rotorcraft with power ratings above 2000 horsepower. The predicted TOGW improvements are up to 9 percent for the medium-sized Sikorsky Black Hawk and up to 20 percent for the large-sized Sikorsky Super Stallion. The small-sized Bell Jet Ranger, however, experienced a penalty in TOGW with the all-electric HTS drive system. Author

N90-21762*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ON THE USE OF EXTERNAL BURNING TO REDUCE AEROSPACE VEHICLE TRANSONIC DRAG
CHARLES J. TREFNY 1990 12 p Proposed for presentation at the 26th Joint Propulsion Conference, Orlando, FL, 16-18 Jul. 1990; cosponsored by AIAA, ASME, SAE, and ASEE
(NASA-TM-103107; E-5431; NAS 1.15:103107; AIAA-90-1935)
Avail: NTIS HC A03/MF A01 CSCL 21E

The external combustion of hydrogen to reduce the transonic drag of aerospace vehicles is currently being investigated. A preliminary analysis based on a constant pressure control volume is discussed. Results indicate that the specific impulse of the external burning process rivals that of a turbojet and depends on the severity of the initial base drag as well as on the Mach flight number and the equivalence ratio. A test program was conducted to investigate hydrogen-air flame stability at the conditions of interest and to demonstrate drag reduction on a simple expansion ramp. Initial test results are presented and compared with the control-volume analysis. The expansion ramp surface pressure coefficient showed little variation with fuel pressure and altitude, in disagreement with the analysis. Flame stability results were encouraging and indicate that stable combustion is possible over an adequate range of conditions. Facility interference and chemical kinetics phenomena that make interpretation of subscale ground test data difficult are discussed. Author

N90-21763*# Sverdrup Technology, Inc., Brookpark, OH.
PRELIMINARY DESIGN OF A LONG-ENDURANCE MARS AIRCRAFT Final Report
ANTHONY J. COLOZZA Apr. 1990 14 p Proposed for presentation at the 26th Joint Propulsion Conference, Orlanda, FL, 16-18 Jul. 1990; sponsored by AIAA, SAE, ASME and ASEE
(Contract NAS3-25266)
(NASA-CR-185243; E-5475; NAS 1.26:185243; AIAA-90-2000)
Avail: NTIS HC A03/MF A01 CSCL 21E

The preliminary design requirements of a long endurance aircraft capable of flight within the Martian environment was determined. Both radioisotope/heat engine and PV solar array power production systems were considered. Various cases for each power system were analyzed in order to determine the necessary size, weight and power requirements of the aircraft. The analysis method used was an adaptation of the method developed by Youngblood and Talay of NASA-Langley used to design a high altitude earth based aircraft. The analysis is set up to design an aircraft which, for the given conditions, has a minimum wingspan and maximum endurance parameter. The results showed that, for a first approximation, a long endurance aircraft is feasible within the Martian environment. The size and weight of the most efficient solar aircraft were comparable to the radioisotope powered one. Author

N90-21981# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
MESH GENERATION FOR FLOW COMPUTATION IN TURBOMACHINE
M. GOUTINES, G. KARADIMAS, and C. HAH (General Electric Co., Schenectady, NY.) *In* AGARD, Applications of Mesh Generation to Complex 3-D Configurations 13 p Mar. 1990
Copyright Avail: NTIS HC A14/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Building grids for flow computation in turbomachine applications is examined. H,I,C, and O types are discussed for 2D or 3D, inviscid or viscous flow cases. The given examples concern 3D Euler application on a fan with part-span damper and splitter, 2D Navier-Stokes on turbine and compressor transonic cascades, and 3D Navier-Stokes on a transonic fan. Author

N90-22565 Stevens Inst. of Tech., Hoboken, NJ.
COMPUTATIONAL AND EXPERIMENTAL INVESTIGATIONS OF ROTATING STALL IN COMPRESSOR CASCADES Ph.D. Thesis
SREENADH S. JONNAVITHULA 1988 207 p
Avail: Univ. Microfilms Order No. DA9001134

The phenomenon of rotating stall appears in compressors operating under severe loadings at off design points. This causes undesirable loss of performance and the resulting periodic loading on the blades leads to noise, vibration and possibly fatigue failure. Numerical and experimental methods are employed to study this phenomenon. The relatively novel discrete vortex method is employed to numerically predict the occurrence of rotating stall in isolated cascades, and also to establish the stall propagation rates in the post stall regime. This method consists of discretizing the flow field by using a large collection of vortex blobs which are then allowed to convect under their mutual influence. The streamline plots of the stalled cascade obtained aid in the visualization of the phenomenon, showing explicit evidence of strong reverse flows within the stall cell. Detailed parametric studies of the influence of the various flow parameters like the inflow angle and stall cell wavelength, and geometric parameters like the cascade solidity, blade camber and stagger have been performed. It is found that the influence of most of these parameters

is quite complex, with strong parameter interaction. Thus, the stall propagation velocity decreased with inflow angle at low stagger angles, but increased with inflow angle for high stagger angles. The effect of camber was found to be primarily in altering the stall inception point and there was little influence on the post stall regime. Increased blade solidity was found to decrease the velocity. An experimental investigation of rotating stall was conducted using the Stevens axial compressor test rig. The occurrence of rotating stall in this research compressor was demonstrated, and some experimental studies were conducted of the effect of the various flow parameters on the propagation velocity. Traverses of the stalled flow field combined with digital data acquisition and ensemble averaging procedures produced detailed information on the variations of axial and tangential velocities throughout the radial extent of the stall cell. Dissert. Abstr.

N90-22566*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A MODELING TECHNIQUE FOR STOVL EJECTOR AND VOLUME DYNAMICS
C. K. DRUMMOND and W. S. BARANKIEWICZ 1990 13 p Presented at the 26th Joint Propulsion Conference, Orlando, FL, 16-18 Jul. 1990; cosponsored by AIAA, SAE, ASME, and ASEE (NASA-TM-103167; E-5539; NAS 1.15:103167; AIAA-90-2417)
Avail: NTIS HC A03/MF A01 CSCL 21/5

New models for thrust augmenting ejector performance prediction and feeder duct dynamic analysis are presented and applied to a proposed Short Take Off and Vertical Landing (STOVL) aircraft configuration. Central to the analysis is the nontraditional treatment of the time-dependent volume integrals in the otherwise conventional control-volume approach. In the case of the thrust augmenting ejector, the analysis required a new relationship for transfer of kinetic energy from the primary flow to the secondary flow. Extraction of the required empirical corrections from current steady-state experimental data is discussed; a possible approach for modeling insight through Computational Fluid Dynamics (CFD) is presented. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A90-35847
FLIGHT BEYOND NORMAL LIMITS
JOHN BAILEY Flight International (ISSN 0015-3710), vol. 137, May 9, 1990, p. 54-56, 59.
Copyright

Development of the MBB/Rockwell X-31A enhanced fighter maneuverability demonstrator is programmed to create an aircraft capable of performing maneuvers that are normally unachievable. This will take the aircraft beyond stall angle-of-attack limits and then flipping it into tight-radius turns at slow speed. Additional requirements called for rapid deceleration, and flight path decoupling to allow fuselage pointing, all aimed at improving performance and survivability during close-in combat. Successful post-stall maneuvering requires that the aircraft should be rolled around its velocity vector without sideslip, through a combination of body-axis yaw and body-axis roll. The design goals specified that the aircraft's control surfaces should retain enough authority at high alpha to recover from unusual attitudes in the event of an engine or thrust-vectoring system failure. The X-31 is the first aircraft to use thrust vectoring to provide both pitch and yaw moments, and the aircraft can be flown entirely with control stick inputs, with the rudder pedals used only for intended sideslips and crosswind landings. R.E.P.

A90-35888
AIR COMBAT BEYOND THE STALL
BRIAN WANSTALL and J. R. WILSON Interavia (ISSN 0020-5168), vol. 45, May 1990, p. 405-407.
Copyright

Two X-31A aircraft are to be built jointly by Rockwell International and MBB in an evaluation and test program managed by the U.S. Navy. The major focus of the program is to demonstrate and test controls, displays, software and tactics for future fighters aiming to take advantage of the previously avoided post-stall region of aerial combat maneuvers. The need for high maneuverability at very low speeds stems from the improvements over the past decade in the sensitivity of infrared seekers used on short-range air-to-air missiles. Conventional fighter controls are less responsive at low speed and the aircraft may well be uncontrollable at the stall, when the turn radius should be at its minimum. Configuration studies showed that aerodynamic controls could provide adequate nose-up pitch control, but that nose-down pitch control and roll control were marginal above the stall. Adequate control power for pitch-down is, however, a vital safety factor for recovery from high angle-of-attack maneuvers with engine out or failure of thrust-vectoring devices. The design therefore had to have the control margin to achieve the desired pitch recovery rate under all conditions. R.E.P.

A90-36030*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PILOTED SIMULATOR ASSESSMENTS OF AGILITY
EDWARD T. SCHNEIDER (NASA, Flight Research Center, Edwards, CA) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 9 p. refs (AIAA PAPER 90-1306)

NASA has utilized piloted simulators for nearly two decades to study high-angle-of-attack flying qualities, agility, and air-to-air combat. These studies have included assessments of an F-16XL aircraft equipped with thrust vectoring, an assessment of the F-18 HARV maneuvering requirements to assist in thrust vectoring control system design, and an agility assessment of the F-18. The F-18 agility assessment was compared with in-flight testing. Open-loop maneuvers such as 180-deg rolls to measure roll rate showed favorable simulator/in-flight comparison. Closed-loop maneuvers such as rolls to 90 deg with precision stops or certain maximum longitudinal pitching maneuvers showed poorer performance due to reduced aggressiveness of pilot inputs in flight to remain within flight envelope limits. Author

A90-36157
AUTOMATION OF FLIGHT SAFETY CONTROL [AVTOMATIZATSIIA UPRAVLENIIA BEZOPASNOST'IU POLETOV]
A. G. GAMULIN, G. V. GROMOV, A. S. KOSTRITSKII, A. M. BORSHCH, IU. A. PONOMAREV et al. Moscow, Izdatel'stvo Transport, 1989, 120 p. In Russian. refs
Copyright

The principles of the design of a multilevel automatic flight safety control system are presented. In particular, attention is given to the formalized description of the automatic flight safety control system, typical subsystems, the functional and organizational structure of the system, and software support. The discussion also covers some problems associated with the development of new subsystems. V.L.

A90-36433#
APPLICATION OF TRANSFORMATIONAL IDEAS TO AUTOMATIC FLIGHT CONTROL DESIGN
WENHUA LI and FENG LIANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, April 1990, p. B165-B170. In Chinese, with abstract in English. refs

To design actual nonlinear systems through a geometric approach, obstacles such as complex transformation and great amount of calculations need to be eliminated. Therefore it is important to make the design procedure simple and clear. In this

paper two methods based upon transformation ideas are developed and applied to the design of the vertical control system of the F-8 Crusader Fighter. Simulation results show that the new control law works much better than the former nonlinear optimal control law and makes high-angle-attack flight available. Author

A90-36434#
A DESIGN METHOD FOR REAL-TIME COMPUTER CONTROL HYDRAULIC FORCE SYSTEM
XIAOBIN CAI and GUANZHONG DAI (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, April 1990, p. B171-B176. In Chinese, with abstract in English. refs

In this paper, a method of designing the digital controller for real-time computer control hydraulic force system with conditional output feedback is presented. The basic principle, the construction of conditional feedback controller, and the design procedure are discussed. This controller is applied to the structural strength loading control system, which is the experimental system of a variable swept aircraft wing. Experiments show that the design method presented in this paper is feasible and the results are quite good. Author

A90-37219#
THE STUDY OF TRANSIENT SUPPRESSION TECHNIQUES FOR MULTIMODE FLIGHT CONTROL SYSTEM
YIDONG YANG, PEIYI NIU, and JIANG HAO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Jan. 1990, p. A88-A92. In Chinese, with abstract in English.

To achieve a successful transition between flight control modes, the amplitude of transients must be suppressed to an allowed extent. This paper takes a digital multimode direct force flight control system as an example and presents several transient suppression methods. The results of hybrid simulations have shown that the present methods are successful in transients suppression and that the aircraft behavior during the transition period is satisfactory. Author

A90-37220#
THE METHOD OF RANDOM VARIABLE STRUCTURE OPTIMAL CONTROL FOR AIRCRAFT
SHOUSONG HU and YAQUN HE (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Jan. 1990, p. A93-A97. In Chinese, with abstract in English.

An approach of variable structure optimal control for stochastic linear continuous systems whose measurement noise is Gaussian white noise is presented. The principle of separation is proven from the design of sliding modes and selection of the control variable. Therefore, the design of variable structure control and optimal estimation of state variables can be investigated separately. It thus simplifies the design of variable structure control for stochastic systems. The design of an aircraft control system is discussed using the above method as an illustration, and a numerical simulation is done. Author

A90-37226#
A STUDY OF THE CONTROL TECHNIQUE FOR AIRCRAFT SPIN RECOVERY
CHANG LIU and MING JIANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Feb. 1990, p. B1-B9. In Chinese, with abstract in English. refs

Based on the bifurcation analysis and catastrophe theory methodology (BACTM) and by using the full six-degree-of-freedom nonlinear equations of motion, the characteristics of equilibrium surfaces were analyzed, and control techniques for aircraft spin recovery were studied. With the employment of the Pontryagin maximum principle, an optimal treatment was carried out on the control history of spin recovery developed by BACTM, and the most rapid spin recovery control history was obtained. Based on this result, a suboptimal spin recovery technique has been founded. Author

A90-37963#
LARGE-AMPLITUDE HIGH-RATE ROLL OSCILLATION SYSTEM FOR THE MEASUREMENT OF NON-LINEAR AIRLOADS
E. S. HANFF, K. KAPOOR, C. R. ANSTEY, and A. PRINI (National Aeronautical Establishment, Ottawa, Canada) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 11 p. refs
(AIAA PAPER 90-1426) Copyright

A large-amplitude high-rate roll oscillation system has been developed to conduct dynamic wind-tunnel tests involving motions with realistic reduced angular rates and amplitudes. The equipment has been used to conduct extensive tests on a delta and double delta-wing models at Re 2.5 x 10 to the 6th. A description of the equipment is presented together with a brief review of the test program. Some interesting results that demonstrate the value of this type of experiment in obtaining aerodynamic data in the nonlinear flight regime are also described. Author

A90-38519
AIR RESONANCE STABILITY OF HINGELESS ROTORS IN FORWARD FLIGHT
JAMES M. WANG, JINSEOK JANG, and INDERJIT CHOPRA (Maryland, University, College Park) Vertica (ISSN 0360-5450), vol. 14, no. 2, 1990, p. 123-136. refs
(Contract DAAL03-88-C-0002)
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Air resonance in forward flight is examined for hingeless rotors using a finite element formulation. The fuselage is modeled as a rigid body undergoing five degrees of freedom. The blade is modeled as an elastic beam undergoing flap bending, lag bending, elastic twist, and axial deformation. The vehicle trim and blade response solutions are calculated as one coupled solution using a modified Newton method. The blade response is calculated using a finite element method in time after the nonlinear finite element equations in space are transformed to normal mode equations. Unsteady aerodynamic effects are included using dynamic inflow modeling. The linearized periodic coupled rotor-body perturbation equations in the nonrotating frame are solved for the stability roots using Floquet transition matrix theory as well as constant coefficient approximation. Systematic parametric studies are then carried out to examine the effects of several design variables on air resonance stability in forward flight. Blade stiffness and fuselage roll inertia were found to have powerful influence on air resonance stability. Author

A90-38521* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A SURVEY OF NONUNIFORM INFLOW MODELS FOR ROTORCRAFT FLIGHT DYNAMICS AND CONTROL APPLICATIONS
ROBERT T. N. CHEN (NASA, Ames Research Center, Moffett Field, CA) (European Rotorcraft Forum, 15th, Amsterdam, Netherlands, Sept. 12-15, 1989) Vertica (ISSN 0360-5450), vol. 14, no. 2, 1990, p. 147-184. Previously announced in STAR as N90-15938. refs
Copyright

The results of a brief survey of nonuniform inflow models was summarized for the calculation of induced velocities at and near a lifting rotor in and out of ground effect. The survey, conducted from the perspective of flight dynamics and control applications, covers a spectrum of flight conditions including hover, vertical flight, and flow-speed and high-speed forward flight, and reviews both static and dynamic aspects of the inflow. A primary emphasis is on the evaluation of various simple first harmonic inflow models developed over the years, in comparison with more sophisticated methods developed for use in performance and airload computations. The results of correlation with several sets of test data obtained at the rotor out of ground effect indicate that the Pitt/Peters first harmonic inflow model works well overall. For inflow

near the rotor or in ground effect, it is suggested that charts similar to those of Heyson/Katzoff and Castles/De Leeuw of NACA be produced using modern free-wake methods for use in flight dynamic analyses and simulations. Author

A90-38522
DEVELOPMENT AND VERIFICATION OF AN ALGORITHM FOR HELICOPTER INVERSE SIMULATIONS
D. G. THOMSON and R. BRADLEY (Glasgow, University, Scotland) Vertica (ISSN 0360-5450), vol. 14, no. 2, 1990, p. 185-200. Sponsorship: Ministry of Defence. refs
(Contract MOD-2048/39/XR/FS)
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The control displacements required for a helicopter to fly a defined maneuver may be calculated by inverse solution of the vehicle's equations of motion. A computer package, HELINV, has been developed to perform such solutions, or inverse simulations, for a series of nap-of-the-earth (NOE) maneuvers. This gives a unique opportunity to study simulated control strategies in constrained freedom nonlinear mathematical model which allows solutions to be found for various helicopter configurations flying a wide range of maneuvers. Some typical results are presented, along with a discussion of the limitations and potential applicability of the algorithm. The method is verified by use of time response calculations. In addition, flight data is used to validate the results of inverse simulations. Author

A90-38524* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
RESULTS OF AN A109 SIMULATION VALIDATION AND HANDLING QUALITIES STUDY
MICHELLE M. ESHOW (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), DIEGO ORLANDI, GIOVANNI BONAITA (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Cascina Costa, Italy), and SERGIO BARBIERI (Aeronautica Militare Italiana, Rome, Italy) (European Rotorcraft Forum, 14th, Milan, Italy, Sept. 20-23, 1988) Vertica (ISSN 0360-5450), vol. 14, no. 2, 1990, p. 217-235. Previously announced in STAR as N89-24323. refs
Copyright

The results for the validation of a mathematical model of the Agusta A109 helicopter, and subsequent use of the model as the baseline for a handling qualities study of cockpit centerstick requirements, are described. The technical approach included flight test, non-realtime analysis, and realtime piloted simulation. Results of the validation illustrate a time- and frequency-domain approach to the model and simulator issues. The final A109 model correlates well with the actual aircraft with the Stability Augmentation System (SAS) engaged, but is unacceptable without the SAS because of instability and response coupling at low speeds. Results of the centerstick study support the current U.S. Army handling qualities requirements for centerstick characteristics. Author

A90-38530*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLIGHT/PROPULSION CONTROL INTEGRATION FOR V/STOL FIGHTER/ATTACK AIRCRAFT
JAMES A. FRANKLIN and MICHAEL W. STORTZ (NASA, Ames Research Center, Moffett Field, CA) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 18 p. refs

A NASA-defined technology program investigating integrated flight/propulsion control system design for vertical and short takeoff and landing (V/STOL) aircraft is outlined, and initial fixed-base simulation experiments for two V/STOL aircraft are covered. It is shown that transition performance can be characterized by the minimum climb or level-flight acceleration that can be achieved. Level-1 flying qualities can be achieved for deceleration to hover in instrument conditions, and for shore-based and shipboard landing when attitude and velocity stabilization and command augmentation modes are provided. Level-1 and Level-2 flying qualities can be expected when only attitude command is provided. During vertical landing aboard a destroyer in heavy seas, substantial bleed flow rates are reported for a control arrangement employing reaction control for the pitch, roll, and yaw axes. Peak bleed flows can be reduced for a control arrangement using lateral-thrust transfer for roll control. V.T.

A90-38758#
PROPORTIONAL CONTROL OF ASYMMETRIC FOREBODY VORTICES WITH THE UNSTEADY BLEED TECHNIQUE
D. R. WILLIAMS and J. E. BERHARDT (Illinois Institute of Technology, Chicago) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 15 p. refs
(Contract F49620-86-C-033)
(AIAA PAPER 90-1629) Copyright

The ability of the unsteady bleed technique to control the degree of asymmetry of a pair of steady tip vortices separating from a forebody model is demonstrated. The vortex system does not respond to the forcing until a threshold amplitude is reached, at which point the vortices switch position and the sign of the sectional side-force coefficient changes. Consequently, proportional control with low-amplitude forcing does not appear to be feasible at angles of attack above 55 degrees. Author

N90-21764 Rutgers Univ., New Brunswick, NJ.
NUMERICAL INVESTIGATION OF SOME CONTROL METHODS FOR 3-D TURBULENT INTERACTIONS DUE TO SHARP FINS Ph.D. Thesis
DATTA V. GAITONDE 1989 203 p
Avail: Univ. Microfilms Order No. DA8923594

Numerical efforts are described for the modification and control of 3-D shock wave-turbulent boundary layer interactions due to supersonic flow past sharp fin/fins mounted on a flat plate. The first set of computations investigates the effect of bleed on single figure configurations (SFCs). For a strong interaction, suction is applied on two regions-Region 1 covering the area on the flat plate between the line of upstream influence and the theoretical inviscid shock line (TISL) and Region 2 covering the remaining portion of the plate between the TISL and the base of the fin. The largest suction case corresponds to bleeding of roughly 25 percent of the incoming boundary layer. Numerical pilot pressure and yaw angles are compared with experimental data obtained in the absence of bleed. Comparison with experimental data and analysis of the computed results indicates that the effect of bleed is primarily due to reduce the surface angularity and upstream influence. The motivation for the second set of computations derives from the conclusion of Mee and Stalker that shock-shock intersections may be capable of producing a given pressure rise with less likelihood of separation. Three computations on symmetric double fin configurations are described. The first (5 x 5 deg) corresponds to the strongest interaction. The overall comparison with experiment is good with modest discrepancies in extent of upstream influence. No flow separation is observed. Two other configurations (4 x 4 deg and 8 x 8 deg) are also simulated. Analysis of the computed flowfield indicates that the first is a weak interaction. In contrast, the 8 x 8 configuration displays an interesting surface pattern with turning angles larger than the shock angle. The consequent separated flowfield is examined with particle traces. Dissert. Abstr.

N90-21765 Stanford Univ., CA.
OPTIMAL CONTROL OF AN AIRCRAFT FLYING THROUGH A DOWNBURST Ph.D. Thesis
YI YUAN ZHAO 1989 280 p
Avail: Univ. Microfilms Order No. DA8925985

A downburst is a mass of cold air that descends to the ground in a column with a diameter of .1 to 1 kilometer. It lasts only five to ten minutes, but during that time, it creates vertical winds up to 50 ft per second and, as it spreads out near the ground, horizontal winds up to 100 ft/sec. The exsistence of downbursts was only recently discovered. Downbursts are the suspected cause of several aircraft accidents. The best way to handle a downburst is not to fly through it. However, a downburst

is difficult to detect until the aircraft starts into it. Thus the problem of how to fly an aircraft through a downburst is of interest. The problem is considered mainly at take-off but also the landing problem is discussed. Downbursts are modeled by three dimensional vortex rings. The concept of pseudo-energy is introduced, which is the kinetic energy of an aircraft relative to the airmass plus the potential energy of the aircraft relative to the inertial ground. The control of an aircraft flying through a downburst is formulated as a dynamic optimization problem with a minimum altitude constraint and two different performance measures. A generalized gradient algorithm is developed to solve this problem numerically. Paths are determined through a downburst that maximize the pseudo-energy just after penetration (survival), and minimize deviation from the intended flight path (performance maintaining). Since the intensity of a downburst is difficult to assess use is recommended of the survival flight path strategy when the pilot believes he has entered a downburst. This strategy involves immediate application of maximum thrust, along with rapid descent to the minimum safe altitude; this increases airspeed and places the aircraft in a region of lower downdraft velocity. Simulation results suggest that the Delta Flight 191 would not have crashed if the proposed strategy had been followed. Dissert. Abstr.

N90-21767 North Carolina State Univ., Raleigh.
AN EXPERIMENTAL INVESTIGATION OF THE PHYSICAL MECHANISMS CONTROLLING THE ASYMMETRIC FLOW PAST SLENDER BODIES AT LARGE ANGLES OF ATTACK Ph.D. Thesis
CARY A. MOSKOVITZ 1989 99 p
Avail: Univ. Microfilms Order No. DA9001176

An experimental investigation of the effects of geometric perturbations on the asymmetric flow past slender bodies was conducted. The perturbations included variations in model tip sharpness, roughness and shape as well as discrete surface perturbations represented by beads of varying height and diameter attached to the model surface. Two cone/cylinder models having 9 and 10 deg semi-apex angles and a 3.0 caliber tangent ogive model, all having base diameters of 3.5 in were tested at laminar flow conditions at angles of attack from 30 to 60 deg. Data were taken with each model from 3 circumferential rows of pressure taps at a flow speed of 45 ft/s corresponding to a Reynolds number of 8.4 x 10(exp 4) based on model base diameter. Also, a helium bubble flow visualization technique was used at a speed of 15 ft/s corresponding to a Reynolds number of 2.5 x 10(exp 4). Beads were tested by placing the model at a roll position having either a symmetric or a highly asymmetric flowfield, and then attaching a bead to the model surface at varying axial and circumferential positions. Bead effectiveness was judged by the extent to which the flowfield was affected. Data showed the beads to be very effective when placed approximately 140 deg from the windward ray, and to decrease in effectiveness with decreasing bead size and distance from the tip. The data showed no significant change in this behavior with variations in angle of attack and tip bluntness. Tests without beads, conducted with sets of tips manufactured to identical specifications, showed the behavior of sectional side-force with roll position to be a function of machining imperfections and surface roughness. Dissert. Abstr.

N90-21768 California Univ., Los Angeles.
AEROELASTIC SIMULATION OF HIGHER HARMONIC CONTROL Ph.D. Thesis
LAWSON HAYES ROBINSON 1989 305 p
Avail: Univ. Microfilms Order No. DA9001751

The development of an aeroelastic analysis of a helicopter and its application to the simulation of helicopter vibration through Higher Harmonic Control (HHC) are described. This analysis is based on an existing aeroelastic code which was modified to allow the modeling of high frequency blade root pitch changes which are used by HHC to modify blade inertia and aerodynamic loads to alleviate vibrations. An improved implementation of a finite-state, time-domain model of unsteady aerodynamics is developed to capture high frequency aerodynamic effects. Helicopter trim parameters are determined using an improved trim procedure accounting for flap, lag, and torsional deformations of the blade. A procedure for calculating 4/rev. rotor hub loads is developed and control algorithms are incorporated in the analysis to determine the optimal HHC inputs necessary to minimize these rotor hub loads. Using this analysis, a study is carried out of the effects on a hingeless rotor of unsteady, as opposed to quasisteady, aerodynamics. Several different HHC algorithms are implemented on a hingeless rotor using both quasisteady and unsteady aerodynamic models, and their effectiveness in reducing rotor hub vibratory shears is compared. Simulations of roughly equivalent articulated and hingeless rotors are carried out, and it is found that hingeless rotors can require considerably larger HHC inputs to reduce rotor vibratory hub shears. This analysis is used to simulate the application of HHC to the rotor of an OH6A light helicopter. This helicopter was used in flight tests of HHC and results from those tests are compared to the results of this simulation. Dissert. Abstr.

N90-21769 California Univ., Los Angeles.
ADVANCES IN OPTIMAL ACTIVE CONTROL TECHNIQUES FOR AEROSPACE SYSTEMS; APPLICATION TO AIRCRAFT ACTIVE LANDING GEAR Ph.D. Thesis
KHAI TRAN VU 1989 163 p
Avail: Univ. Microfilms Order No. DA8926454

The problem of runaway denial is a real threat to the Air Force. The effectiveness of a counterattack after a hostile airraid depends on the capabilities of the airbase to make rapid runway repair. Aircrafts with conventional landing gears can operate on rough repaired surfaces under certain limited conditions. When the surface roughness is severe, and the taxing speed of the aircraft over the runway is high, landing gear forces start exceeding design structural limits causing catastrophic failures and damages to the aircraft. Active control landing gears present a solution to this problem. An active control landing gear can reduce landing impact loads, provide better ground handling capabilities to the aircraft, and negotiate runway damages more effectively than a conventional landing gear. Optimal control techniques can be applied on active landing gears to provide the best control laws for different conditions. A performance index can be chosen to minimize the load transmitted to the aircraft and the aircraft vertical and angular motion thus improving aircraft stability and ground handling characteristics. Active control concept is discussed and then the problem of optimal control of active landing gears (semi-active concept) is described. The problem formulation is done for an aircraft that has three landing gears (one nose gear and two main gears) and flexible dynamics. The technique of steepest descent that is used to solve the resulting nonlinear two point boundary problem is given together with numerical results of an exemplary optimal solution. Dissert. Abstr.

N90-21771 Texas A&M Univ., College Station.
A VIDEO-BASED EXPERIMENTAL INVESTIGATION OF WING ROCK Ph.D. Thesis
STEVEN LYNN MORRIS 1989 260 p
Avail: Univ. Microfilms Order No. DA9007508

The primary objective of this research was to develop a definitive theory on the cause of wing rock. The study was based on dynamic measurements in both a water tunnel and a wind tunnel on a sharp-edged delta wing with an 80 deg leading-edge sweep angle. Experimental data were compared with analytical results from a mathematical model and a fourth order Runge-Kutta integration. In the water tunnel tests, conducted at alpha = 35 deg and Reynolds numbers from 3 x 10(exp 4)/ft to 7.5 x 10(exp 4)/ft, the movement of the leading edge vortices and the model motion were simultaneously tracked and analyzed using a video-based motion analysis system, Expert Vision. Quantified vortex movement data were not obtained in the wind tunnel study; however, an extensive investigation of wing rock dynamics was performed at angles of attack from 24 to 50 deg and Reynolds numbers from 1.09 x 10(exp 5)/ft to 3.44 x 10(exp 5)/ft. The initial phase of the study validated Expert Vision accuracy using stationary and forced oscillation tests on 70 and 80 deg delta wings. Vortex trajectory, core velocity, and burst point results from

stationary tests were in good agreement with published data. Wing rock is caused by the dynamic behavior of the leading-edge vortices. Specifically, the alternate lift-off and reattachment of the vortices generate an asymmetry in vortex lift and cause changes in rolling moment that initiate and sustain roll oscillations. Since wind tunnel and water tunnel tests showed opposite direction hysteresis loops, it was concluded that roll damping could not be the primary aerodynamic mechanism that sets the limit on roll amplitude. Wing rock dynamics were significantly different between water tunnel and wind tunnel experiments. Apparent mass terms must be included in the equations of motion when converting water tunnel acceleration data to rolling moment coefficients; with no apparent mass correction, C(sub l) calculated from accelerations in the water tunnel were about 15 times greater than those from the wind tunnel. Dissert. Abstr.

N90-21772*# Boeing Commercial Airplane Co., Seattle, WA.
A CONFLICT ANALYSIS OF 4D DESCENT STRATEGIES IN A METERED, MULTIPLE-ARRIVAL ROUTE ENVIRONMENT Final Report
K. H. IZUMI and C. S. HARRIS 10 May 1990 48 p
(Contract NAS1-18027)
(NASA-CR-182019; NAS 1.26:182019) Avail: NTIS HC A03/MF A01 CSCL 17G

A conflict analysis was performed on multiple arrival traffic at a typical metered airport. The Flow Management Evaluation Model (FMEM) was used to simulate arrival operations using Denver Stapleton's arrival route structure. Sensitivities of conflict performance to three different 4-D descent strategies (clear-idle Mach/Constant AirSpeed (CAS), constant descent angle Mach/CAS and energy optimal) were examined for three traffic mixes represented by those found at Denver Stapleton, John F. Kennedy and typical en route metering (ERM) airports. The Monte Carlo technique was used to generate simulation entry point times. Analysis results indicate that the clean-idle descent strategy offers the best compromise in overall performance. Performance measures primarily include susceptibility to conflict and conflict severity. Fuel usage performance is extrapolated from previous descent strategy studies. Author

N90-22570# Aeronautical Research Labs., Melbourne (Australia).
FLUTTER INVESTIGATIONS ON A TRANSAVIA PL12/T-400 AIRCRAFT
A. GOLDMAN, C. D. RIDER, and P. PIPERIAS Jul. 1989 41 p
(AD-A219108; ARL-STRUC-TM-515; DODA-AR-005-626) Avail: NTIS HC A03/MF A01 CSCL 01/3

The Transavia T-400 Skyfarmer is the latest version of the twin-boom agricultural aircraft and incorporates several changes from the T-300 aircraft. In a ferrying flight in weather conditions which would not normally be experienced during agricultural work, an incident occurred which is believed to have been a limited amplitude flutter of the rudder and tail boom at a frequency around 3.5 Hz. In subsequent tests, the test pilot found that he could induce a similar oscillation by applying more than 50 percent rudder actuation in a series of quick jabs in alternate directions. The subsequent activity to find a solution to the problem is detailed, as are the tests conducted to verify the effectiveness of the solution. GRA

N90-23032*# Kansas Univ., Lawrence. Dept. of Aerospace Engineering.
APPLICATION OF NUMERICAL OPTIMIZATION TECHNIQUES TO CONTROL SYSTEM DESIGN FOR NONLINEAR DYNAMIC MODELS OF AIRCRAFT
C. EDWARD LAN and FUYING GE *In* JPL, Proceedings of the 3rd Annual Conference on Aerospace Computational Control, Volume 1 p 394-406 15 Dec. 1989
Avail: NTIS HC A21/MF A03 CSCL 01/3

Control system design for general nonlinear flight dynamic models is considered through numerical simulation. The design is accomplished through a numerical optimizer coupled with analysis of flight dynamic equations. The general flight dynamic equations are numerically integrated and dynamic characteristics are then identified from the dynamic response. The design variables are determined iteratively by the optimizer to optimize a prescribed objective function which is related to desired dynamic characteristics. Generality of the method allows nonlinear effects to aerodynamics and dynamic coupling to be considered in the design process. To demonstrate the method, nonlinear simulation models for an F-5A and an F-16 configurations are used to design dampers to satisfy specifications on flying qualities and control systems to prevent departure. The results indicate that the present method is simple in formulation and effective in satisfying the design objectives. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A90-35756#
BLOCKAGE CORRECTIONS AT HIGH ANGLES OF ATTACK IN A WIND TUNNEL
P. A. GILI, F. B. QUAGLIOTTI (Torino, Politecnico, Turin, Italy), E. BARBANTINI (Aeritalia, S.p.A., Turin, Italy), and D. M. PASTRONE (ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2, p. 1192-1198) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 413-417. Previously cited in issue 03, p. 273, Accession no. A89-13621. refs
Copyright

A90-36153
GROUND AVIATION EQUIPMENT: HANDBOOK [AVIATSIONNAIA NAZEMNAIA TEKHNIKA: SPRAVOCHNIK]
VADIM E. KANARCHUK, GEORGII N. GELETUKHA, VLADIMIR V. ZAPOROZHETS, V. I. LYCHIK, A. D. CHIGRINETS et al. Moscow, Izdatel'stvo Transport, 1989, 280 p. In Russian.
Copyright

Data are presented on the technical and performance characteristics, general design, and operation of typical ground-based aviation equipment. In particular, attention is given to the service characteristics and reliability of ground equipment, power supply and start-up equipment, fueling equipment, cleaning machines, ground passenger transport, and luggage and container handling equipment. The discussion also covers airfield maintenance equipment, safety engineering in the operation of specialized equipment, and nondestructive inspection of ground equipment. V.L.

A90-36418#
DYNAMIC ANALYSIS OF AIRPORT PAVEMENT
XIAOPING ZHENG and SHANGWEN WANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, March 1990, p. A146-A155. In Chinese, with abstract in English. refs

This paper discusses the dynamic response of rectangular plates with free edges on viscoelastic foundations under moving loads and gives an approximate solution. The solution is used to solve the problem of the dynamic response of airport pavement, and an illustrative example is presented. The numerical results show good agreement with experiments. Finally, the curves and tables affected by different physical constants are given. Author

A90-36437#
A WALL PRESSURE CORRECTION METHOD FOR HALF-MODEL EXPERIMENT IN CLOSED SUBSONIC WIND TUNNEL TEST SECTION

WENHUA ZHANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, April 1990, p. B188-B191. In Chinese, with abstract in English. refs

A wall pressure correction method for half-model experiment in a closed subsonic wind tunnel test section is presented. Not only forces but also pressure distributions on the model are corrected. Experimental tests of the method give good results for high angles of attack, as well as large blockings. The method provided by this paper is applicable for practical purposes. Author

A90-37232#
A GROUND SIMULATION-INSPECTION SYSTEM FOR AVIONIC DEVICES
RENZHOU FAN, RUILIN CHEN, and XIMING ZHANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Feb. 1990, p. B47-B53. In Chinese, with abstract in English. refs

The function of the hardware and software structure of ground simulating and inspecting systems for airborne electronic devices is discussed, and a real simulation and test system is given. The system connects 11 different microcomputers to compose a distributed simulation and test network through an 8-terminal optic fiber communication net. The system can imitate signals of the motive target of radars and signals of ARINC-429 and the Navigation Subsystem and the air data computer. It can receive, store, and process real-time data from airborne electronic devices, perform error analysis, draw curves of the motive target, and print tables of various test parameters by directly interfacing to the airborne devices. Author

A90-37926*# National Aeronautics and Space Administration, Washington, DC.
AERONAUTICAL FACILITY REQUIREMENTS INTO THE 2,000'S
H. L. BEACH, JR. (NASA, Washington, DC) and D. M. BUSHNELL (NASA, Langley Research Center, Hampton, VA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 23 p. refs
(AIAA PAPER 90-1375)

This paper delineates and speculates upon aeronautical systems, trends, and requirements into the 2,000's and indicates ground facility capability enhancements which are needed to support these devlopments. New facility capabilities required include (1) higher Reynolds number at low speeds especially for the high-lift and vortex hazard problems, (2) low-disturbance, high-speed aerodynamic and hypersonic propulsion facilities for transition and mixing studies, (3) large-scale and relatively long test-time hypersonic propulsion tunnels to allow multidisciplinary integration, (4) a large-scale, high-speed acoustics facility for en route noise minimization, (5) a large-scale ballistic range for planetary entry studies, and (6) development of advanced (full simultaneous 3-space and time) nonintrusive instrumentation for CFD transition/turbulence modeling/code validation and interacting flow physics determination. Author

A90-37928#
THE NEW HIGH REYNOLDS NUMBER MACH 8 CAPABILITY IN THE NSWC HYPERVELOCITY WIND TUNNEL 9
ERIC R. HEDLUND, CRAIG W. HIGGINS, CHARLES S. ROZANSKI, NANCY P. FEHRING, and DAVE KRUEGER (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 7 p. refs
(AIAA PAPER 90-1379)

The Naval Surface Warfare Center completed the development and calibration of a Mach 8 leg for the Hypervelocity Wind Tunnel 9 in January, 1989. A new 20-foot-long Mach 8 nozzle was designed and constructed along with associated tunnel components. The tunnel was calibrated using a twenty-one finger Pitot rake as well as a 20-m base diameter sharp cone model. Reynolds numbers exceeding 50 million/ft and a 24-m diameter uniform test core were demonstrated. This paper discusses the design and fabrication of the tunnel components as well as the results from the calibration tests. Author

A90-37930#
DEVELOPMENT AND CALIBRATION OF A CONTINUOUS-FLOW ARC-HEATED HYPERSONIC WIND TUNNEL
DONALD R. WILSON (Texas, University, Arlington) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 8 p. refs
(AIAA PAPER 90-1381) Copyright

The development of a new continuous-flow, arc-heated hypersonic wind tunnel is described. The facility employs a 2 MW, vortex-stabilized DC electric arc heater. Descriptions of the arc heater, nozzle, test section, diffuser, and vacuum tank; together with the supporting electrical, pneumatic, cooling water, vacuum, instrumentation, and data acquisition/control systems are provided. The estimated facility performance is given, and proposed research programs utilizing the new facility capability are briefly described. Author

A90-37934#
HYPERSONIC TEST FACILITY REQUIREMENTS FOR THE 1990'S
D. A. WAGNER, R. K. SMITH, J. A. GUNN (Sverdrup Technology, Inc., Tullahoma, TN), and S. HASEGAWA (Sumitomo Heavy Industries, Ltd., Tokyo, Japan) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 16 p. refs
(AIAA PAPER 90-1389) Copyright

Hypersonic test requirements in three categories of aerothermodynamic, materials and structures, and propulsion testing are reviewed. Consideration is given to duplication of Mach number and Reynolds number, viscous interaction testing, real-gas effects, and small tunnels. It is noted that the use of large arc heaters should provide an adequate ground test capability for development of materials and structural cooling systems. Propulsion test conditions are currently limited to the Mach 7 to 8 range in facilities that provide long run times; shock tunnels offer test conditions corresponding to much higher flight Mach numbers, but are limited to run time to the millisecond range. In the future, larger arc heated facilities may be needed for propulsion testing, and would be useful for material and structure testing as well. V.T.

A90-37935# General Applied Science Labs., Inc., Ronkonkoma, NY.
HYPERVELOCITY REAL GAS CAPABILITIES OF GASL'S EXPANSION TUBE (HYPULSE) FACILITY
JOSE TAMAGNO, ROBERT BAKOS, MARIA V. PULSONETTI, and JOHN ERDOS (General Applied Science Laboratories, Inc., Ronkonkoma, NY) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 11 p. Research supported by USAF and NASA. refs
(AIAA PAPER 90-1390) Copyright

Operating experience with an expansion tube developed as a means of generating hypervelocity flows with negligible levels of dissociation of the test gas or other forms of contamination is reviewed. Calibration data at the nominal operating point is assessed, along with the ability to vary test conditions by changing driver pressure and/or composition. Present simulation capabilities are described, and future capabilities are assessed. Results from internal flow combustion tests are presented, and plans for using the facility to study hypervelocity aeroheating in external flows are outlined. V.T.

A90-37936*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN AND OPERATIONAL FEATURES OF LOW-DISTURBANCE WIND TUNNELS AT NASA LANGLEY FOR MACH NUMBERS FROM 3.5 TO 18
I. E. BECKWITH, F.-J. CHEN, S. P. WILKINSON, M. R. MALIK,

and D. G. TUTTLE (NASA, Langley Research Center, Hampton, VA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 18 p. refs
(AIAA PAPER 90-1391) Copyright

The experimental and theoretical program at NASA Langley to develop high-speed low-disturbance wind tunnels for transition research is reviewed. Design and operational details of three new low-disturbance wind tunnels - the Mach-18 quiet helium, Mach-8 variable density, and Mach-3.5/Mach-6 high-speed low-disturbance tunnels, are presented. Focus is placed on the high-speed low-disturbance wind tunnel, which will have relatively large mass flows and run times from about 6 to 25 minutes. This facility is designed to provide direct simulation of low-disturbance flight conditions in the atmosphere. The Mach-8 facility will provide uniform flow conditions suitable for validation of aerodynamic codes, while the helium facility will be used for validation of boundary-layer and free shear-layer stability and transition prediction codes. V.T.

A90-37939#
AUTOMATIC CALIBRATION MACHINE FOR CRYOGENIC AND CONVENTIONAL INTERNAL STRAIN GAGE BALANCES
B. EWALD (Darmstadt, Technische Hochschule, Federal Republic of Germany), P. GIESECKE, L. POLANSKI (Carl Schenck AG, Darmstadt, Federal Republic of Germany), and E. GRAEWE (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 10 p. refs
(AIAA PAPER 90-1396) Copyright

A fully automatic calibration machine designed to calibrate internal strain gauge balances for conventional tunnels as well as special balances for cryogenic tunnels is described. The general principle of the selected design is presented, with emphasis on a system of force generators and an algorithm for processing calibration data mixed with interferences. This algorithm extracts a third-order calibration matrix as a closest least square error solution from the complete calibration data set. The mechanical design of the machine including its basic frame, external balance, and loading system is addressed. A load generation system, external balance technology, and computer control and data system are outlined. V.T.

A90-37940*# Maryland Univ., College Park.
DESIGN OF A THREE-COMPONENT WALL-MOUNTED BALANCE
ALLEN E. WINKELMANN (Maryland, University, College Park) and HUGO A. GONZALEZ AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 14 p. refs
(Contract NAG1-681; NGT-70090)
(AIAA PAPER 90-1397) Copyright

The design and evaluation of a three-component, wall-mounted pyramidal balance for a small wind tunnel is discussed. The balance was designed to measure lift, drag, pitching moment, and angle of attack. The specific design of each component and mathematical models used to design the balance are covered. Balance evaluation consisted of calibration, tare, and interaction analysis. Author

A90-37944#
ADAPTIVE WIND TUNNEL WALLS: COMPENDIUM OF FINAL REPORT - AGARD FDP WORKING GROUP 12
J. C. ERICKSON, JR. (Calspan Corp., Arnold AFB, TN) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 24 p. refs
(AIAA PAPER 90-1405)

Highlights of early adaptive-wall development are described, along with complete adaptation in both two-dimensional and three-dimensional flows, and partial adaptation of three-dimensional flows in two-dimensional adaptive-wall test sections with flexible impermeable top and bottom walls. Calculation procedures for the evaluation of residual interference in linear and nonlinear two-dimensional and three-dimensional flows are presented, as well as sidewall-boundary-layer effects for three-dimensional half-model and two-dimensional configurations. Representative experimental results for two-dimensional and three-dimensional test articles are assessed, including results of complete and partial adaptation and of residual-interference calculations. V.T.

A90-37945*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WALL INTERFERENCE ASSESSMENT/CORRECTION (WIAC) FOR TRANSONIC AIRFOIL DATA FROM POROUS AND SHAPED WALL TEST SECTIONS
RAYMOND E. MINECK and LAWRENCE L. GREEN (NASA, Langley Research Center, Hampton, VA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 16 p. refs
(AIAA PAPER 90-1406) Copyright

An existing computational wall interference assessment/correction (WIAC) procedure is applied to two sets of transonic airfoil data obtained from the same model tested in both a porous, planar-wall and a solid, shaped-wall test section. The published airfoil data from the porous test section agrees reasonably well with the published data from the shaped wall test section, although some differences exist. The WIAC procedure is applied to the data to assess and correct any wall interference effects; WIAC corrections generally improve the correlation between the two data sets. As an independent verification, both the published and WIAC corrected airfoil data are compared to Navier-Stokes calculations. Correlations are generally better between the WIAC corrected data and the Navier-Stokes calculations than between similar correlations with the published data. Author

A90-37946#
SLOTTED-WALL RESEARCH WITH DISK AND PARACHUTE MODELS IN A LOW-SPEED WIND TUNNEL
J. M. MACHA, R. J. BUFFINGTON, J. F. HENFLING (Sandia National Laboratories, Albuquerque, NM), D. VAN EVERY, and J. L. HARRIS (DSMA International, Inc., Mississauga, Canada) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 11 p. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 90-1407)

Bluff bodies such as parachutes often require large blockage corrections when tested in solid-wall wind tunnels. The magnitude of the correction is much smaller in test sections with slotted walls, but the blockage becomes a complicated function of model size, wall porosity and upstream and downstream boundary conditions. Disk and parachute models were tested in a low-speed wind tunnel where the slotted-wall open area ratio and model axial position were systematically varied. In steady flow, the benefit of the wall slots was achieved asymptotically as the models were moved downstream from the leading edge of the slots, and this flow development length increased with decreasing wall porosity and increasing model size. The experiments with the parachutes provide the first quantitative information on wall interference and tunnel circuit response during the transient inflation process. There was no observable blockage effect during the inflations with any of the slotted-wall configurations studied. Author

A90-37949#
HIGH SPEED INLET TESTING IN THE NAVSWC WIND TUNNELS
RONALD S. MCCANDLESS, MELISSA A. LEDERER, and WILLIAM J. YANTA (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 5 p. refs
(AIAA PAPER 90-1412)

The testing of high speed inlets is particularly suited for NSWC Wind Tunnels 2 and 9. Tunnel conditions, flow time, size of test cell, and instrumentation in Hypervelocity Tunnel 9 contribute toward accurately determining inlet efficiency and system performance. In contrast, easily varied flow conditions and continuous operation make Supersonic Tunnel 2 ideal for inlet technology demonstration programs. Both types of tests in turn

can be used to validate computational fluid dynamics design codes. Author

A90-37950#
PRIORITIES FOR HIGH-LIFT TESTING IN THE 1990S
D. L. I. KIRKPATRICK and D. S. WOODWARD (Royal Aerospace Establishment, Farnborough, England) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 14 p. refs
(AIAA PAPER 90-1413) Copyright

The diverse forms of scale effects which appear in wind-tunnel tests of high-lift systems are reviewed, including conventional, bubble-dominated, slot-flow-dominated, 3D-transition-dominated, and vortex-flow-dominated scale effects. It is shown that the classical method of correcting the results of high-lift tests for wake blockage can at high incidences yield misleading results; an improved method based on wall pressure measurements is considered. The effect of using remotely-actuated control systems enhancing the productivity of testing in pressurized tunnels and facilitating the rapid investigation of novel combinations of control deflections is discussed. It is noted that future high-lift testing of combat or transport aircraft will require high-pressure air supplied to represent vectorable jets or to drive turbine-powered engine simulators. V.T.

A90-37953*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NATIONAL TRANSONIC FACILITY MODEL AND MODEL SUPPORT VIBRATION PROBLEMS
CLARENCE P. YOUNG, JR., THOMAS G. POPERNACK, JR., and BLAIR B. GLOSS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 10 p. refs
(AIAA PAPER 90-1416) Copyright

Vibrations of models and model support system were encountered during testing in the National Transonic Facility. Model support system yaw plane vibrations have resulted in model strain gage balance design load limits being reached. These high levels of vibrations resulted in limited aerodynamic testing for several wind tunnel models. The yaw vibration problem was the subject of an intensive experimental and analytical investigation which identified the primary source of the yaw excitation and resulted in attenuation of the yaw oscillations to acceptable levels. This paper presents the principal results of analyses and experimental investigation of the yaw plane vibration problems. Also, an overview of plans for development and installation of a permanent model system dynamic and aeroelastic response measurement and monitoring system for the National Transonic Facility is presented. Author

A90-37957#
THE NEW FFA T1500 TRANSONIC WIND TUNNEL INITIAL OPERATION, CALIBRATION, AND TEST RESULTS
LARS TORNGREN (Flygtekniska Forsoksanstalten, Bromma, Sweden), JAMES L. GRUNNET, DAVID M. NELSON, and DONALD N. KAMIS (FluiDyne Engineering Corp., Minneapolis, MN) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 12 p. refs
(AIAA PAPER 90-1420) Copyright

A new European aerodynamic test facility is described; this transonic wind tunnel has a 1.5-m square test section, and can operate over a Mach-number range of 0.3 to 1.2 using a conventional convergent nozzle, and at Mach number 1.4 using a convergent-divergent nozzle. The tunnel is a closed-circuit configuration, powered by an injector system, utilizing high-pressure air from a 250-bar air storage system. Tunnel stagnation pressure is controlled by a circuit exhaust system equipped with three main exhaust valves. Flow quality requirements are met by employing a second throat, downstream of the model support strut, which functions both to control test section Mach number and prevent acoustic disturbances generated by the injector from propagating into the test section. A digital control system for run control and a programmable controller for interlocks and permissives are covered, along with a data acquisition and reduction system. V.T.

A90-37960#
ON THE POSSIBILITIES FOR IMPROVEMENT AND MODERNIZATION OF SUBSONIC WIND TUNNELS
T. WOLF (Darmstadt, Technische Hochschule, Federal Republic of Germany) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 12 p. refs
(AIAA PAPER 90-1423) Copyright

The possibilities and limits for improvement and modernization of subsonic wind tunnels are discussed. A low-speed single return wind tunnel with an open jet test section and a contraction exit diameter of three meters is considered, with emphasis placed on its flow quality before modernization. Objectives and possibilities for modernization are analyzed, and conversion to a closed test section design is addressed. Design and geometry of the settling chamber, contraction, test section, and diffusers are covered. It is shown that after modernization the new closed test section and the new settling chamber designs yield an improved turbulence level with a maximum value of 0.15 percent compared to a value of 0.75 percent for the previous tunnel configuration. V.T.

A90-37961#
A MULTIPURPOSE AERODYNAMIC RESEARCH FACILITY UTILIZING THE ABANDONED CINCINNATI SUBWAY TUBES
P. J. DISIMILE (Cincinnati, University, OH), J. W. HERRMANN, and T. J. HEIST AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 12 p. refs
(AIAA PAPER 90-1424) Copyright

The paper deals with a large multipurpose wind tunnel utilizing two parallel abandoned subway tubes. The tunnel site is described along with the tunnel circuit layout and fan system. Controlling the pressure loss through the circuit and conditioning the flow to attain a research quality airflow are addressed, and the results of scale-model tests are presented. Two distinct testing areas are analyzed. The first test section has an adjustable cross sectional area with a maximum speed of 171 mph; this section will be used for research in aircraft engine inlet and exhaust performance and for basic aerodynamic research. The second test section has a maximum speed of 43 mph; also included in this section is a 75-foot hydrodynamic test pool. The main purpose of this area is to reproduce the earth's boundary layer in both ocean and land environments. V.T.

A90-38483*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LANGLEY HYPERSONIC AERODYNAMIC/AEROTHERMODYNAMIC TESTING CAPABILITIES - PRESENT AND FUTURE
C. G. MILLER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 33 p. refs
(AIAA PAPER 90-1376) Copyright

The Langley Hypersonic Facilities Complex consists of nine hypersonic, blowdown-to-vacuum wind tunnels that complement one another to provide a range of Mach number from 6 to 22, with Reynolds number from 0.03 to 40 million per foot and, most importantly for blunt configurations, a normal shock density ratio from 4 to 12. Presently, most of these facilities are receiving modifications and upgrades to hardware components and instrumentation to increase their capability, reliability, and productivity. Descriptions and capabilities of these facilities are presented along with measurement techniques routinely used. Future facility plans are discussed, with the focus on an Advanced Hypervelocity Aerophysics Facility being proposed for construction in the mid-1990s. Author

A90-38484*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE DEVELOPMENT OF A 3-D LASER VELOCIMETER FOR THE NASA LANGLEY LOW TURBULENCE PRESSURE WIND TUNNEL
GREGORY S. JONES, WENDELL G. ADAMS, PIERRE H. CRESPI (NASA, Langley Research Center, Hampton, VA), MICHAEL J. HOUSER, and ANDREW S. INENAGA (Aerometrics, Inc., Sunnyvale, CA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 15 p. refs
(AIAA PAPER 90-1385) Copyright

The design of an orthogonal, three-dimensional laser velocimeter with in situ sizing (LVIS) system for a high-Reynolds-number facility, the NASA Langley low turbulence pressure wind tunnel (LTPT), is discussed. Special attention is paid to the laser velocimeter seeding subsystems, while all other subsystems are approached from the users standpoint. The evaluation of the LVIS system leads to the conclusion that seeding of large scale pressure wind tunnels remains a problem, while using the polydispersed seeding requires further investigation. A Cassegrain mirror receiver optics may be successfully implemented in lieu of similar lens systems. General agreement is observed between the mean velocity LVIS measurements as compared to conventional pitot and hot-wire data. N.B.

A90-38485*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SCRAMJET TESTING FROM MACH 4 TO 20 - PRESENT CAPABILITY AND NEEDS FOR THE NINETIES
SCOTT R. THOMAS and R. WAYNE GUY (NASA, Langley Research Center, Hampton, VA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 28 p. refs
(AIAA PAPER 90-1388) Copyright

Consideration is given to the development of testing methods for the National Aerospace Plane (NASP) program, focusing on techniques for simulating and testing scramjet engines and scramjet engine components during flight from Mach 4 to Mach 20. The flight conditions associated with the NASP are outlined and the stagnation temperatures and pressures required to simulate flight up to orbital speeds are presented. The types of test facilities needed for scramjet propulsion testing are discussed, including combustion-heated facilities, electric arc-heated facilities, convection-heated facilities, shock tunnels, and expansion tubes. Issues related to assessing the flow quality in the scramjet ground testing facilities are examined, including uniformity, contamination, dissociation, ionization, nonequilibrium, and turbulence. Direct-connect combustor versus free-jet scramjet engine tests are compared and the capabilities of current and near-future scramjet engine test facilities are evaluated. R.B.

A90-38487*# Vigyan Research Associates, Inc., Hampton, VA.
EVALUATION OF TRANSONIC WALL INTERFERENCE ASSESSMENT AND CORRECTION FOR SEMI-SPAN WING DATA
JAVIER A. GARRIZ (Vigyan Research Associates, Inc., Hampton, VA), PARRY A. NEWMAN, VEER N. VATSA, KARA J. HAIGLER (NASA, Langley Research Center, Hampton, VA), and KENNETH P. BURDGES (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 18 p. refs
(AIAA PAPER 90-1433) Copyright

A newly developed transonic wall interference assessment and correction (WIAC) code is applied to transonic semispan wing data taken in the Lockheed-Georgia Compressible Flow Wind Tunnel (CFWT), in order to evaluate previous WIAC results and corrections. A current state-of-the-art Navier-Stokes free-air code is used as an independent check. Results are presented for Wing C at the transonic edge of its test data matrix in the CFWT. The results demonstrate the effects of wall porosity, Mach number, and angle-of-attack on the transonic wall interference correction. I.S.

A90-38489#
REQUIREMENTS IN THE 1990'S FOR HIGH ENTHALPY GROUND TEST FACILITIES FOR CFD VALIDATION
RICHARD D. NEUMANN (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 21 p. refs
(AIAA PAPER 90-1401)

The validation of real gas numerical solutions requires an experimental capability which does not currently exist. The needed 'facilities' consist of the hardware necessary to generate a real gas flow, the instrumentation required to measure the conditions attained and the affordability to conduct sufficient research to understand the measurements. This paper will focus on difficulties of instrumenting such facilities; both to understand the test point achieved and to define the character of the flow about the experiment with sensitive indicators of real gas phenomena.
Author

A90-38497
TWO-DIMENSIONAL WALL ADAPTION IN THE TRANSONIC WINDTUNNEL OF THE AIA
H.-J. ROMBERG (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) Experiments in Fluids (ISSN 0723-4864), vol. 9, no. 3, May 1990, p. 177-180. Research supported by DFG. refs
Copyright

To demonstrate the flow quality of the AIA transonic windtunnel, the flow around a supercritical airfoil is investigated in the adaptive wall test section. The mechanism of the wall adaption is described. The convergence of one adaption cycle is shown by means of the wall contours as well as the wing surface pressures. The shape and pressure distribution of the adapted wall is compared with results obtained in the ONERA T2 windtunnel in Toulouse. That tunnel is equipped with an adaptive wall test section of nearly the same geometry. Author

N90-21775*# North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering.
ANALYSIS OF A SIX-COMPONENT, FLOW-THROUGH, STRAIN-GAGE, FORCE BALANCE USED FOR HYPERSONIC WIND TUNNEL MODELS WITH SCRAMJET EXHAUST FLOW SIMULATION M.S. *Thesis Final Report*
MARC W. KNISKERN 1990 57 p
(Contract NCC1-129)
(NASA-CR-186585; NAS 1.26:186585) Avail: NTIS HC A04/MF A01 CSCL 14B

The thermal effects of simulant gas injection and aerodynamic heating at the model's surface on the measurements of a non-watercooled, flow through balance were investigated. A stainless steel model of a hypersonic air breathing propulsion cruise missile concept (HAPCM-50) was used to evaluate this balance. The tests were conducted in the 20-inch Mach 6 wind tunnel at NASA-Langley. The balance thermal effects were evaluated at freestream Reynolds numbers ranging from .5 to 7 x 10(exp 6) ft and angles of attack between -3.5 to 5 deg at Mach 6. The injection gases considered included cold air, hot air, and a mixture of 50 percent Argon and 50 percent Freon-12. The stagnation temperatures of the cold air, hot air, and Ar-Fr(12) reached 111, 214, and 283 F, respectively within the balance. A bakelite sleeve was inserted into the inner tube of the balance to minimize the thermal effects of these injection gases. Throughout the tests, the normal force, side force, yaw moment, roll moment, and pitching moment balance measurements were unaffected by the balance thermal effects of the injection gases and the wind tunnel flow. However, the axial force (AF) measurement was significantly affected by balance heating. The average zero shifts in the AF measurements were 1.9, 3.8, and 5.9 percent for cold air, hot air, and Ar-Fr(12) injection, respectively. The AF measurements decreased throughout these tests which lasted from 70 to 110 seconds. During the cold air injection tests, the AF measurements were accurate up to at least ten seconds after the model was

injected into the wind tunnel test section. For the hot air and Ar-Fr(12) tests, the AF measurements were accurate up to at least five seconds after model injection. Author

N90-21776*# Pittsburgh Univ., PA. Dept. of Electrical Engineering.
THE INSERTION OF HUMAN DYNAMICS MODELS IN THE FLIGHT CONTROL LOOPS OF V/STOL RESEARCH AIRCRAFT. APPENDIX 2: THE OPTIMAL CONTROL MODEL OF A PILOT IN V/STOL AIRCRAFT CONTROL LOOPS Final Report
MARK E. ZIPF 1989 210 p
(Contract NAG3-729)
(NASA-CR-186598; NAS 1.26:186598) Avail: NTIS HC A10/MF A02 CSCL 05H

An overview is presented of research work focussed on the design and insertion of classical models of human pilot dynamics within the flight control loops of V/STOL aircraft. The pilots were designed and configured for use in integrated control system research and design. The models of human behavior that were considered are: McRuer-Krendel (a single variable transfer function model); and Optimal Control Model (a multi-variable approach based on optimal control and stochastic estimation theory). These models attempt to predict human control response characteristics when confronted with compensatory tracking and state regulation tasks. An overview, mathematical description, and discussion of predictive limitations of the pilot models is presented. Design strategies and closed loop insertion configurations are introduced and considered for various flight control scenarios. Models of aircraft dynamics (both transfer function and state space based) are developed and discussed for their use in pilot design and application. Pilot design and insertion are illustrated for various flight control objectives. Results of pilot insertion within the control loops of two V/STOL research aricraft (Sikorski Black Hawk UH-60A, McDonnell Douglas Harrier II AV-8B) are presented and compared against actual pilot flight data. Conclusions are reached on the ability of the pilot models to adequately predict human behavior when confronted with similar control objectives. Author

N90-21777*# Pittsburgh Univ., PA. Dept. of Electrical Engineering.
AN ADAPTIVE HUMAN RESPONSE MECHANISM CONTROLLING THE V/STOL AIRCRAFT. APPENDIX 3: THE ADAPTIVE CONTROL MODEL OF A PILOT IN V/STOL AIRCRAFT CONTROL LOOPS M.S. Thesis. Final Report
SENOL KUCUK 1988 183 p
(Contract NAG3-729)
(NASA-CR-186599; NAS 1.26:186599) Avail: NTIS HC A09/MF A01 CSCL 05H

Importance of the role of human operator in control systems has led to the particular area of manual control theory. Human describing functions were developed to model human behavior for manual control studies to take advantage of the successful and safe human operations. A single variable approach is presented that can be extended for multi-variable tasks where a low order human response model is used together with its rules, to adapt the model on-line, being capable of responding to the changes in the controlled element dynamics. Basic control theory concepts are used to combine the model, constrained with the physical observations, particularly, for the case of aircraft control. Pilot experience is represented as the initial model parameters. An adaptive root-locus method is presented as the adaptation law of the model where the closed loop bandwidth of the system is to be preserved in a stable manner with the adjustments of the pilot handling qualities which relate the latter to the closed loop bandwidth and damping of the closed loop pilot aircraft combination. A Kalman filter parameter estimator is presented as the controlled element identifier of the adaptive model where any discrepancies of the open loop dynamics from the presented one, are sensed to be compensated. Author

N90-21778*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THEORETICAL AND EXPERIMENTAL STUDY OF FLOW-CONTROL DEVICES FOR INLETS OF INDRAFT WIND TUNNELS
JAMES C. ROSS Sep. 1989 74 p
(NASA-TM-100050; A-88040; NAS 1.15:100050) Avail: NTIS HC A04/MF A01 CSCL 14B

The design of closed circuit wind tunnels has historically been performed using rule of thumb which have evolved over the years into a body of useful guidelines. The development of indraft wind tunnels, however, has not been as well documented. The design of indraft wind tunnels is therefore generally performed using a more intuitive approach, often resulting in a facility with disappointing flow quality. The primary problem is a lack of understanding of the flow in the inlet as it passes through the required antiturbulence treatment. For wind tunnels which employ large contraction ratio inlets, this lack of understanding is not serious since the relatively low velocity of the flow through the inlet treatment reduces the sensitivity to improper inlet design. When designing a small contraction ratio inlet, much more careful design is needed in order to reduce the flow distortions generated by the inlet treatment. As part of the National Full Scale Aerodynamics Complex Modification Project, 2-D computational methods were developed which account for the effect of both inlet screens and guide vanes on the test section velocity distribution. Comparisons with experimental data are presented which indicate that the methods accurately compute the flow distortions generated by a screen in a nonuniform velocity field. The use of inlet guide vanes to eliminate the screen induced distortion is also demonstrated both computationally and experimentally. Extensions of the results to 3-D is demonstrated and a successful wind tunnel design is presented. Author

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ASTRONAUTICS

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

A90-35757*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRESSURE AND HEAT-TRANSFER INVESTIGATION OF A HYPERSONIC CONFIGURATION
DAVID E. REUBUSH (NASA, Langley Research Center, Hampton, VA) and M. EMMETT OMAR (Boeing Advanced Systems Co., Seattle, WA) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 418-422. Previously cited in issue 09, p. 1301, Accession no. A89-25208.
Copyright

A90-37929#
PERFORMANCE POTENTIAL AND TECHNOLOGY ISSUES OF MHD AUGMENTED HYPERSONIC SIMULATION FACILITIES
R. A. CRAWFORD, J. N. CHAPMAN, and R. P. RHODES (Tennessee, University, Tullahoma) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 10 p. Research supported by USAF. refs
(AIAA PAPER 90-1380) Copyright

Technical results from a theoretical analysis of the simulation capabilities of an MHD-augmented hypersonic-flow facility are reviewed. Simulation requirements including correct free-stream velocity, density, hypersonic Mach number, and low dissociation level are outlined. A one-dimensional MHD accelerator model is described, with emphasis on a chemical equilibrium code originated by NASA and used to calculate dynamic properties of air seeded

with either potassium or cesium. Molecular properties, specifically viscosity and Prandtl numbers, are calculated by another NASA-originated computer code. It is noted that a single-channel geometry accelerator supplied by an arc-heated airstream with one-percent potassium seed, a magnetic field strength of six-tesla, and variable power segmented electrodes can simulate Mach 15-25 flow conditions. Combustor inlet conditions for hypersonic flight vehicles can be simulated with nearly exact properties. V.T.

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CHEMISTRY AND MATERIALS

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

A90-35926
MRS INTERNATIONAL MEETING ON ADVANCED MATERIALS, 1ST, TOKYO, JAPAN, MAY 31-JUNE 3, 1988, PROCEEDINGS. VOLUME 5 - STRUCTURAL CERAMICS/FRACTURE MECHANICS
YOSHITERU HAMANO, ED. (Kyocera Corp., Kyoto, Japan), OSAMI KAMIGAITO, ED. (Toyota Central Research and Development Laboratories, Inc., Aichi, Japan), TERUO KISHI, ED. (Tokyo, University, Japan), and MOTOTSUGU SAKAI, ED. (Toyohashi University of Technology, Japan) Meeting sponsored by the Nikkan Kogyo Shimbun, Ltd., Architectural Institute of Japan, Association of Mechanical Technology, et al. Pittsburgh, PA, Materials Research Society, 1989, 585 p. For individual items see A90-35927 to A90-35974.

Papers on structural ceramics and fracture mechanics are presented, covering topics such as the effects of additives on sintering silicon oxynitride, toughening Y-tetragonal zirconia polycrystal, stress-induced transformation in Mg-PSZ, and the properties of fine-grained zirconia-toughened alumina, nitride ceramics, sintered silicon nitride, and SiC. Other topics include processing Si3N4-SiC composites, whisker reinforced glass-ceramics, Al2O3 ceramics, black and machinable glass ceramics in the CaO-Y2O3-Al2O3-SiO2-TR(x)O(y) system, grinding technologies, advanced materials for heat engine components, ceramic composites for high-temperature gas turbines, toughening brittle matrix composites, crack resistance measurements, dynamic fracture toughenss in ceramics and on brittle materials, softening in MgAl2O4 single crystal, computer simulation of fracture in small crystals, stress triaxiality effects on fracture morphology in Al-Zn-Mg-Cu alloys, crack identification by acoustic emission and boundary element method, the micromechanics of dilatancy in brittle materials, nonlinear stress-strain behavior predictions, erosive wear of Si3N4-SiC composites, whisker/glass composites fabricated from hydrothermally oxidized Si3N4 whisker, subcritical crack extension in ceramics, and crack propagation behavior of sintered Si3N4 under static and cyclic load. R.B.

A90-35950
DEVELOPMENT OF MONOLITHIC AND COMPOSITE CERAMICS AT ALLIED-SIGNAL AEROSPACE COMPANY
M. D. MEISER (Allied-Signal Aerospace Co., Garrett Ceramic Components Div., Torrance, CA) IN: MRS International Meeting on Advanced Materials, 1st, Tokyo, Japan, May 31-June 3, 1988, Proceedings. Volume 5. Pittsburgh, PA, Materials Research Society, 1989, p. 187-199.

An overview of development programs on monolithic silicon nitride and silicon nitride matrix composites is presented. Results are given from a study on the processing of silicon nitride and studies to develop high-temperature monolithic Si3N4. The development of ceramic composites consisting of silicon carbide whiskers dispersed in a silicon nitride matrix is examined. R.B.

A90-36672
CARBON-CARBON FOR NASP
FRANK COLUCCI Aerospace Composites and Materials (ISSN 0954-5832), vol. 2, May-June 1990, p. 30, 31, 33, 34.

An advanced carbon-carbon (ACC) control surface test component for the conceptual X-30 National Aerosphace Plane (NASP) is described. The X-30 research aircraft is expected to climb to earth orbit from an ordinary runway, and maintain hypersonic cruise within the atmosphere; it is supposed to have support requirements and turn-around times between missions far less than those of the Space Shuttle and more in line with conventional aircraft. The first major flight-weight structural component made of ACC is the 38.7-in-wide 56-in-long elevon section; it will begin static load testing at ambient temperature late this year. Subsequent tests under quartz lamps will simulate the thermal profiles of the NASP mission. I.S.

A90-37441
AL-LI ALLOYS AND ULTRAHIGH-STRENGTH STEELS FOR U.S. NAVY AIRCRAFT
E. W. LEE, C. E. NEU, and J. KOZOL (U.S. Navy, Naval Air Development Center, Warminster, PA) JOM (ISSN 1047-4838), vol. 42, May 1990, p. 11-14. refs

An evaluation is made of the development status and prospective performance advantages and cost reductions obtainable through the application of state-of-the-art Al-Li alloys to naval aircraft airframes and ultrahigh strength Ni-Co alloy steels to their landing gears. Structural weight fractions are expected to be reduced by 8-10 percent through substitution of high-stiffness Al-Li for conventional Al alloys. Ni-Co alloy steels enhance landing gear damage tolerance and resistance to environmental degradation, without associated weight penalty, when supplanting conventional low-alloy steels. Both materials are judged ready for immediate application to existing and next-generation U.S. Navy aircraft. O.C.

A90-37442
ALUMINUM ALLOY 6013 SHEET FOR NEW U.S. NAVY AIRCRAFT
R. S. KANEKO, L. BAKOW (Lockheed Aeronautical Systems Co., Burbank, CA), and E. W. LEE (U.S. Navy, Naval Air Development Center, Warminster, PA) JOM (ISSN 1047-4838), vol. 42, May 1990, p. 16-18. refs

The recently developed aluminum alloy 6013-T6 has been selected for the fuselage skin and other applications on the U.S. Navy's P-7A airplane, in place of the traditional 2024-T3 clad sheet. Alloy 6013-T6 is naturally corrosion resistant, like the well-established alloy 6061, and hence is used unclad. Its fatigue strength, fatigue crack growth and fracture toughness compare favorably with 2024-T3. Replacement of alloy 2024 with alloy 6013 also reduces manufacturing costs for formed parts, because 6013 is readily formed in the T4 temper, then simply aged to T6, thus avoiding the costly heat treatments and straightening required for alloy 2024. Author

A90-37443
ULTRAHIGH-STRENGTH STEELS FOR AEROSPACE APPLICATIONS
W. M. GARRISON, JR. (Carnegie-Mellon University, Pittsburgh, PA) JOM (ISSN 1047-4838), vol. 42, May 1990, p. 20-24. Research supported by the U.S. Army and Latrobe Steel Co. refs

An account is given of the development status, compositions, microstructural characteristics, and processing requirements of alloy steels with yield strengths in excess of 1725 MPa, in association with high resistance to stress-corrosion cracking. The control of sulfide-type inclusions, and maintenance of very low sulfur levels, appear to be feasible ways of achieving the requisite toughness at high strength levels. While the improvement of stress corrosion cracking resistance remains a less tractable matter, a general

solution for the case of intergranular fracture by stress-corrosion cracking will emerge from current studies of the effects of segregating impurities and alloying additions on grain-boundary cohesion. O.C.

A90-37444
DEVELOPMENT OF A SIMULATED BIRD-STRIKE TEST METHOD
G. N. COLVIN and J. R. FALLS (Howmet Corp., Muskegon, MI) JOM (ISSN 1047-4838), vol. 42, May 1990, p. 26-29. refs
Copyright

An inexpensive test method has been developed to predict the dynamic impact-response (bird-strike resistance) of aircraft turbine engine fan blade materials. The test utilizes an instrumented pendulum to transfer energy to a machined fan blade cross section. To validate the test, the relative performance of one wrought and four cast Ti-6Al-4V materials subjected to the simulated bird-strike test was compared to that of the same materials tested at Wright-Patterson Air Force Base by conventional bird-strike testing. The relative ranking of crack initiation loads determined from the simulated test corresponded to fan blade failure velocities determined by the Air Force test, thereby validating the simulated method as a screening tool for fan blade material development. Author

A90-37662
A TECHNIQUE FOR RAPID IMPACT DAMAGE DETECTION WITH IMPLICATION FOR COMPOSITE AIRCRAFT STRUCTURES
J. P. KOMOROWSKI, D. L. SIMPSON, and R. W. GOULD (National Aeronautical Establishment, Ottawa, Canada) Composites (ISSN 0010-4361), vol. 21, March 1990, p. 169-173. Research supported by the National Aeronautical Establishment. refs
Copyright

A technique using a simple optical arrangement (called D-sight) involving a source of light and a retroreflective screen is used to locate indentations associated with low-energy impact damage. In graphite/epoxy specimens good correlation is observed between internal impact damage as shown on ultrasonic C-scan images and indentations detected with the D-sight method. Test specimens are mounted on an aircraft to observe the influence of in-service surface degradation on technique resolution. The method has the potential for inexpensive, rapid, and objective detection of low-energy impact damage over large areas of composite aircraft structure. Author

A90-37902
CORROSION PROTECTION AND EMP/EMI SHIELDING
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 10, June 1990, p. 27-30.
Copyright

The high-voltage electrical surges which are released from nuclear explosions are called electromagnetic pulses (EMP). Because they can have adverse effects on aircraft and other weapon system electrical circuits, the DOD has evaluated a variety of approaches to providing protection against EMP and electromagnetic interference (EMI). Researchers are now working to develop conductive sealants which can provide corrosion protection while meeting the EMP/EMI shielding requirements of military aircraft and missiles. Test results indicate that shielding effectiveness increases as dc resistance decreases, and shielding effectiveness does not appear to be a strong function of frequency above the 500-1000 MHz test frequency range. The correlations of resistance and shielding effectiveness necessitates that a low resistance exists across a joint or bond. Thus the researchers recommended that the conductive sealants successfully tested be used on existing and future aircraft and missiles where sealants can be liquid-applied. In addition to the test findings and their applications to the operational arena, a primary outcome of these tests is a set of recommended changes to selected military standards, specifications, and handbooks. These recommendations will be used as inputs to any proceedings conducted for the purpose of modifying those documents. R.E.P.

A90-38693#
HF SHOCK TUNNEL FACILITY FOR STUDYING SUPERSONIC COMBUSTION
DAVID A. RUSSELL (Washington, University, Seattle) and MICHAEL J. AARINO AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. refs
(AIAA PAPER 90-1551) Copyright

Many features of supersonic combustion can be modeled in a small laboratory facility by using hydrogen-fluorine chemistry. In this paper a shock tunnel is used to shock heat a flurine-argon mixture, which is expanded through a screen nozzle to a nominal Mach number of 4.5. Hydrogen fed from a Ludwieg tube is then injected into the flow. The resulting combustion creates vibrationally excited HF molecules, some of which will spontaneously emit visible radiation. The facility and its operation is described, as is the use of the overtone emission for tracking local mixing processes in the supersonic flow. Author

A90-38711*# North Carolina State Univ., Raleigh.
A HYBRID REYNOLDS AVERAGED/PDF CLOSURE MODEL FOR SUPERSONIC TURBULENT COMBUSTION
STEVEN H. FRANKEL, H. A. HASSAN (North Carolina State University, Raleigh), and J. PHILIP DRUMMOND (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 15 p. Research supported by USAF and U.S. Navy. refs
(Contract NAG1-244; NAGW-1072; NAGW-1331)
(AIAA PAPER 90-1573) Copyright

A hybrid Reynolds averaged/assumed pdf approach has been developed and applied to the study of turbulent combustion in a supersonic mixing layer. This approach is used to address the 'laminar-like' treatment of the thermochemical terms that appear in the conservation equations. Calculations were carried out for two experiments involving H2-air supersonic turbulent mixing. Two different forms of the pdf were implemented. In general, the results show modest improvement from previous calculations. Moreover, the results appear to be somewhat independent of the form of the assumed pdf. Author

N90-21869*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH SPEED COMMERCIAL TRANSPORT FUELS CONSIDERATIONS AND RESEARCH NEEDS
C. M. LEE and R. W. NIEDZWIECKI 1989 10 p Presented at the Symposium on the Structure of Future Jet Fuels 2, Miami Beach, FL, 10-15 Sep. 1989; sponsored by American Chemical Society
(NASA-TM-102535; E-5345; NAS 1.15:102535) Avail: NTIS HC A02/MF A01 CSCL 21D

NASA is currently evaluating the potential of incorporating High Speed Civil Transport (HSCT) aircraft in the commercial fleet in the beginning of the 21st century. NASA sponsored HSCT enabling studies currently underway with airframers and engine manufacturers, are addressing a broad range of technical, environmental, economic, and related issues. Supersonic cruise speeds for these aircraft were originally focused in the Mach 2 to 5 range. At these flight speeds, both jet fuels and liquid methane were considered potential fuel candidates. For the year 2000 to 2010, cruise Mach numbers of 2 to 3+ are projected for aircraft fuel with thermally stable liquid jet fuels. For 2015 and beyond, liquid methane fueled aircraft cruising at Mach numbers of 4+ may be viable candidates. Operation at supersonic speeds will be much more severe than those encountered at subsonic flight. One of the most critical problems is the potential deterioration of the fuel due to the high temperature environment. HSCT fuels will not only be required to provide the energy necessary for flight, but will also be subject to aerodynamic heating and, will be required to serve as the primary heat sink for cooling the engine and airframe. To define fuel problems for high speed flight, a fuels workshop was conducted at NASA Lewis Research Center. The purpose of the workshop was to gather experts on aviation fuels, airframe fuel systems, airport infrastructure, and combustion

systems to discuss high speed fuel alternatives, fuel supply scenarios, increased thermal stability approaches and measurements, safety considerations, and to provide directional guidance for future R and D efforts. Subsequent follow-up studies defined airport infrastructure impacts of high speed fuel candidates. The results of these activities are summarized. In addition, an initial case study using modified in-house refinery simulation model Gordian code (1) is briefly discussed. This code can be used to simulate different types of refineries, emphasizing jet fuel production and relative cost factors. Author

N90-22609*# Boeing Co., Seattle, WA.
BOEING/NASA COMPOSITE COMPONENTS FLIGHT SERVICE EVALUATION Final Progress Report No. 10, Jan. 1987 - Jun. 1989
RANDY L. COGGESHALL Sep. 1989 43 p
(Contract NAS1-11668)
(NASA-CR-181898; NAS 1.26:181898) Avail: NTIS HC A03/MF A01 CSCL 11/4

This tenth and final flight service report covers the flight service experience of 111 graphite-epoxy spoilers on 737 transport aircraft after 15 years of worldwide service. As of June 30, 1989, a total of 2,593,741 spoiler flight hours and 3,499,941 spoiler landings have been accumulated by the fleet. The high time spoiler had 42,007 flight hours. Results of 15 years of residual strength tests conducted on selected spoilers are reported. In addition, the flight service histories of composite elevators and stabilizers developed under NASA contracts NAS1-14952 and NAS1-15025, respectively, are reported. Author

N90-22651*# Virginia Univ., Charlottesville. School of Engineering and Applied Science.
NASA-UVA LIGHT AEROSPACE ALLOY AND STRUCTURES TECHNOLOGY PROGRAM Progress Report, 1 Jan. - 30 Jun. 1990
RICHARD P. GANGLOFF, JOHN K. HAVILAND, CARL T. HERAKOVICH, WALTER D. PILKEY, MAREK-JERZY PINDERA, GLENN E. STONER, ROBERT E. SWANSON (Virginia Polytechnic Inst., Blacksburg.), EARL A. THORNTON, FRANKLIN E. WAWNER, JR., and JOHN A. WERT Jun. 1990 400 p
(Contract NAG1-745)
(NASA-CR-182607; NAS 1.26:182607; UVA/528266/MS90/106)
Avail: NTIS HC A17/MF A03 CSCL 11/6

The objective of the Light Aerospace Alloy and Structures Technology Program is to conduct interdisciplinary graduate student research on the performance of next generation, light weight aerospace alloys, composites, and associated thermal gradient structures. Individual technical objectives are established for each project. Efforts aim to produce basic understanding of material behavior, monolithic and composite alloys, processing methods, solid and mechanics analyses, measurement advances, and a pool of educated graduate students. Progress is reported for 11 areas of study.

N90-22695# Federal Aviation Administration, Atlantic City, NJ.
TURBINE FUEL ALTERNATIVES (NEAR TERM) Final Report
AUGUSTO M. FERRARA Oct. 1989 49 p
(AD-A219405; DOT/FAA/CT-89/23) Avail: NTIS HC A03/MF A01 CSCL 21/4

This report discusses the results of a study which investigated several alternatives for turbine fuels, which are being considered for use in the near term, with the intent of identifying the necessary certification criteria. The fuels investigated include Jet-A/ethanol blends, Jet-A/methanol blends, JP-4/ethanol blends, and neat ethanol. The tests were conducted using a T-63 turboshaft engine, which was mounted on the Technical Center's dynamometer. The use of dual fuel systems was also considered. A short series of flight tests was conducted with a T-34, Mentor aircraft. These tests were used to identify the operating conditions which might result in elevated fuel temperature. 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.

A90-35394
HEAT TRANSFER IN SUPERSONIC COAXIAL REACTING JETS
S. I. BARANOVSKY, V. M. LEVIN, A. S. NADVORSKY, and A. I. TURISHCHEV (Moskovskii Aviatsionnyi Institut, Moscow, USSR) International Journal of Heat and Mass Transfer (ISSN 0017-9310), vol. 33, April 1990, p. 641-648. refs
Copyright

The paper deals with the study of thermal and gas dynamics of coaxial supersonic turbulent reacting jets of hydrogen and air at a low initial oxidation temperature, the air being contaminated with combustion products of petrol B-70. The two-dimensional mathematical model involves the k-epsilon turbulence model, modified for supersonic compressibility, and a detailed kinetic mechanism of mixture combustion. It is shown that recent experiments can be correctly described within the framework of the theory developed. Author

A90-35507
PROBABILISTIC DESIGN TECHNOLOGY FOR CERAMIC COMPONENTS
JOHN S. CUCCIO, HARRY L. KINGTON, and JOE H. ADAMS (Allied-Signal Aerospace Co., Phoenix, AZ) IN: Ceramic materials and components for engines; Proceedings of the Third International Symposium, Las Vegas, NV, Nov. 27-30, 1988. Westerville, OH, American Ceramic Society, Inc., 1989, p. 1273-1288. refs
Copyright

This paper addresses probabilistic life prediction methods that are applicable to ceramic gas turbine component design. Current promising life prediction methods are discussed with emphasis on fast fracture and slow crack growth. Examples of turbine rotor life predictions made with these methods are provided. The inadequacy of these methods are identified along with areas for future research to support turbine engine design. Author

A90-35508* Allied-Signal Aerospace Co., Phoenix, AZ.
THE ROLE OF NDE IN CERAMIC TURBINE ENGINE COMPONENT DEVELOPMENT
JANET MINTER (Allied-Signal Aerospace Co., Garrett Auxiliary Power Div., Phoenix, AZ) IN: Ceramic materials and components for engines; Proceedings of the Third International Symposium, Las Vegas, NV, Nov. 27-30, 1988. Westerville, OH, American Ceramic Society, Inc., 1989, p. 1289-1298. Research supported by DOE. refs
(Contract DEN3-335)
Copyright

A systematic approach to the use of nondestructive evaluation (NDE) throughout the ceramic engine component development cycle is necessary to achieve the high reliability required for turbine engine applications. Specifically, NDE techniques must be developed and applied to component design, development, fabrication, and test to ensure adequate materials characterization. This approach has the potential of reducing ceramic component cost by optimizing the initial design and eliminating unacceptable components early in the fabrication cycle. Although research NDE techniques have been developed that have the potential to solve the problems of ceramic component inspection, systematic application of these NDE techniques for inspection and process control has not yet occurred. The application of NDE techniques for both material characterization and flaw detection is discussed

as well as an approach for applying NDE throughout the fabrication process to achieve highly reliable ceramic components. Author

A90-35670
A MODAL PARAMETER IDENTIFICATION TECHNIQUE AND ITS APPLICATION TO LARGE COMPLEX STRUCTURES WITH MULTIPLE STEADY SINUSOIDAL EXCITATION
J.-S. JIANG, S.-N. GU (Northwestern Polytechnical University, Xian, People's Republic of China), Y.-J. WANG, and Q.-H. YAO (Ministry of Aerospace Industry, Strength Research Institute, Xian, People's Republic of China) Journal of Sound and Vibration (ISSN 0022-460X), vol. 138, April 22, 1990, p. 221-231. refs
Copyright

In this paper, a modal parameter identification technique with multiple steady sinusoidal excitation is proposed. The force amplitudes are proportional to each other, and the phases are either coincident or opposite. The frequency response function does not exist in the usual sense in these circumstances. Therefore, the Laplace transform of the response is taken as the function to be curve-fitted directly according to the principle of superposition for linear systems. Some advanced measures for improving the accuracy of the identified parameters are used. Application of this technique to some aircraft, and comparison with conventional ground vibration testing approaches, shows that the accuracies are comparable and that there is a significant reduction in the time required for testing by this technique. The technique requires neither prior knowledge of the test article, shaker placement, nor 'fine tuning' to a resonant state. Author

A90-35760*# Purdue Univ., West Lafayette, IN.
EULER FLUTTER ANALYSIS OF AIRFOILS USING UNSTRUCTURED DYNAMIC MESHES
RUSS D. RAUSCH, HENRY T. Y. YANG (Purdue University, West Lafayette, IN), and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 436-443. Previously cited in issue 12, p. 1859, Accession no. A89-30857. refs
(Contract NAG1-372)
Copyright

A90-35831#
ANALYSES OF REVISING THE INLET PROFILE OF A RADIAL INFLOW TURBINE IMPELLER
ZHENPING FENG, JINFENG XU, and ZUDA SHEN (Xian Jiaotong University, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, Feb. 1990, p. 47-49. In Chinese, with abstract in English. refs

In this paper, theoretical and numerical analyses are made in order to revise the inlet profile of a radial inflow turbine impeller for WZJ-70 vehicular turbocharger. The impeller inlet conditions which depend on the vaneless nozzle exit flow field, the engine pulsating discharge, and its off-design running are taken into account. A new-design plan of impeller which is characterized by its inlet profile, forward-curved in the middle part and swept-back near the shroud and hub, has been proposed. Author

A90-35951
DEVELOPMENT OF CERAMIC COMPONENTS FOR HIGH-TEMPERATURE GAS TURBINES
Y. HAMANO, T. MAEDA, M. CHIKARAISHI, and M. MATSUNAKA (Kyocera Corp., Kyoto, Japan) IN: MRS International Meeting on Advanced Materials, 1st, Tokyo, Japan, May 31-June 3, 1988, Proceedings. Volume 5. Pittsburgh, PA, Materials Research Society, 1989, p. 229-239.
Copyright

The activities of a Japanese company in the U.S. Advanced Gas Turbine Project is reviewed. Improvement of the fracture strength, stress rupture characteristics, and oxidation resistance of silicon nitride are discussed. The development of materials, process control technology, turbine rotors, and static components is examined and results from engine and rig tests are reviewed. R.B.

A90-36253*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DEVELOPMENT OF A THREE-DIMENSIONAL UPWIND PARABOLIZED NAVIER-STOKES CODE
SCOTT L. LAWRENCE, DENNY S. CHAUSSEE (NASA, Ames Research Center, Moffett Field, CA), and JOHN C. TANNEHILL (Iowa State University of Science and Technology, Ames) (Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers, p. 112-125) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 971, 972. Abridged. Research supported by Iowa State University of Science and Technology. Previously cited in issue 18, p. 2799, Accession no. A87-42061. refs
(Contract NCA2-IR-340-501)
Copyright

A90-36254*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPLICIT FLUX-SPLIT SCHEMES FOR THE EULER EQUATIONS
JAMES L. THOMAS (NASA, Langley Research Center, Hampton, VA), BRAM VAN LEER (Michigan, University, Ann Arbor), and ROBERT W. WALTERS (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 973, 974. Abridged. Previously cited in issue 19, p. 2856, Accession no. A85-41743.
Copyright

A90-36263#
INTERACTION BETWEEN BOUNDARY LAYER AND WAKES OF DIFFERENT BODIES
E. G. TULAPURKARA, V. RAMJEE, and R. RAJASEKAR (Indian Institute of Technology, Madras, India) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1032-1037. Research supported by the Aeronautical Research and Development Board of India. refs
Copyright

Measurements of mean velocity and Reynolds stresses have been made when the wakes of streamlined body and a bluff body interact with the boundary layer on a flat wall. The streamlined body is the NACA 0012 airfoil, and the bluff body is a rectangular cylinder. The two bodies have the same drag and are placed such that at the initial station behind the wake-producing body, the lower edge of the wake in the two cases is at the same height above the bottom wall. It is found that, though at the initial station the bluff-body wake is narrower and shallower than the airfoil wake, the level of turbulent fluctuations is higher in it, which causes faster mixing, and the velocity profile becomes monotonic earlier in the bluff-body case. Thus, for the same drag, the mixing is faster with a bluff body than with a streamlined body. Author

A90-36265# Virginia Polytechnic Inst. and State Univ., Blacksburg.
LARGE-SCALE STRUCTURE IN A SUPERSONIC SLOT-INJECTED FLOWFIELD
R. L. CLARK, JR., W. F. NG, D. A. WALKER, and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1045-1051. Research supported by Johns Hopkins University and NASA. refs
Copyright

Experimental results that show the existence of organized structures in a high-speed shear-layer flow are presented. Results were obtained using a parallel-array, dual-wire probe in a shear layer created by the mixing of tangential slot injection of supersonic air (Mach 1.7) into a supersonic air mainstream (Mach 3). The slot-injected flowfield was studied at three streamwise locations. At each station, a region dominated by the upstream boundary layer resulted in structure angles on the order of 50 deg. Structures in this region appeared to be the remnants of structures observed in the upstream boundary layer. Integral length scale in this region was on the order of 3 mm or less and increased to 4 mm at the longest streamwise location. The effect of a shock impingement

upon the shear layer was also investigated. The oblique shock had a nominal pressure ratio of 1.82. Structure angles and integral length scales appeared unaffected by the streamwise pressure gradient caused by the shock impingement. Author

A90-36271#
EXACT SOLUTIONS TO THE OSCILLATIONS OF COMPOSITE AIRCRAFT WINGS WITH WARPING CONSTRAINT AND ELASTIC COUPLING
GABRIEL A. OYIBO and JAMES BENTSON (Polytechnic University, Farmingdale, NY) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1075-1081. refs
(Contract F49620-85-C-0090; F49620-87-C-0046; AF-AFOSR-89-0055)
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Exact solutions within the framework of standard aeroelastic bending and twisting assumptions are found to the free oscillations of composite aircraft wings with warping constraint and elastic coupling. The problem is treated as a regular boundary-value problem consisting of two fourth-order partial differential equations coupled by the presence of elastic coupling. This system is therefore equivalent to an eight-order ordinary differential equation. Classical linear 'operator' methods are used to extract fundamental solutions that are superimposed appropriately to obtain an exact functional form for the mode shapes. These mode shapes are then required to satisfy the necessary boundary conditions, a process that leads to the formulation of the required eigenvalue problem. The eigenvalues are extracted numerically by using appropriate ordering of the eight roots of the operator equation. The bending-torsion frequencies obtained as a result of this analysis are compared favorably with existing results. New insights made possible by these results appear to be that (1) the first coupled frequency decreases with increasing coupling, and (2) the phenomenon of modal transformations found by earlier investigators is explainable in terms of some conservative intermodal energy transfer. Author

A90-36277#
HIGH-QUALITY APPROXIMATION OF EIGENVALUES IN STRUCTURAL OPTIMIZATION
R. A. CANFIELD (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1116-1122. refs

A new function for approximating natural frequency constraints during structural optimization is presented. Modern procedures for optimizing a structure typically solve a sequence of approximate subproblems as a means of efficiently finding the solution to the full-design problem. The subproblem is constructed by approximating the response quantities with a first-order Taylor series approximation to the actual functions, using appropriate intermediate design varibles. The nonlinearity of frequency constraint functions has historically required the imposition of strict move limits or the use of a second-order Taylor series approximation. The Rayleigh quotient approximation (RQA) presented here increases the quality of the approximate frequency constraint by approximating the modal strain and kinetic energies instead of the frequency eigenvalue itself. Numerical examples demonstrate that the RQA achieves fast and stable convergence with generous move limits. Author

A90-36285#
RESPONSE OF ORTHOGONALLY STIFFENED CYLINDRICAL SHELL PANELS
R. S. SRINIVASAN and P. A. KRISHNAN (Indian Institute of Technology, Madras, India) AIAA Journal (ISSN 0001-1452), vol. 28, June 1990, p. 1144, 1145. refs
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The dynamic response of orthogonally stiffened cylindrical shell panels which are clamped on all sides and subjected to a uniformly distributed step load is considered. For the free vibration analysis, a series solution, in conjunction with the Galerkin method, has been employed; a normal mode method is used to obtain the dynamic response. The stiffened shells in question find extensive use in aircraft fuselages. O.C.

A90-36417#
A QUADRATIC PROGRAMMING METHOD FOR SOLVING THREE DIMENSIONAL ELASTIC-PLASTIC CONTACT PROBLEMS
JINXIAN WANG (Chinese Academy of Sciences, Computing Center, People's Republic of China), BAIPENG WANG, and HUA YU (Xian Aircraft Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, March 1990, p. A140-A145. In Chinese, with abstract in English. refs

This paper discusses a solution method for three dimensional elastoplastic contact problems based on the quadratic programming theory. The numerical method, a max-min dual iterative method, is simple and very easy in programming. The convergence of the algorithm has been proved. Finally, a numerical example is given which is an axle-tube structure connecting the fuselage and landing gear of an aircraft. The numerical results show that the method is efficient. Author

A90-36431#
A FRACTURE ANALYSIS USING EIGHT-NODE-ISOPARAMETRIC SINGULAR ELEMENTS AND ITS APPLICATION IN FUSELAGE PANELS
JUNPING AN (Aircraft Structural Strength Research Institute, People's Republic of China) and QINGGUO SONG (Shanxi Aircraft Manufacture Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, April 1990, p. B151-B156. In Chinese, with abstract in English.

In order to develop an effective engineering method for fracture analysis of structures, an SIF solution represented only by the node displacements of an eight-node-isoparametric singular element is derived. A fracture analysis of stiffened fuselage panels is performed using the SIF solution. The results show that the solution is satisfactory for engineering purposes. C.D.

A90-36538
RESEARCH DEPARTMENT FLUID MECHANICS - SCIENTIFIC REPORT (1988)
Cologne, DLR, 1989, 8103 p. For individual items see A90-36539 to A90-36541.

The research activities of the DLR fluid-mechanics department (Forschungsbereich Stroemungsmechanik) during 1988 are surveyed. The organization, personnel, and facilities of the department are described, and particular attention is given to work in design aerodynamics, theoretical fluid mechanics, experimental fluid mechanics, turbulent flow, and propulsion technology. Extensive diagrams, drawings, graphs, and photographs are provided. T.K.

A90-36782
APPLICATIONS OF FIBER OPTIC SENSORS IN THE AEROSPACE AND MARINE INDUSTRIES
BRIAN CULSHAW (Strathclyde, University, Glasgow, Scotland) IN: Optical fiber sensors: Systems and applications. Volume 2. Boston, MA, Artech House, 1989, p. 701-720. refs
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Current and potential aerospace and marine applications of fiber-optic device technology are surveyed and illustrated with diagrams, drawings, and photographs. Consideration is given to fiber-optic gyros for guidance and navigation; temperature, pressure, displacement, smoke-detection, fuel-level and fuel-flow, vibration, and acceleration sensors for flight-control systems; sensors for turbine-engine monitoring and testing; and embedded-fiber testing and process-monitoring methods for advanced composite materials. The specifically marine applications discussed are arrays of hydrophones and magnetometers based on fibers with acoustic and magnetic coatings, respectively. T.K.

A90-36784#
EFFECT OF CONDENSATION IN A DIFFUSER ON THE FLOW FIELD

WANGXING SHI and JIAJU MA (Nanjing Aeronautical Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), June 1990, p. 6-11. In Chinese, with abstract in English.

Condensation is possible when the ambient humidity and Mach number of the air flow in the inlet are both sufficiently high. The condensation leads the average turbulence to be increased by 12-25 percent and the steady-state distortion factor DC60 to be changed in the experimental range. The condensation effect on the distortion flowfield should be considered in the study of tolerability between engine and inlet. Author

A90-37240#
A SIMPLE PREDICTION METHOD FOR LOW-CYCLE FATIGUE LIFE OF STRUCTURES
ZHONGLIANG ZHUANG, DEPING GAO, and SONGSHI GU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Feb. 1990, p. B98-B100. In Chinese, with abstract in English.

A simple prediction method for low-cycle fatigue life of structures under field load is described. Under rotating speed spectrum, the prediction of the fatigue life of a jet engine compressor disk is given. The results compare favorably with actual test results for the same material and under the same rotating speed spectrum. The key in this prediction is to obtain a typical load versus local damage curve at the critical load and existing material properties. Author

A90-37337*# Analytical Services and Materials, Inc., Hampton, VA.
APPLICATION OF OPTIMIZATION METHODS TO HELICOPTER ROTOR BLADE DESIGN
A. CHATTOPADHYAY (Analytical Services and Materials, Inc., Hampton, VA) and J. L. WALSH (NASA, Langley Research Center, Hampton, VA) Structural Optimization (ISSN 0934-4373), vol. 2, no. 1, 1990, p. 11-22. refs

A procedure for the minimum weight design of helicopter rotor blades with constraints on multiple coupled flap-lag natural frequencies, autorotational inertia, and centrifugal stress is presented. Optimum designs are obtained for blades with both rectangular and tapered planforms and are compared within a reference blade. The effects of higher-frequency constraints and stress constraints on the optimum blade designs are assessed. The results indicate that there is an increase in blade weight and a significant change in the design variable distributions with an increase in the number of frequency constraints. The inclusion of stress constraints has different effects on the wall thickness distributions of rectangular and tapered blades, but tends to increase the magnitude of the nonstructural segment weight distributions for both blade types. C.D.

A90-37830
VIBRATION EQUATIONS FOR A HELICOPTER ROTOR BLADE [URAVNENIIA KOLEBANII LOPASTI NESUSHCHEGO VINTA VERTOLETA]
R. A. MIKHEEV and T. D. SMOL'IANINOVA Raschety na Prochnost', no. 29, 1989, p. 196-201. In Russian. refs
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The problem of rotor blade vibration is analyzed using a mathematical problem based on differential equations describing blade motions. The differential equations of blade motion are derived using equilibrium equations for a blade element. A linearized system of differential equations of blade motion can be solved using an efficient method based on the Vlasov-Kantorovich approach. The same method can also be used in a more complex (nonlinear) approach. V.L.

A90-37881
NUMERICAL METHODS FOR THE TREATMENT OF PERIODIC SYSTEMS WITH APPLICATIONS TO STRUCTURAL DYNAMICS AND HELICOPTER ROTOR DYNAMICS
P. P. FRIEDMANN (California, University, Los Angeles) Computers and Structures (ISSN 0045-7949), vol. 35, no. 4, 1990, p. 329-347. refs
Copyright

The numerical techniques available for analyzing the stability, linear response and nonlinear response of periodic systems, which are governed by ordinary differential equations with periodic coefficients, are discussed. It is shown that numerically effective treatment of periodic systems is linked to efficient numerical computation of transition matrices for both the linear and the nonlinear case. After discussion of the linear case, the numerical treatment of the nonlinear response problem is considered using quasi-linearization and periodic shooting. Some recent research on the application of the finite element method in the time domain is also reviewed. Applications, taken from structural dynamics and helicopter rotor dynamics, which illustrate the numerical properties of these methods, are also presented. Author

A90-37901
AN ADVANCED X-RAY TECHNIQUE FOR NDI
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 10, June 1990, p. 23-25.
Copyright

Most of the mature technologies used in the nondestructive inspection (NDI) of aircraft, such as radiography, eddy current, acoustics, and ultrasonics, are designed to detect flaws by transmitting some form of energy into the structure and reflecting that energy back from the imperfections within the structure. X-ray tomographic microscopy (XTM) is a technique which offers promise because it can image in three dimensions, and it allows inspectors to observe cracks while they are forming. The XTM technique is applicable to all types of materials, including metals, ceramics, polymers, and composite materials. The unique facet of XTM is that it has demonstrated the ability to characterize the microstructures of aircraft structures to provide a time evolution of the chemical changes or damage that they undergo, as they experience those changes, and it does so in three dimensions. Current research efforts are centered on enhancing XTM resolution and sensitivity and researchers are confident that these refinements can be made in the near future, so that XTM can become a practical means for detecting aircraft structural damage. R.E.P.

A90-37933#
DEVELOPMENT OF AN X-RAY BACKSCATTER DENSITOMETER FOR MEASUREMENT OF FREESTREAM DENSITY DURING HYPERSONIC FLIGHT
R. S. CROOKS, D. SIMPSON (General Dynamics Corp., Convair Div., San Diego, CA), V. V. VERBINSKI, and V. J. ORPHAN (Science Applications International Corp., San Diego, CA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 13 p. refs
(AIAA PAPER 90-1384) Copyright

A feasibility study and demonstration test performed on a nonobtrusive concept for direct measurement of freestreem density for hypersonic flight vehicle air-data applications are presented. Compton scattered photons are measured in a region defined by the intersection of a collimated beam of X-ray energy, and a detector; the resulting backscattered photon count is directly proportional to the atomic/number density in the illuminated region. The relationship of backscattered counts to air density as a function of X-ray power, skin thickness, and geometry is analyzed, and the optimum source-detector spacing and crosstalk noise are determined. Test results are used to predict flight performance for a given hypersonic vehicle geometry and trajectory. Response time and uncertainty calculated for both 3-percent and 5-percent statistical density measurement accuracies are addressed. V.T.

A90-37954#
AN EXPERIMENTAL INVESTIGATION OF PRESSURE FLUCTUATION MECHANISM FOR DIFFERENT TRANSONIC POROUS WALL CONFIGURATIONS
B. L. MEDVED (DSMA International, Inc., Toronto, Canada) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June

18-20, 1990. 7 p. refs
(AIAA PAPER 90-1417) Copyright

An experimental investigation of the static pressure fluctuation generation mechanism for different transonic wind tunnel test section porous wall configurations has been performed. Different hole diameters and geometrical configurations were tested. Most testing was carried out with isolated holes, while some were done with three hole, 16 degree hole pattern. Results show that data from a specific porous wall configuration cannot be applied to other geometrically proportional, smaller or larger hole configurations. Author

A90-37958*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A NUMERICAL STUDY ON THE USE OF SULFUR HEXAFLUORIDE AS A TEST GAS FOR WIND TUNNELS
W. KYLE ANDERSON (NASA, Langley Research Center, Hampton, VA) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 12 p. refs
(AIAA PAPER 90-1421) Copyright

A numerical study is presented which investigates effects of using sulfur hexafluoride, S F6, as a substitute for air. Inviscid results for airfoils indicate that for transonic cases the shock location calculated for S F6 is vastly different from that in air and moves progressively forward on the airfoil as the freestream pressure is increased and real gas effects become more pronounced. Application of a simple Mach number scaling procedure results in good correlation between S F6 abnd air even for pressures at which nonideal gas effects are significant. Computations for subsonic turbulent flows over a NACA 0012 airfoil show that the maximum angle of attack at which steady lift can be obtained is different between air and S F6. In addition, for S F6, this angle of attack depends greatly on the freestream conditions. Close agreement with air can be achieved by altering the freestream Mach number according to the inviscid scaling procedure. Author

A90-37966#
REVIEW OF VORTICAL FLOW UTILIZATION
AHMAD D. VAKILI (Tennessee, University, Tullahoma) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 28 p. Research supported by the U.S. Navy and USAF. refs
(AIAA PAPER 90-1429) Copyright

In is shown that various interactions between shear flows and geometries and/or external forcing of different forms can be employed to accomplish certain flow processes; other features of vortical flows such as nonlinear interactions and high energy density concentration are also used to create specific flow effects. Selected examples of these type of interactions are presented. They include symmetric and nonsymmetric jets, wingtip jets, vortex rings, swirling flows, and slender wings. Emphasis is placed on the role geometry may play and how the vortex flow utilization can be enhanced by passive global interactions and accommodation of different vortices. It is noted that fundamental features of vortices such as nonlinearity, instability, and the potential for high energy density must be exploited for optimum utilization of the vortical flows. V.T.

A90-38097
HIGH VOLTAGE DESIGN GUIDE SUMMARY
BILL DOBBS, CHRISTINA TARVIN (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH), and W. G. DUNBAR IN: IECEC-89; Proceedings of the Twenty-fourth Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug. 6-11, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1989, p. 423-428.
Copyright

A summary is presented of the work completed on the High Voltage Design Guide developed for the US Air Force Materials Lab. The design guide presents information on fields, materials and processes, component selection, packaging, manufacturing and testing. Formulas and empirical equations are shown for typical high-voltage electrode configurations found in electrical equipment. A designer using these empirical formulas and the field plotting methods shown can locate maximum field stresses within electrical insulation systems. Then the proper dielectrics can be selected for the development of high-quality, long-life power supplies. I.E.

A90-38132
APPLYING AVIP TO HIGH VOLTAGE POWER SUPPLY DESIGNS
WILLIAM DUNBAR and JOSE A. RUGAMA (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: IECEC-89; Proceedings of the Twenty-fourth Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug. 6-11, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1989, p. 645-649.
Copyright

Several avionic integrity program (AVIP) requirements are described and applied to high-voltage power supply (HVPS) designs. The requirements are: environment, materials characterization, design criteria, durability, manufacturing/process controls, and testing. Related integrity design topics dealing with HVPS failures, insulating material properties, packaging, and fatigue life predictions are also discussed. I.E.

A90-38175
EXTRACTING PULSE POWER FROM BATTERIES
HENRY OMAN (Boeing Aerospace, Seattle, WA) IN: IECEC-89; Proceedings of the Twenty-fourth Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug. 6-11, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1989, p. 1067-1071. refs
Copyright

The capability of lead-acid batteries for supplying very high power for a short time is discussed. An example is given of a 400-metric-ton hypersonic passenger-carrying airplane that could be accelerated to Mach 2.3 on a launch ramp. During the last second of a 3-g acceleration the plane's kinetic energy increases by a 2.6-MWh increment. The 9300 MW of power required during this last second is not a desirable load for an electric utility, but it could be supplied with lead-acid batteries. Various lead-acid batteries are evaluated for applications with these kinds of requirements. Alternatives to batteries are briefly discussed. I.E.

A90-38353
HIERARCHICAL FINITE ELEMENT METHOD FOR ROTATING BEAMS
K. M. UDUPA (Hindustan Aeronautics, Ltd., Helicopter Design Bureau, Bangalore, India) and T. K. VARADAN (Indian Institute of Technology, Department of Aerospace Engineering, Madras, India) Journal of Sound and Vibration (ISSN 0022-460X), vol. 138, May 8, 1990, p. 447-456. refs
Copyright

The free vibration characteristics of rotating beams are analyzed by means of a finite element method of hierarchical form, in which the displacement function for the element is taken to be a polynomial of variable degree. The first four terms of the polynomial are expressed in terms of the displacements and slopes at the extremities of the elements, and the rest of the terms are considered as internal degrees of freedom. Numerical results are presented for cantilever beams with uniform, non-uniform and discontinuous sectional properties. A comparison of the present results with those in the published literature indicates that the present relatively simple formulation is as efficient as the other well established techniques. Finally, some clarification is also provided of certain subtle issues concerning the accuracy of the finite element solution and monotonic convergence characteristics, and their dependence on the arithmetic precision of the computer employed is indicated. Author

A90-38493
BOUNDARY LAYER DIAGNOSTICS BY MEANS OF AN INFRARED SCANNING RADIOMETER
L. DE LUCA, G. M. CARLOMAGNO (Napoli, Universita, Naples,

Italy), and G. BURESTI (Pisa, Universita, Italy) Experiments in Fluids (ISSN 0723-4864), vol. 9, no. 3, May 1990, p. 121-128. refs
Copyright

A computerized infrared (IR) scanning radiometer is employed to characterize the boundary layer development over a model wing, having a Goettingen 797 cross-section, by measuring the temperature distribution over its heated surface. The Reynolds analogy is used to relate heat transfer measurements to skin friction. The results show that IR thermography is capable of rapidly detecting location and extent of transition and separation regions of the boundary layer over the whole surface of the tested model wing. Thus, the IR technique appears to be a suitable and effective diagnostic tool for aerodynamic research in wind tunnels. Author

A90-38544
NON-CONSERVATIVE STABILITY OF A CRACKED THICK ROTATING BLADE
L.-W. CHEN and J.-L. CHEN (National Cheng Kung University, Tainan, Republic of China) Computers and Structures (ISSN 0045-7949), vol. 35, no. 6, 1990, p. 653-660. refs
Copyright

A finite element model is applied to the non-conservative stability problems of a cracked thick rotating blade. This finite element model can satisfy all the geometric and natural boundary conditions of a rotating blade. The blade is considered to be subjected to follower moments and aerodynamic forces. The effects of crack locations and crack sizes are studied. It is found that the rotation speed and crack can change the stability characteristics of a non-conservative system. Author

A90-38610#
INFRARED CAMERAS FOR DETECTION OF BOUNDARY LAYER TRANSITION IN TRANSONIC AND SUBSONIC WIND TUNNELS
JAMES P. CROWDER (Boeing Commercial Airplanes, Seattle, WA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. refs
(AIAA PAPER 90-1450) Copyright

The requirement for the routine detection of boundary layer transition on low-speed and transonic wind tunnel models is reviewed. The basis for the use of infrared cameras for this task and the particular problems of that application are described. Results of an initial evaluation in low-speed and transonic wind tunnels are provided. A new technique for enhancing infrared camera transition images using liquid nitrogen injection is presented. Author

A90-38614*# Princeton Univ., NJ.
A STUDY OF THE UNSTEADINESS OF CROSSING SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTIONS
K. PODDAR and S. M. BOGDONOFF (Princeton University, NJ) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 14 p. refs
(Contract AF-AFOSR-89-0033; NAG3-926)
(AIAA PAPER 90-1456) Copyright

The unsteadiness of crossing shock wave turbulent boundary layer interactions at a nominal Mach number of 3 was examined by measuring wall pressure fluctuations using multiple, high frequency response, pressure transducers. The unsteadiness in the initial part of the interaction for all the interactions is similar to that of single fin interaction as studied by Tran and Bogdonoff (1987). However, for stronger interactions, flow downstream of the inviscid shock crossing position has a significant unsteady characteristic. In this unsteady region of the interaction, mean surface pressure rises significantly over the value obtained from the inviscid shock approximation. The energy spectrum of the fluctuating pressure signal shows a significant increase in the energy level at the higher frequencies. Author

A90-38651*# Tennessee Univ., Tullahoma.
INFLUENCE OF BULK TURBULENCE AND ENTRANCE BOUNDARY LAYER THICKNESS ON THE CURVED DUCT FLOW FIELD
AHMAD A. SHOHADAEE, ROGER A. CRAWFORD, and ALI HEDAYATPOUR (Tennessee, University, Tullahoma) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 7 p. Previously announced in STAR as N89-12896.
(Contract NAG3-617)
(AIAA PAPER 90-1502) Copyright

The objective of this investigation was the experimental evaluation of bulk turbulence and boundary thickness influence on the secondary flow development in a square, 90 deg turning duct. A three dimensional laser velocimetry system was utilized to measure the mean and fluctuating components of velocity in the large curved duct facility. The three dimensional development of the viscous shear layers in the curved duct has a strong influence on the complete flow field. Since ducted three dimensional flows are found in many engineering applications, including gas turbine engines, and contain high turbulence levels and high wall heat transfer rates, they present a difficult challenge to computational fluid mechanics codes. Turbulence modeling remains one of constraints to CFD advance due to inadequate physical understanding and experimental definition of turbulent shear flows. The results of this investigation expand the curved duct data base to higher turbulence levels and thicker entrance boundary layers. The experimental results provide a challenging benchmark data base for computational fluid dynamics code development and validation. The variation of inlet bulk turbulence intensity provides additional information to aid in turbulence model evaluation. Author

A90-38663*# Virginia Univ., Charlottesville.
EXPERIMENTAL INVESTIGATION OF A SUPERSONIC SWEPT RAMP INJECTOR USING LASER-INDUCED IODINE FLUORESCENCE
ROY J. HARTFIELD, STEVEN D. HOLLO, and JAMES C. MCDANIEL (Virginia, University, Charlottesville) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p. refs
(Contract NAG1-795)
(AIAA PAPER 90-1518) Copyright

Planar measurements of injectant mole fraction and temperature have been conducted in a nonreacting supersonic combustor configured with underexpanded injection in the base of a swept ramp. The temperature measurements were conducted with a Mach 2 test section inlet in streamwise planes perpendicular to the test section wall on which the ramp was mounted. Injection concentration measurements, conducted in cross flow planes with both Mach 2 and Mach 2.9 free stream conditions, dramatically illustrate the domination of the mixing process by streamwise vorticity generated by the ramp. These measurements, conducted using a nonintrusive optical technique (laser-induced iodine fluorescence), provide an accurate and extensive experimental data base for the validation of computation fluid dynamic codes for the calculation of highly three-dimensional supersonic combustor flow fields. Author

A90-38677#
THE LATERAL SPREADING OF FINITE-SPAN INSTABILITY WAVES IN A LAMINAR MIXING LAYER
FREDERICK W. ROOS and JEROME T. KEGELMAN (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 10 p. Research supported by McDonnell Douglas Corp. refs
(Contract F49620-86-C-0090)
(AIAA PAPER 90-1532) Copyright

Experiments have been conducted in a laminar, two-dimensional, two-stream mixing layer to investigate the lateral spreading of acoustically excited, finite-span instability waves. Excitation-synchronized flow visualization and extensive hot-wire

measurements were made in the mixing layer to define the amplitude and phase characteristics of the vortex-rollup and wave-spreading phenomena. The spreading rate was found to increase with increases in excitation frequency and amplitude; close proximity of a bounding wall retarded lateral spreading. Behind a swept trailing edge, the spreading rate is asymmetrical, especially at the higher frequency and amplitude studied. A pronounced, localized crossflow exists in the velocity profile downstream of the swept trailing edge. The lateral-spreading phenomenon is not, in general, sufficiently strong to produce the unswept instability-wave patterns previously observed in laminar mixing layers behind swept trailing edges. Author

A90-38725#
BOUNDARY CONDITIONS FOR EULER EQUATIONS AT INTERNAL BLOCK FACES OF MULTI-BLOCK DOMAINS USING LOCAL GRID REFINEMENT
A. KASSIES (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) and R. TOGNACCINI (Aeritalia S.p.A., Naples, Italy) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 13 p. Research supported by Netherlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs
(AIAA PAPER 90-1590) Copyright

A method is developed for multiblock flow solvers based on an explicit cell-centered finite-volume scheme with adaptive numerical dissipation. By implementing the method in a 3D multiblock solver, a powerful aerodynamic analysis tool for solving the Euler equations in an arbitrary flow domain has been obtained. The ability of the flow solver to handle grid discontinuities over internal faces allows much freedom in the grid generation process. Finally, the use of local grid refinement per block offers the desired flow simulation accuracy with grids of reasonable size. R.E.P.

A90-38730#
INVESTIGATION OF SEVERAL PASSIVE AND ACTIVE METHODS FOR TURBULENT FLOW SEPARATION CONTROL
J. C. LIN, F. G. HOWARD, D. M. BUSHNELL (NASA, Langley Research Center, Hampton, VA), and G. V. SELBY (Old Dominion University, Norfolk, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 21 p. refs
(AIAA PAPER 90-1598)

Relative performance of several passive and active methods for controlling two-dimensional turbulent separated flow associated with a curved backward-facing ramp were investigated at low speeds. Surface static pressure measurement and oil flow visualization results indicate that submerged vortex generators, vortex generator jets, elongated arches at +-alpha, and large-eddy breakup devices at +-alpha placed near the baseline separation location reduce flow separation and increase pressure recovery. Spanwise cylinders reduce flow separation but decrease pressure recovery downstream. Arches with alpha = 0 deg, Helmholtz resonators, and Viets' fluidic flappers examined so far have no significant effect in reducing separation. Wall cooling computation indicates that separation delay on a partially cooled ramp is nearly the same as on a fully-cooled ramp while minimizing the frictional drag increase associated with the wall cooling process. Author

A90-38746#
AERODYNAMIC BREAKUP OF LIQUID JETS - A REVIEW
L. R. UTREJA and D. B. HARMON (BDM International, Inc., Huntsville, AL) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 14 p. refs
(AIAA PAPER 90-1616) Copyright

There are many applications for which it is important to understand the breakup of a liquid glob or jet into droplets (e.g., propulsion, control, and cooling of system components). The aerodynamic breakup of liquids is a complex process and is affected by the geometry, flow conditions and the liquid properties. This paper summarizes the results of several studies on the subject and discusses features of the phenomena which appear to be possible mechanisms in the liquid breakup process. The acceleration waves are the most likely mechanism responsible for the liquid breakup with secondary influence from the liquid properties, surface tension and viscosity. Correlations are presented for predicting the stability of liquid drops and breakup conditions. The results of this analysis will help toward better understanding of the role of aerodynamic forces in the breakup of liquids. Author

A90-38750#
TOTAL TEMPERATURE SEPARATION IN JETS
M. KUROSAKA, K. HIRANO (Washington, University, Seattle), and MICHAEL FOX AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 13 p.
(Contract F49620-88-C-0041)
(AIAA PAPER 90-1621) Copyright

The effect of large-scale vortical structures on the total-temperature, T(t), distribution is examined for both a free and an impingint jet. Time-averaged T(t) measurements are made in an air jet facility, and a water jet is used for flow visualization. The data shows a substantial modification of the T(t) distribution caused by the vortical structure. Acoustic resonance, when it occurs, is found to have a significant influence. Author

A90-38752#
THE EFFECT OF CONSTRUCTIVE AND DESTRUCTIVE INTERFERENCE ON THE DOWNSTREAM DEVELOPMENT OF TWIN JETS IN A CROSSFLOW. I - DESTRUCTIVE INTERFERENCE OF LATERALLY SPACED JETS
R. G. DIMICCO, P. J. DISIMILE (Cincinnati, University, OH), and D. FABRIS AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 9 p. refs
(AIAA PAPER 90-1623) Copyright

This experimental study focuses on the interaction between two circular jets exhausting into an otherwise undisturbed crossflow. In this study, flow visualization has been used to study the penetration of twin jets transversely injected into a crossflow. The parameters investigated include jet centerline-to-centerline spacing and momentum flux ratio. The jets were studied laterally spaced across the approaching freestream flow. Qualitative information such as penetration versus downstream position was extracted from the visualization data. It was determined that when the momentum flux ratio was low and the jet-to-jet spacing was small, the growth of the penetration was reduced as the jets developed downstream. For high momentum flux ratios and large jet-to-jet spacings, the penetration of the jet structures was found to be within 5 percent of the single jet case. Author

A90-38765*# AS&M, Inc., Hampton, VA.
MEASUREMENT OF CROSSFLOW VORTICES, ATTACHMENT-LINE FLOW, AND TRANSITION USING MICROTHIN HOT FILMS
S. M. MANGALAM, N. K. AGARWAL (AS & M, Inc., Hampton, VA), D. V. MADDALON (NASA, Langley Research Center, Hampton, VA), and W. S. SARIC (Arizona State University, Tempe) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 10 p. refs
(Contract NAS1-18599; NAG1-805; NAG1-937)
(AIAA PAPER 90-1636) Copyright

A flow diagnostic experiment was conducted on a 45-deg swept-wing model using surface-mounted, multielement, microthin, hot-film sensors. The cross-flow vortex spacing, the attachment-line flow characteristics, and the transition region were all determined using an advanced data acquisition and instrumentation system. In addition to the frequencies of traveling waves predicted by linear stability theory, amplified disturbances at much higher frequencies were observed. Simultaneous measurements from sensors located at a number of chord and span locations highlighted the strong three-dimensionality of the boundary-layer flow in the presence of cross-flow vortices. The state of the attachment-line boundary layer was determined using a multielement sensor wrapped around the wing leading edge. The transition region flow characteristics were also identified. Author

A90-38769#
NUMERICAL SIMULATION OF A TURBULENT FLOW THROUGH A SHOCK WAVE
D. NIXON, G. D. KUHN, and M. FARSHCHI (Nielsen Engineering & Research, Inc., Mountain View, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 16 p. refs
(Contract AF-AFOSR-87-0032; AF-AFOSR-88-0007; N00014-87-C-0483)
(AIAA PAPER 90-1641) Copyright

In this paper, a numerical simulation of a turbulent flow through a shock wave is developed using an explicit second-order accurate MacCormack scheme as the numerical method. The results demonstrated that shock-turbulence interaction contains influences from the shock motion that are quite unapparent from a Reynolds averaged point of view. An examination of the solutions generated by the two-dimensional code indicated that the numerical errors that are inherent in the explicit MacCormack algorithm do not affect the turbulence calculations. I.S.

A90-38781*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ALGEBRAIC TURBULENCE MODELING FOR UNSTRUCTURED AND ADAPTIVE MESHES
DIMITRI J. MAVRIPLIS (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. refs
(AIAA PAPER 90-1653) Copyright

An algebraic turbulence model based on the Baldwin-Lomax model, has been implemented for use on unstructured grids. The implementation is based on the use of local background structured turbulence meshes. At each time-step, flow variables are interpolated from the unstructured mesh onto the background structured meshes, the turbulence model is executed on these meshes, and the resulting eddy viscosity values are interpolated back to the unstructured mesh. Modifications to the algebraic model were required to enable the treatment of more complicated flows, such as confluent boundary layers and wakes. The model is used in conjuction with an efficient unstructured multigrid finite-element Navier-Stokes solver in order to compute compressible turbulent flows on fully unstructured meshes. Solutions about single and multiple element airfoils are obtained and compared with experimental data. Author

N90-21988# Royal Aerospace Establishment, Farnborough (England).
FEATURE-ASSOCIATED MESH EMBEDDING FOR COMPLEX CONFIGURATIONS
C. M. ALBONE and GAYNOR JOYCE (City Univ., London, England) *In* AGARD, Applications of Mesh Generation to Complex 3-D Configurations 12 p Mar. 1990
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The mesh-generation scheme described was designed to cope with complex geometric and flow features by employing many regular three-dimensional overlying meshes. Features are classified according to the number of geometric constraints to which they are subject, and each feature has its own purpose-built mesh. Four different mesh topologies are required to deal with all possible geometric and flow features. Progress to date is described and meshes for simple three-dimensional configurations are shown together with results of some Euler flow calculations. Author

N90-21991# Aircraft Research Association Ltd., Bedford (England).
A DISCUSSION ON ISSUES RELATING TO MULTIBLOCK GRID GENERATION
J. M. GEORGALA and J. A. SHAW *In* AGARD, Applications of Mesh Generation to Complex 3-D Configurations 13 p Mar. 1990 Sponsored in part by Ministry of Defence, England
Copyright Avail: NTIS HC A14/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Efforts aimed at bringing a multiblock grid generation system to the state of maturity necessary for practical use are discussed. Attention is focused upon the interrelated areas of topology generation and grid control. An algorithm for automatically decomposing a flow domain about an aircraft configuration into a component-adaptive topology is given. Two techniques for controlling the resulting grid topology are described. The first automatically produces default grids, which will generally be of an acceptable quality. The second is a user-friendly interactive grid editor which allows any deficiencies in the default grids to be rapidly identified and modified. Examples of the multiblock approach are applied to a range of aircraft geometries. Author

N90-21992# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France). Departement des Etudes Theoriques Aerodynamiques.
AUTOMATIC GRID GENERATION IN COMPLEX THREE-DIMENSIONAL CONFIGURATIONS USING A FRONTAL SYSTEM [GENERATION DE MAILLAGE AUTOMATIQUE DANS DES CONFIGURATIONS TRIDIMENSIONNELLES COMPLEXES UTILISATION D'UNE METHODE DE FRONT]
F. HUET *In* AGARD, Applications of Mesh Generation to Complex 3-D Configurations 12 p Mar. 1990 In FRENCH
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Among the types of grid generation, the frontal construction method, starting from the limiting preset parameters, seems to be the most promising with respect to complex configurations within the framework of the finite element method. Its flexibility and its great adaptability makes it a tool with a very large area of application. The algorithm presented functions for the grids of complex configurations encounterd in aeronautics: engine nozzles with multiflow, Hermes shuttle, and Falcon. Transl. by E.R.

N90-21993*# University Coll. of Swansea (Wales). Dept. of Civil Engineering.
UNSTRUCTURED FINITE ELEMENT MESH GENERATION AND ADAPTIVE PROCEDURES FOR CFD
J. PERAIRE, K. MORGAN, and J. PEIRO *In* AGARD, Applications of Mesh Generation to Complex 3-D Configurations 12 p Mar. 1990 Sponsored by NASA; Avions Marcel Dassault; and Civil and Military Aircraft Div., British Aerospace Public Ltd. Co.
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A method is described for generating unstructured meshes of triangles or tetrahedra for computational domains of complex geometrical shape. To illustrate the power of the approach, it is applied to the solution of flows past several complete aircraft configurations. The advocated approach allows for the natural incorporation of mesh adaptivity and this is demonstrated for both inviscid and viscous computations in two and three dimensions. Author

N90-22003# Argonne National Lab., IL.
DEVELOPMENT OF A COMPUTATIONAL FLUID DYNAMICS AND CHEMISTRY MODEL FOR THE FOULING OF JET FUELS
J. L. KRAZINSKI, S. P. VANKA, J. A. PEARCE, and W. M. ROQUEMORE (Air Force Aero Propulsion Lab., Wright-Patterson AFB, OH.) 1990 41 p Presented at the 35th International Gas Turbine and Aeroengine Congress and Exposition, Brussels, Belgium, 11-14 Jun. 1990 Sponsored by Air Force Aero Propulsion Lab., Wright-Patterson AFB, OH and Pittsburgh Energy Technology Center, PA
(Contract W-31-109-ENG-38)
(DE90-005664; CONF-900615-1) Avail: NTIS HC A03/MF A01

A new approach has been devised in which Computational Fluid Dynamic and Chemistry (CFDC) models are employed to predict the fluid mechanics, heat transfer, and deposition in fuel

system components. The structure of this model is such that it has the potential of being used as a tool for research or to assist in the design of heat exchangers or other fuel system components. The model contains several unknown parameters that must be calibrated using experimental data for a particular fuel. This paper describes the development of the model, a method of calibrating the model, and a sensitivity analysis of the effects of different model parameters on predicted deposition rates in a heated tube. DOE

N90-22014# National Aerospace Lab., Amsterdam (Netherlands).
EUROPEAN RESEARCH ON VISCOUS FLOW (EUROVISC) Annual Report No. 17, 1988
J. P. F. LINDHOUT, ed., J. COUSTEIX, ed., D. A. HUMPHREYS, ed., W. KORDULLA, ed., and P. D. SMITH, ed. (Royal Aeronautical Society, London, England) Jan. 1989 163 p
(NLR-TP-89077-U; ETN-90-96399) Avail: NTIS HC A09/MF A01

A survey of research work going on today in Europe on viscous flow problems, is given. The reports of associations include: the experimental investigation of the turbulent shear layers of a swept wing, experimental turbulent boundary layers in ducts, the missions of CERFACS and studies on numerical methods in fluid mechanics. Specific activities within the high speed aerodynamics, study of transition models, both active and passive laminar flow control, experimental techniques and computational methods, are discussed. ESA

N90-22025* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVICE FOR QUICKLY SENSING THE AMOUNT OF O2 IN A COMBUSTION PRODUCT GAS Patent
JAG J. SINGH, inventor (to NASA), WILLIAM T. DAVIS, inventor (to NASA), and RICHARD L. PUSTER, inventor (to NASA) 27 Mar. 1990 7 p Filed 9 Mar. 1988
(NASA-CASE-LAR-13816-1; US-PATENT-4,911,890; US-PATENT-APPL-SN-165945; US-PATENT-CLASS-422-62; US-PATENT-CLASS-422-98; US-PATENT-CLASS-422-111; US-PATENT-CLASS-422-126; US-PATENT-CLASS-436-55; US-PATENT-CLASS-436-137; US-PATENT-CLASS-436-143)
Avail: US Patent and Trademark Office CSCL 14B

A sensing device comprising an O2 sensor, a pump, a compressor, and a heater is provided to quickly sense the amount of O2 in a combustion product gas. A sample of the combustion product gas is compressed to a pressure slightly above one atmosphere by the compressor. Next, the heater heats the sample between 800 C and 900 C. Next, the pump causes the sample to be flushed against the electrode located in O2 sensor 6000 to 10,000 times per second. Reference air at approximately one atmosphere is provided to the electrode of O2 sensor. Accordingly, the O2 sensor produces a voltage which is proportional to the amount of oxygen in the combustion product gas. This voltage may be used to control the amount of O2 entering into the combustion chamber which produces the combustion product gas. Official Gazette of the U.S. Patent and Trademark Office

N90-22048# Oak Ridge National Lab., TN.
ROBOTS FOR AIRCRAFT COATINGS REMOVAL: PARAMETERS AND REQUIREMENTS
URI GAT 1990 3 p Presented at the DOD Conference on Industry Advanced Coatings Removal, Atlanta, GA, 1-3 May 1990 (Contract DE-AC05-84OR-21400)
(DE90-009429; CONF-9005155-1) Avail: NTIS HC A01/MF A01

The chemical stripping of coatings of aircraft is being phased out, primarily for environmental reasons. The search is on for methods that are more economical, more efficient, non-damaging and environmentally acceptable. Two of several prime candidates for the new methods are laser stripping and media stripping. Amongst the media stripping methods several are being considered, some of which are plastic media, bicarbonates, and frozen carbon dioxide. To achieve better quality, uniformity, efficiency, and economy and to reduce to a minimum any possible environmental hazards, it is desirable to utilize robots and automatic methods for the aircraft stripping. It is desirable that the robots be flexible and versatile to the extent possible. The flexibility and versatility refers to the ability to recognize and adjust to: variations within an aircraft type; different types of aircraft, including segments of aircraft; accommodation of different stripping methods, primarily laser stripping and plastic media blasting (PMB). However it is realized that flexability or versatility may not be available. Furthermore no practical robots or even partial levels of automation may be readily available for implementation. This paper summarizes desired features and characteristics for robots for coatings removals from aircraft. DOE

N90-22058 Princeton Univ., NJ.
A METHODOLOGY FOR KNOWLEDGE-BASED RESTRUCTURABLE CONTROL TO ACCOMMODATE SYSTEM FAILURES Ph.D. Thesis
CHIEN YU HUANG 1989 212 p
Avail: Univ. Microfilms Order No. DA9008352

The problem of dealing with unanticipated failures of dynamic systems is addressed. The solution centers on developing a knowledge based approach to perform online failure isolation and system reconfiguration. The failure analysis employs inference mechanisms and causal relationships among the devices to generate probable failure models, which are pruned and ranked by the use of heuristic measures. Hypotheses for other probable causes are made if the failure model does not adequately account for the anomalies. After the source of the failure is identified, the system knowledge is updated and the impact of failure is assessed. Any degradation of the system performance caused by failures is restored by restructuring the control. This issue is studied in depth and addressed by the analysis and design of an implicit model following control law. The concepts and methodologies of the approach are illustrated via many examples and further substantiated using a number of failure scenarios involving a tandem rotor helicopter. The results show that by providing a form of intelligent self organization, the knowledge based restructurable control approach potentially is capable of accommodating unanticipated failures. Dissert. Abstr.

N90-22059# Vibration Inst., Clarendon Hills, IL.
THE SHOCK AND VIBRATION DIGEST, VOLUME 21, NO. 2 Monthly Report
VICKI M. PATE, ed. Feb. 1989 76 p
Avail: NTIS HC A05/MF A01

A feature article on vibration analysis of systems with random parametric excitations is presented. A book on the rotordynamics of turbomachinery is reviewed. Abstracts dealing with such shock and vibration related topics as machine tools, bridges, automobiles, gears, beams, mechanical properties, fatigue tests, computational methods and modeling techniques are given

N90-22064# Vibration Inst., Clarendon Hills, IL.
THE SHOCK AND VIBRATION DIGEST, VOLUME 21, NO. 3 Monthly Report
VICKI M. PATE, ed. Mar. 1989 72 p
Avail: NTIS HC A04/MF A01

A feature article on rotor to stationary element rub-related vibration phenomena in rotating machinery is presented. A book concerned with the dynamics of multibody systems is reviewed. Abstracts on shock and vibration related topics such as mechanical drives, towers, automobiles, expert systems, gears, beams, mechanical properties, vibration tests, computational methods and modeling techniques are given.

N90-22662*# Virginia Univ., Charlottesville.
DESIGN OF CRYOGENIC TANKS FOR LAUNCH VEHICLES
CHARLES COPPER, WALTER D. PILKEY, and JOHN K. HAVILAND *In its* NASA-UVA Light Aerospace Alloy and Structures Technology Program 20 p Jun. 1990
Avail: NTIS HC A17/MF A03 CSCL 13/9

During the period since January 1990, work was concentrated on the problem of the buckling of the structure of an ALS (advanced launch systems) tank during the boost phase. The primary problem

was to analyze a proposed hat stringer made by superplastic forming, and to compare it with an integrally stiffened stringer design. A secondary objective was to determine whether structural rings having the identical section to the stringers will provide adequate support against overall buckling. All of the analytical work was carried out with the TESTBED program on the CONVEX computer, using PATRAN programs to create models. Analyses of skin/stringer combinations have shown that the proposed stringer design is an adequate substitute for the integrally stiffened stringer. Using a highly refined mesh to represent the corrugations in the vertical webs of the hat stringers, effective values were obtained for cross-sectional area, moment of inertia, centroid height, and torsional constant. Not only can these values be used for comparison with experimental values, but they can also be used for beams to replace the stringers and frames in analytical models of complete sections of tank. The same highly refined model was used to represent a section of skin reinforced by a stringer and a ring segment in the configuration of a cross. It was intended that this would provide a baseline buckling analysis representing a basic mode, however, the analysis proved to be beyond the scope of the CONVEX computer. One quarter of this model was analyzed, however, to provide information on buckling between the spot welds. Models of large sections of the tank structure were made, using beam elements to model the stringers and frames. In order to represent the stiffening effects of pressure, stresses and deflections under pressure should first be obtained, and then the buckling analysis should be made on the structure so deflected. So far, uncharacteristic deflections under pressure were obtained from the TESTBED program using two types of structural elements. Similar results were obtained using the ANSYS program on a mainframe computer, although two finite element programs on microcomputers have yielded realistic results.

Author

N90-22703*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ELEMENTS OF ACTIVE VIBRATION CONTROL FOR ROTATING MACHINERY

HEINZ ULBRICH May 1990 50 p

(NASA-TM-102368; E-5036; NAS 1.15:102368) Avail: NTIS HC A03/MF A01 CSCL 13/2

The success or failure of active vibration control is determined by the availability of suitable actuators, modeling of the entire system including all active elements, positioning of the actuators and sensors, and implementation of problem-adapted control concepts. All of these topics are outlined and their special problems are discussed in detail. Special attention is given to efficient modeling of systems, especially for considering the active elements. Finally, design methods for and the application of active vibration control on rotating machinery are demonstrated by several real applications. Author

N90-22746*# Rockwell International Science Center, Thousand Oaks, CA.

SUPERSONIC FLOW COMPUTATIONS FOR AN ASTOVL AIRCRAFT CONFIGURATION, PHASE 2, PART 2 Final Report

SEKARIPURAM V. RAMAKRISHNAN, SUKUMAR R. CHAKRAVARTHY, and KUO-YEN SZEMA Washington NASA May 1990 43 p

(Contract NAS1-17492)

(NASA-CR-4284; NAS 1.26:4284) Avail: NTIS HC A03/MF A01 CSCL 20/4

A unified space/time marching method was used to solve the Euler and Reynolds-averaged Navier-Stokes equations for supersonic flow past an Advanced Short Take-off and Vertical Landing (ASTOVL) aircraft configuration. Lift and drag values obtained from the computations compare well with wind tunnel measurements. The entire calculation procedure is described starting from the geometry to final postprocessing for lift and drag. The intermediate steps include conversion from IGES to the patch specification needed for the CFD code, grid generation, and solution procedure. The calculations demonstrate the capability of the method used to accurately predict design parameters such as lift and drag for very complex aircraft configurations. Author

N90-22807*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THERMAL/STRUCTURAL ANALYSIS OF THE SHAFT-DISK REGION OF A FAN DRIVE SYSTEM

PEYTON B. GREGORY and ANNE D. HOLLAND Mar. 1990 29 p Original contains color illustrations

(NASA-TM-101687; NAS 1.15:101687) Avail: NTIS HC A03/MF A01; 8 functional color pages CSCL 20/11

In January 1989, a mishap occurred in the National Transonic Facility wind tunnel at NASA-Langley. It is believed that the failure of an insulation retainer holding foam insulation around the exterior of the fan drive shaft resulted in the subsequent damage to other components in the tunnel. The effect was determined of removing the external thermal insulation on the shaft would have on the stresses on the shaft, disk and bolts holding the two together. To accomplish this, a detailed thermal/structural finite element analysis of the shaft-disk interface was performed. The maximum stresses on the three components were determined for several configurations and conditions with and without the external thermal insulation, and then these results were compared to the original analyses to access the effect of removing the external thermal insulation on the proposed future operation of the shaft/disk structures of the fan drive system. Although the stresses were higher without the external insulation, the stresses did meet all stress criteria. In addition, all stresses were within the infinite life regime of the Modified Goodman diagram. Therefore, it was determined that the structural integrity of the shaft-disk region is not compromised if the external insulation is removed. Author

N90-22808*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FINITE ELEMENT ELASTIC-PLASTIC-CREEP AND CYCLIC LIFE ANALYSIS OF A COWL LIP

VINOD K. ARYA (Toledo Univ., OH.), MATTHEW E. MELIS, and GARY R. HALFORD Apr. 1990 10 p Submitted for publication Original contains color illustrations

(NASA-TM-102342; E-5050; NAS 1.15:102342) Avail: NTIS HC A02/MF A01; 3 functional color pages CSCL 20/11

Results are presented of elastic, elastic-plastic, and elastic-plastic-creep analyses of a test-rig component of an actively cooled cowl lip. A cowl lip is part of the leading edge of an engine inlet of proposed hypersonic aircraft and is subject to severe thermal loadings and gradients during flight. Values of stresses calculated by elastic analysis are well above the yield strength of the cowl lip material. Such values are highly unrealistic, and thus elastic stress analyses are inappropriate. The inelastic (elastic-plastic and elastic-plastic-creep) analyses produce more reasonable and acceptable stress and strain distributions in the component. Finally, using the results from these analyses, predictions are made for the cyclic crack initiation life of a cowl lip. A comparison of predicted cyclic lives shows the cyclic life prediction from the elastic-plastic-creep analysis to be the lowest and, hence, most realistic. Author

N90-23172# Office of Naval Research Liaison Office, Far East, APO San Francisco, CA.

CURRENT JAPANESE SUPERCOMPUTERS FOR COMPUTATIONAL FLUID DYNAMICS APPLICATIONS

HIDEO YOSHIHARA *In its* ONR Far East Scientific Information Bulletin, Volume 13, No. 4 p 61-68 Dec. 1988

Avail: NTIS HC A05/MF A01 CSCL 20/12

Current top of the line Japanese supercomputers are described, stressing the vector features significant for highly vectorized computational fluid dynamics (CFD) codes. Covered are the Fujitsu VP400E, Hitachi S820, and NEC SX-24 computers. A benchmarking of these computers, scheduled in the near future, is described using the Navier/Stokes calculation over a delta wing with about one million mesh points. Author

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GEOSCIENCES

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

A90-36427#
DIGITAL GENERATION OF TWO-DIMENSIONAL FIELD OF TURBULENCE FOR FLIGHT SIMULATION
YELUN XIAO (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, April 1990, p. B124-B130. In Chinese, with abstract in English.

In some special cases of flight simulation, it is necessary to generate two-dimensional fields of turbulence, in which the turbulent wind speeds are stochastic functions of two coordinates. A simple and efficient technique is presented here for digital generation of two-dimensional fields of turbulence involving turbulent speed sequences on a rectangular network. The correlation of such a field generated with this method is found to be in good agreement with the theoretical correlation of the Dryden model, demonstrating the feasibility of the method. Two possible operational modes (on-line and off-line) of the turbulence generator in flight simulation are also discussed. C.D.

A90-37748
FOG FORMATION AT PERTH AIRPORT
XINMEI HUANG, T. J. LYONS, and R. O. PITTS (Murdoch University, Australia) Australian Meteorological Magazine (ISSN 0004-9743), vol. 38, June 1990, p. 99-106. refs
Copyright

A modified numerical mesoscale model, neglecting the microphysics of condensation, is developed to predict fog formation and validated against detailed case studies. When initialized with routinely available airport observations, simulations illustrate an ability to predict fog formation in the vicinity of Perth Airport. Although requiring saturation to indicate fog formation, these studies illustrate the potential of a simplified version for routine fog forecasting. Author

N90-22155# National Oceanic and Atmospheric Administration, Silver Spring, MD. Air Resources Lab.
AEROSOL SEPARATOR FOR USE IN AIRCRAFT
JOE F. BOATMAN, DENNIS L. WELLMAN, WILLIAM D. KEENE, and JAMES N. GALLOWAY (Virginia Univ., Charlottesville.) Dec. 1989 26 p
(PB90-142217; NOAA-TM-ERL-ARL-179) Avail: NTIS HC A03/MF A01 CSCL 13B

When sampling atmospheric aerosols using aircraft, it is sometimes advantageous to separate a portion of the aerosol from the sample stream. During flights through clouds, one may wish to separate all cloud water from the air stream so that interstitial aerosol particles and gases can be measured. Alternately, when flying within the marine boundary layer, one may wish to separate large sea-salt particles from the air stream in order to increase resolution in the calculation of non-sea-salt constituents. The goal of the work was to build and test an aerosol separator. To achieve this goal, a separator was developed, tested in the laboratory and during flights aboard the National Oceanic and Atmospheric Administration King Air research aircraft. The results of the effort are summarized. Author

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A90-35769#
ALTERNATE TABLE LOOK-UP ROUTINE FOR REAL-TIME DIGITAL FLIGHT SIMULATION
BRUCE P. SELBERT, ROBERT B. OETTING (Missouri-Rolla, University, Rolla), MICHAEL K. SINNETT, and JAMES E. STECK Journal of Aircraft (ISSN 0021-8669), vol. 27, May 1990, p. 471-473. Previously cited in issue 21, p. 3389, Accession no. A89-48418.
Copyright

A90-36151
IDENTIFICATION AND DIAGNOSTICS IN THE DATA PROCESSING AND CONTROL SYSTEMS OF AEROSPACE POWERPLANTS [IDENTIFIKATSIIA I DIAGNOSTIKA V INFORMATSIONNO-UPRAVLIAIUSHCHIKH SISTEMAKH AVIAKOSMICHESKOI ENERGETIKI]
BORIS V. BOEV, VIKTOR V. BUGROVSKII, MIKHAIL P. VERSHININ, D. A. GOL'DIN, V. V. GUSHCHIN et al. Moscow, Izdatel'stvo Nauka, 1988, 168 p. In Russian. refs
Copyright

The book is concerned with the methodological aspects of solving identification and diagnostic problems for aircraft and spacecraft powerplants. Identification and diagnostic problems are considered for both the bench testing of powerplants and their flight operation. Specific algorithms for the identification of mathematical models of powerplants are presented. The structure and algorithms are developed for a three-level diagnostic system that is part of an airborne data processing and control system. V.L.

A90-37218#
A COMBINED RICCATI TRANSFER MATRIX-DIRECT INTEGRATION METHOD WITH ITS APPLICATIONS
WEIDONG WEN (Nanjing Aeronautical Institute, People's Republic of China) and JIALIU GU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Jan. 1990, p. A83-A87. In Chinese, with abstract in English.

A combined Riccati transfer matrix-direct integration method is proposed. The present method is used to study the dynamical behavior of a rotor-bearing system. Equations of motion for a twin-spool rotor-bearing system are derived, and an example is given to analyze the critical speeds and modes of a twin-spool engine. The results are in satisfactory agreement with those of the transfer matrix method and the combined transfer matrix-direct integration method. Author

A90-38533#
AUTOMATED HELICOPTER STRUCTURAL ANALYSIS DATA PROCESSING
MICHAEL SHENBERGER and PAUL RALEY (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: National Technical Specialists' Meeting on Tactical V/STOL, New Bern, NC, Sept. 19-21, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 4 p.

The Helicopter Structural Analysis Computer Program (HELSAP) built around the commercially available SAS software system is described, along with the criteria used to define the initial program requirements, the current program configuration and capabilities, and plans for future enhancements. Data acquisition, automatic flight summary statistics, program flow, and compatibility with real-time analysis are discussed. It is shown that HELSAP is useful in automation of the reduction and analysis of large amounts of aircraft structural data obtained during flight testing. Completely

menu-driven, HELSAP enables an analyst to produce report-quality plots, tables, and charts after the completion of a test flight. Some of the data reduction routines currently available include minimum/maximum analysis, statistical analysis, and spectral analysis. V.T.

A90-38738#
VISUALGRID - A SOFTWARE PACKAGE FOR INTERACTIVE GRID GENERATION
J. Q. CORDOVA (Visual Computing, Inc., Mountain View, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 11 p. refs
(AIAA PAPER 90-1607) Copyright

A software package for interactive grid generation (VisualGrid) has been developed. This software offers users an environment for rapid prototyping of complex grids. Case studies indicate that using VisualGrid can vastly accelerate the grid generation design cycle. The effectiveness of VisualGrid is due largely to its modern architecture, which emphasizes extensibility. This is demonstrated by constructing a two-element airfoil grid. Author

N90-22322*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PRELIMINARY DEVELOPMENT OF AN INTELLIGENT COMPUTER ASSISTANT FOR ENGINE MONITORING
JAMES D. DISBROW (PRC Systems Services Co., Edwards, CA.), EUGENE L. DUKE, and RONALD J. RAY Aug. 1989 12 p Previously announced in IAA as A89-46910
(NASA-TM-101702; H-1553; NAS 1.15:101702) Avail: NTIS HC A03/MF A01 CSCL 09B

As part of the F-18 high-angle-of-attack vehicle program, an AI method was developed for the real time monitoring of the propulsion system and for the identification of recovery procedures for the F404 engine. The aim of the development program is to provide enhanced flight safety and to reduce the duties of the propulsion engineers. As telemetry data is received, the results are continually displayed in a number of different color graphical formats. The system makes possible the monitoring of the engine state and the individual parameters. Anomaly information is immediately displayed to the engineer. Author

N90-22975# Fokker B.V., Schipol-Oost (Netherlands).
AIRCRAFT TECHNOLOGY MANAGEMENT AND THE RELATED SIGNIFICANCE OF THE SUPERCOMPUTER [VLIEGTUIGTECHNOLOGIEBELEID EN DE BETEKENIS VAN DE SUPERCOMPUTER DAARVOOR]
M. VANDERVEEN *In* NLR, Supercomputer and Technology p 3-9 1988 In DUTCH
Avail: NTIS HC A05/MF A01; 1 functional color page

The development efforts of Fokker in the field of supercomputer applications with a view to aeronautics research and development are presented. The strong connection between design requirements, the narrower and narrower margins imposed upon these requirements, the shorter and shorter times in fulfilling these requirements, and the effect of changes on the design process is outlined. A large computer capacity is indispensable. The changing role of the design specialist in the design process is elucidated, together with the positive and negative effects of an aid such as a supercomputer. ESA

N90-22976# National Aerospace Lab., Amsterdam (Netherlands). Hoofdafdeling Stromingen.
NUMERICAL FLOW SIMULATION AND SUPERCOMPUTERS: MORE THAN A DIGITAL WIND TUNNEL [NUMERIEKE STROMINGSSIMULATIE EN SUPERCOMPUTERS: MEER DAN EEN DIGITALE WINDTUNNEL]
J. W. SLOOFF and B. OSKAM *In its* Supercomputer and Technology p 11-28 1988 In DUTCH Original contains color illustrations
Avail: NTIS HC A05/MF A01; 1 functional color page

The fundamentals of numerical flow simulation and the role of supercomputers are outlined. The technique of numerical flow simulation is summarized. The different levels of completeness of mathematical models and the ensuing computer capacity requirements are discussed. The role of numerical flow simulation versus that of wind tunnel tests in the aircraft design processes is examined. Some recent examples of aeronautical applications of numerical flow simulation are given. The importance of numerical flow simulation for the aircraft industry in the fields of competition and risk reduction is explained. ESA

N90-22977# National Aerospace Lab., Amsterdam (Netherlands). Hoofdafdeling Constructies en Materialen.
THE USE OF SUPERCOMPUTERS FOR THE DESIGN AND ANALYSIS OF CONSTRUCTIONS [SUPERCOMPUTERGEBRUIK BIJ ONTWERP EN ANALYSE VAN CONSTRUCTIES]
H. P. VANLEEUWEN and H. H. OTTENS *In its* Supercomputer and Technology p 29-40 1988 In DUTCH
Avail: NTIS HC A05/MF A01; 1 functional color page

The design possibilities offered by the use of supercomputers for strength calculations are discussed. The role of supercomputers in computer aided design, strength calculations, and the maintenance and lifetime surveillance of aircrafts is outlined. Large computer capacity allows the integration of different specialized disciplines by optimizations at different levels. ESA

N90-22978# National Aerospace Lab., Amsterdam (Netherlands). Hoofdafdeling Informatica.
THE AUTOMATION MANAGEMENT TO SUPPORT RESEARCH AND DEVELOPMENT [HET BELEID VOOR AUTOMATISERING TER ONDERSTEUNING VAN ONDERZOEK EN ONTWIKKELING]
W. LOEVE *In its* Supercomputer and Technology p 41-52 1988 In DUTCH
Avail: NTIS HC A05/MF A01; 1 functional color page

The necessity for the application of digital simulation methods in present and future aircraft production processes is discussed. The role of the digital simulation method in the technical-scientific research as a whole is outlined, and compared with the classical experimental approach. It is shown that simulation methods have to be integrated in an infrastructure of mutually connected methods, such that the user has a single source of information. ESA

N90-22980# National Aerospace Lab., Amsterdam (Netherlands). Afdeling Wiskundige Modellen en Methoden.
THE DEVELOPMENT OF A SYSTEM FOR THE NUMERICAL SIMULATION OF EULER FLOWS [DE ONTWIKKELING VAN EEN SYSTEEM VOOR DE NUMERIEKE SIMULATIE VAN EULER-STROMINGEN]
J. W. BOERSTOEL *In its* Supercomputer and Technology p 65-83 1988 In DUTCH
Avail: NTIS HC A05/MF A01; 1 functional color page

The status of the development of a simulation system for the flow about aircrafts, based on the Euler flow model, is summarized. The most important requirements and boundary conditions for the simulation system are explained. General considerations concerning the design and development of a system for the simulation of Euler flows that fulfills these requirements are given. The present status of the simulation system is described. ESA

N90-22999*# Northrop Corp., Hawthorne, CA. Flight Control Research.
ALGORITHMS FOR COMPUTING THE MULTIVARIABLE STABILITY MARGIN
JONATHAN A. TEKAWY, MICHAEL G. SAFONOV (University of Southern California, Los Angeles.), and RICHARD Y. CHIANG *In* JPL, Proceedings of the 3rd Annual Conference on Aerospace Computational Control, Volume 1 p 104-118 15 Dec. 1989
Avail: NTIS HC A21/MF A03 CSCL 09/2

Stability margin for multiloop flight control systems has become a critical issue, especially in highly maneuverable aircraft designs where there are inherent strong cross-couplings between the various feedback control loops. To cope with this issue, we have developed computer algorithms based on non-differentiable optimization theory. These algorithms have been developed for

computing the Multivariable Stability Margin (MSM). The MSM of a dynamical system is the size of the smallest structured perturbation in component dynamics that will destabilize the system. These algorithms have been coded and appear to be reliable. As illustrated by examples, they provide the basis for evaluating the robustness and performance of flight control systems. Author

N90-23023*# Harris Corp., Melbourne, FL.
INTEGRATED CONTROL-SYSTEM DESIGN VIA GENERALIZED LQG (GLQG) THEORY Abstract Only
DENNIS S. BERNSTEIN, DAVID C. HYLAND, STEPHEN RICHTER, and WASSIM M. HADDAD (Florida Inst. of Tech., Melbourne.) *In* JPL, Proceedings of the 3rd Annual Conference on Aerospace Computational Control, Volume 1 p 293 15 Dec. 1989
Avail: NTIS HC A21/MF A03 CSCL 09/2

Thirty years of control systems research has produced an enormous body of theoretical results in feedback synthesis. Yet such results see relatively little practical application, and there remains an unsettling gap between classical single-loop techniques (Nyquist, Bode, root locus, pole placement) and modern multivariable approaches (LQG and H infinity theory). Large scale, complex systems, such as high performance aircraft and flexible space structures, now demand efficient, reliable design of multivariable feedback controllers which optimally tradeoff performance against modeling accuracy, bandwidth, sensor noise, actuator power, and control law complexity. A methodology is described which encompasses numerous practical design constraints within a single unified formulation. The approach, which is based upon coupled systems or modified Riccati and Lyapunov equations, encompasses time-domain linear-quadratic-Gaussian theory and frequency-domain H theory, as well as classical objectives such as gain and phase margin via the Nyquist circle criterion. In addition, this approach encompasses the optimal projection approach to reduced-order controller design. The current status of the overall theory will be reviewed including both continuous-time and discrete-time (sampled-data) formulations.
Author

N90-23050*# Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH.
MULTIDISCIPLINARY EXPERT-AIDED ANALYSIS AND DESIGN (MEAD)
THOMAS C. HUMMEL and JAMES TAYLOR (General Electric Co., Schenectady, NY.) *In* Jet Propulsion Lab., California Inst. of Tech., Proceedings of the 3rd Annual Conference on Aerospace Computational Control, Volume 2 p 585-598 15 Dec. 1989
Avail: NTIS HC A20/MF A03 CSCL 09/2

The MEAD Computer Program (MCP) is being developed under the Multidisciplinary Expert-Aided Analysis and Design (MEAD) Project as a CAD environment in which integrated flight, propulsion, and structural control systems can be designed and analyzed. The MCP has several embedded computer-aided control engineering (CACE) packages, a user interface (UI), a supervisor, a data-base manager (DBM), and an expert system (ES). The supervisor monitors and coordinates the operation of the CACE packages, the DBM; the ES, and the UI. The DBM tracks the control design process. Models created or installed by the MCP are tracked by date and version, and results are associated with the specific model version with which they were generated. The ES is used to relieve the control engineer from tedious and cumbersome tasks in the iterative design process. The UI provides the capability for a novice as well as an expert to utilize the MCP easily and effectively. The MCP version 2(MCP-2.0) is fully developed for flight control system design and analysis. Propulsion system modeling, analysis, and simulation is also supported; the same is true for structural models represented in state-space form. The ultimate goal is to cover the integration of flight, propulsion, and structural control engineering, including all discipline-specific functionality and interfaces. The current MCP-2.0 components and functionality are discussed. Author

N90-23060*# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.
MULTIVARIABLE FREQUENCY WEIGHTED MODEL ORDER REDUCTION FOR CONTROL SYNTHESIS
DAVID K. SCHMIDT *In* Jet Propulsion Lab., California Inst. of Tech., Proceedings of the 3rd Annual Conference on Aerospace Computational Control, Volume 2 p 649-663 15 Dec. 1989
(AIAA-89-3558) Avail: NTIS HC A20/MF A03 CSCL 09/2

Quantitative criteria are presented for model simplification, or order reduction, such that the reduced order model may be used to synthesize and evaluate a control law, and the stability robustness obtained using the reduced order model will be preserved when controlling the full-order system. The error introduced due to model simplification is treated as modeling uncertainty, and some of the results from multivariate robustness theory are brought to bear on the model simplification problem. A numerical procedure developed previously is shown to lead to results that meet the necessary criteria. The procedure is applied to reduce the model of a flexible aircraft. Also, the importance of the control law itself, in meeting the modeling criteria, is underscored. An example is included that demonstrates that an apparently robust control law actually amplifies modest modeling errors in the critical frequency region, and leads to undesirable results. The cause of this problem is associated with the canceling of lightly damped transmission zeroes in the plant. An attempt is made to expand on some of the earlier results and to further clarify the theoretical basis behind the proposed methodology.
Author

N90-23067*# Applied Dynamics International, Ann Arbor, MI.
SIX-DEGREE-OF-FREEDOM AIRCRAFT SIMULATION WITH MIXED-DATA STRUCTURE USING THE APPLIED DYNAMICS SIMULATION LANGUAGE, ADSIM
CLARE SAVAGLIO *In* Jet Propulsion Lab., California Inst. of Tech., Proceedings of the 3rd Annual Conference on Aerospace Computational Control, Volume 2 p 715-723 15 Dec. 1989
Avail: NTIS HC A20/MF A03 CSCL 09/2

A realistic simulation of an aircraft in the flight using the AD 100 digital computer is presented. The implementation of three model features is specifically discussed: (1) a large aerodynamic data base (130,00 function values) which is evaluated using function interpolation to obtain the aerodynamic coefficients; (2) an option to trim the aircraft in longitudinal flight; and (3) a flight control system which includes a digital controller. Since the model includes a digital controller the simulation implements not only continuous time equations but also discrete time equations, thus the model has a mixed-data structure. Author

N90-23069*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REAL-TIME CLOSED-LOOP SIMULATION AND UPSET EVALUATION OF CONTROL SYSTEMS IN HARSH ELECTROMAGNETIC ENVIRONMENTS
CELESTE M. BELCASTRO *In* Jet Propulsion Lab., California Inst. of Tech., Proceedings of the 3rd Annual Conference on Aerospace Computational Control, Volume 2 p 729-738 15 Dec. 1989
Avail: NTIS HC A20/MF A03 CSCL 09/2

Digital control systems for applications such as aircraft avionics and multibody systems must maintain adequate control integrity in adverse as well as nominal operating conditions. For example, control systems for advanced aircraft, and especially those with relaxed static stability, will be critical to flight and will, therefore, have very high reliability specifications which must be met regardless of operating conditions. In addition, multibody systems such as robotic manipulators performing critical functions must have control systems capable of robust performance in any operating environment in order to complete the assigned task reliably. Severe operating conditions for electronic control systems can result from electromagnetic disturbances caused by lightning, high energy radio frequency (HERF) transmitters, and nuclear electromagnetic pulses (NEMP). For this reason, techniques must be developed to evaluate the integrity of the control system in

adverse operating environments. The most difficult and illusive perturbations to computer-based control systems that can be caused by an electromagnetic environment (EME) are functional error modes that involve no component damage. These error modes are collectively known as upset, can occur simultaneously in all of the channels of a redundant control system, and are software dependent. Upset studies performed to date have not addressed the assessment of fault tolerant systems and do not involve the evaluation of a control system operating in a closed-loop with the plant. A methodology for performing a real-time simulation of the closed-loop dynamics of a fault tolerant control system with a simulated plant operating in an electromagnetically harsh environment is presented. In particular, considerations for performing upset tests on the controller are discussed. Some of these considerations are the generation and coupling of analog signals representative of electromagnetic disturbances to a control system under test, analog data acquisition, and digital data acquisition from fault tolerant systems. In addition, a case study of an upset test methodology for a fault tolerant electromagnetic aircraft engine control system is presented. Author

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PHYSICS

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

A90-36541#
ACOUSTICS
IN: Research department fluid mechanics - Scientific report (1988). Cologne, DLR, 1989, p. 22-28.

The acoustics research activities of the DLR fluid-mechanics department (Forschungsbereich Stroemungsmechanik) during 1988 are surveyed and illustrated with extensive diagrams, drawings, graphs, and photographs. Particular attention is given to studies of helicopter rotor noise (high-speed impulsive noise, blade/vortex interaction noise, and main/tail-rotor interaction noise), propeller noise (temperature, angle-of-attack, and nonuniform-flow effects), noise certification, and industrial acoustics (road-vehicle flow noise and airport noise-control installations). T.K.

A90-37955#
BROADBAND NOISE MEASUREMENT IN THE TRANSONIC TEST SECTION OF THE VTI T-38 WIND TUNNEL
B. L. MEDVED, G. M. ELFSTROM (DSMA International, Inc., Toronto, Canada), and A. VITIC (Vazduhoplovnotehnicki Institut, Belgrade, Yugoslavia) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 6 p. refs
(AIAA PAPER 90-1418) Copyright

Broadband noise level measurements in the T-38 wind tunnel trisonic test section having slanted holes treated for edgetone reduction have been performed. Results show that the splitter-plates have shifted the test section resonant peak condition toward lower Mach numbers, providing low broadband noise level at transonic speeds. No presence of high resonant frequencies was experienced. All resonant frequencies are located in the low frequency domain (below 100 Hz) which is not usually observed in other transonic facilities. No Reynolds number or wall porosity effect on results were found. Author

A90-37956#
AN EXPERIMENTAL EVALUATION OF TEST SECTION NOISE IN TRANSONIC WIND TUNNELS
DEAN F. LONG (FluiDyne Engineering Corp., Minneapolis, MN) AIAA, Aerodynamic Ground Testing Conference, 16th, Seattle, WA, June 18-20, 1990. 9 p. refs
(AIAA PAPER 90-1419) Copyright

The test section noise level of two ejector powered transonic wind tunnels is measured and compared to other transonic wind tunnels. It is shown that the noise generated by the ejector drive system can be prevented from entering the test section by using acoustic baffles in the stilling chamber upstream of the test section and a variable area second throat downstream of the test section. The second throat, however, must be carefully designed to avoid self-generated noise. Author

A90-38520
AERODYNAMIC LOADS AND BLADE VORTEX INTERACTION NOISE PREDICTION
M. SCHAFFAR, J. HAERTIG, and P. GNEMMI (Saint-Louis, Institut Franco-Allemand de Recherches, France) Vertica (ISSN 0360-5450), vol. 14, no. 2, 1990, p. 137-145. refs
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The vortex lattice method is described and applied in order to predict the aerodynamic loads on a thin two-bladed rotor. A local conformal mapping for each position in span is used to transform the thin rotor into a thick one. The pressure coefficients obtained for the thick rotor are fed into an acoustic code which is based on the Ffowcs-Williams-Hawkings (FW-H) equation. The results obtained with this method show the importance of the rotor and flight parameters; they are compared with results found in the literature for a two-bladed rotor in hovering and advancing flight. The comparison shows a good agreement and exhibits that the cut-off length for limiting the instabilities from the Blot and Savart law must be chosen carefully. Author

N90-22363# Vibration Inst., Clarendon Hills, IL.
THE SHOCK AND VIBRATION DIGEST, VOLUME 21, NO. 6 Monthly Report
JUDITH NAGLE-ESHLEMAN, ed. Jun. 1989 76 p
Avail: NTIS HC A05/MF A01

A feature article on noise transmission into propeller-driven airplanes, a review of a book on composite structures, and a bibliography of shock and vibration related topics are included. The bibliography covers such areas of interest as: machine tools, bridges, helicopters, gears, beams, mechanical properties, computational methods and modeling techniques.

N90-22364# Atlantic Applied Research Corp., Van Nuys, CA.
NOISE TRANSMISSION INTO PROPELLER-DRIVEN AIRPLANES
J. F. WILBY *In* Vibration Inst., The Shock and Vibration Digest, Volume 21, No. 6 p 3-10 Jun. 1989
Avail: NTIS HC A05/MF A01

Recent progress in the understanding of noise transmission in propeller-driven airplnes since 1985 is reviewed. The discussion includes airborne and structure-borne noise transmission and passive and active noise control. It is concluded that the following work is required before current results can be implemented in an actual airplane environment: (1) development of a detailed structure-borne noise model for typical airplane structures, (2) development of improved passive noise control treatments tuned to propeller noise harmonic components, (3) implementation of active noise control methods in typical aircraft environments, and (4) improved understanding of noise transmission through aircraft structures made from composite materials. Author

N90-22368 Pennsylvania State Univ., University Park.
AN INVESTIGATION OF THE GENERATION AND RADIATION OF AERODYNAMIC NOISE IN REAL PIPING SYSTEMS Ph.D. Thesis
WILLIAM CARL WARD 1989 262 p
Avail: Univ. Microfilms Order No. DA9007942

The response of finite length cylindrical shells to excitation by broadband, aerodynamically generated internal sound flow was investigated. The response is shown to be damping controlled; the nonresonant coincidence response can be modeled by an exponential buildup over the acoustic propagation time in the shell: $t = c/l$. For an infinite pipe or when the coincidence frequency closely matches a finite length resonance, the response approaches the damping limit. A simple theory for the narrowband

transmission loss, termed the Damping Controlled Arbitrary Length Coincidence method (DCALC), is proposed and verified experimentally. By modeling each coincidence as a simple damped oscillator, the method gives the off-resonance and near-resonance limits of the transmission loss, as well as the approximate shape of the transmission loss dips and the maximum values between adjacent coincidences. Knowledge of the pipe resonances is not required, and the calculation effort for the method is less than for statistical methods, even though a narrowband prediction is obtained. The DCALC method was evaluated through wall response measurements of industrial steel pipes, ranging from 0.5 to 3 meters in length, driven by throttling noise from a globe valve over a variety of flow conditions. The measured pipe responses showed good agreement with theory, and the results demonstrate the limits of accuracy for transmission loss predictions. Dissert. Abstr.

N90-23188# BBN Systems and Technologies Corp., Canoga Park, CA.
ASSESSMENT SYSTEM FOR AIRCRAFT NOISE (ASAN) CITATION DATABASE. VOLUME 1: USER'S MANUAL Final Report, 25 Feb. 1988 - 15 Feb. 1989
NICOLAAS REDDINGIUS Dec. 1989 74 p
(Contract F33615-86-C-0530; AF PROJ. 3037)
(AD-A219175; BBN-6832-VOL-1; HSD-TP-89-011-VOL-1) Avail: NTIS HC A04/MF A01 CSCL 20/1

The Assessment System for Aircraft Noise (ASAN) includes a database of several thousand references to the literature on the impact of noise and sonic booms on humans, animals and structures. Bibliographic data, abstracts and critical reviews of key documents can be retrieved. A user's manual for the retrievable module is presented. It describes the types of searches that can be conducted, the options for each and explains all user screens. Installation instructions for the stand-along MS-DOS version are included. GRA

N90-23189# BBN Systems and Technologies Corp., Canoga Park, CA.
ASSESSMENT SYSTEM FOR AIRCRAFT NOISE (ASAN) CITATION DATABASE. VOLUME 2: DATABASE UPDATE MANUAL Final Report, 25 Feb. 1988 - 15 Feb. 1989
NICOLAAS REDDINGIUS Dec. 1989 75 p
(Contract F33615-86-C-0530; AF PROJ. 3037)
(AD-A219176; BBN-6833-VOL-2; HSD-TP-89-011-VOL-2) Avail: NTIS HC A04/MF A01 CSCL 20/1

The Assessment System for Aircraft Noise (ASAN) includes a database of several thousand references to the literature on the impact of noise and sonic booms on humans, animals and structures. Bibliographic data, abstracts and critical reviews of key documents can be retrieved. The manual for the database maintenance module is presented. It is only intended for use by the critical maintenance organization to prepare new releases of the database. Several programs used to add, delete and update the database are discussed are needed together with Vol. 2 to properly maintain the database. GRA

N90-23190# BBN Systems and Technologies Corp., Canoga Park, CA.
ASSESSMENT SYSTEM FOR AIRCRAFT NOISE (ASAN) CITATION DATABASE. VOLUME 3: NEW CITATION REVIEW PROCEDURES Final Report, 25 Feb. 1988 - 15 Feb. 1989
NICOLAAS REDDINGIUS and ANDREW B. KUGLER Dec. 1989 61 p
(Contract F33615-86-C-0530; AF PROJ. 3037)
(AD-A219177; BBN-6953-VOL-3; HSD-TP-89-011-VOL-3) Avail: NTIS HC A04/MF A01 CSCL 20/1

The Assessment System for Aircraft Noise (ASAN) includes a database of several thousand references to the literature on the impact of noise and sonic booms on humans, animals and structures. Bibliographic data, abstracts and critical reviews of key documents can be retrieved. A systematic methodology for the selection and evaluation of new citations to be added to the database consistent with the procedures used in CITASAN is described. GRA

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GENERAL

N90-23338*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN TRENDS FOR ARMY/AIR FORCE AIRPLANES IN THE UNITED STATES
M. LEROY SPEARMAN Washington Jun. 1990 23 p
(NASA-TM-4179; L-16636; NAS 1.15:4179) Avail: NTIS HC A03/MF A01 CSCL 01/2

Some design trends in Army/Air Force airplane systems in the U.S. are traced from the pre-World War 2 era to the present time. Various types of aircraft systems are reviewed with a view toward noting design features that were used. Some observations concerning the design trends indicate that some may be driven by advanced technology and some by a need for new mission requirements. In addition, it is noted that some design trends are evolutionary and result in an extension of service life or utility of existing systems. In other cases the design trends may be more revolutionary with the intent of creating a system with a new capability. Some examples are included of designs that did not proceed to production for reasons that sometimes were technical and sometimes were not. Author

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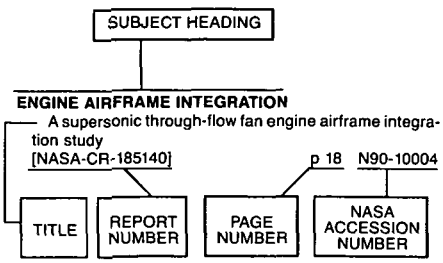

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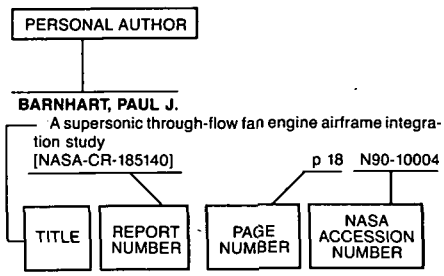

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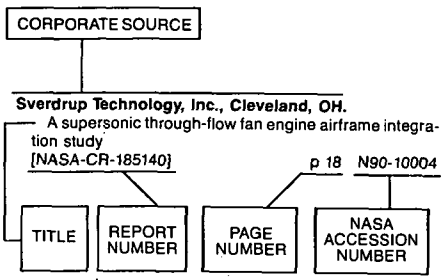

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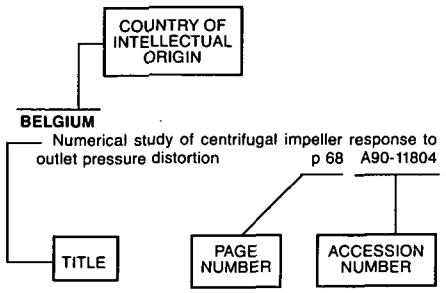

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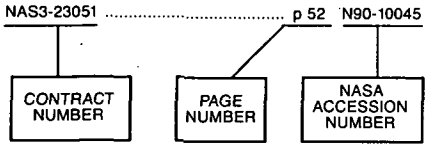

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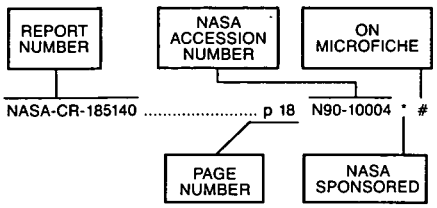

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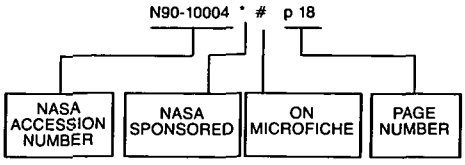

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