NASA SP-7037 (308)
September 1994

95P

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

The NASA STI Program ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program plays a key part in helping NASA maintain this important role.

The NASA STI Program provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program is also NASA's institutional mechanism for disseminating the results of its research and development activities.

Specialized services that help round out the Program's diverse offerings include creating custom thesauri, translating material to or from 34 foreign languages, building customized databases, organizing and publishing research results ... even providing videos.

For more information about the NASA STI Program, you can:

- **Phone** the NASA Access Help Desk at (301) 621-0390
- **Fax** your question to the NASA Access Help Desk at (301) 621-0134
- **E-mail** your question via the **Internet** to help@sti.nasa.gov
- **Write** to:

NASA Access Help Desk
NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934

NASA SP-7037 (308)
September 1994

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1994

This publication was prepared by the NASA Center for AeroSpace Information,
800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934, (301) 621-0390.

INTRODUCTION

This issue of *Aeronautical Engineering — A Continuing Bibliography with Indexes* (NASA SP-7037) lists 269 reports, journal articles, and other documents recently announced in the NASA STI Database.

Accession numbers cited in this issue include:

Scientific and Technical Aerospace Reports (STAR) (N-10000 Series)	N94-34467 — N94-36230
Open Literature (A-10000 Series)	A94-13207 — A94-61023

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 publication 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.

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

A cumulative index for 1994 will be published in early 1995.

Information on availability of documents listed, addresses of organizations, and CASI price schedules are located at the back of this issue.

TABLE OF CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

↓↓

ACCESSION NUMBER → N94-10675*# National Aeronautics and Space Administration. ← CORPORATE SOURCE
Langley Research Center, Hampton, VA.

TITLE → **STATIC INTERNAL PERFORMANCE OF A SINGLE EXPANSION RAMP NOZZLE WITH MULTIAXIS THRUST VECTORING CAPABILITY**

AUTHORS → FRANCIS J. CAPONE and ALBERTO W. SCHIRMER (George Washington Univ., Hampton, VA.) Washington Jul. 1993 ← PUBLICATION DATE
272 p

CONTRACT NUMBER → (Contract RTOP 505-62-30-01)

REPORT NUMBERS → (NASA-TM-4450; L-17163; NAS 1.15:4450) Avail: CASI HC A12/ ← AVAILABILITY AND PRICE CODE
MF A03

An investigation was conducted at static conditions in order to determine the internal performance characteristics of a multiaxis thrust vectoring single expansion ramp nozzle. Yaw vectoring was achieved by deflecting yaw flaps in the nozzle sidewall into the nozzle exhaust flow. In order to eliminate any physical interference between the variable angle yaw flap deflected into the exhaust flow and the nozzle upper ramp and lower flap which were deflected for pitch vectoring, the downstream corners of both the nozzle ramp and lower flap were cut off to allow for up to 30 deg of yaw vectoring. The effects of nozzle upper ramp and lower flap cutout, yaw flap hinge line location and hinge inclination angle, sidewall containment, geometric pitch vector angle, and geometric yaw vector angle were studied. This investigation was conducted in the static-test facility of the Langley 16-foot Transonic Tunnel at nozzle pressure ratios up to 8.0. Author (revised)

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

↓

ACCESSION NUMBER → A94-60042* National Aeronautics and Space Administration. ← CORPORATE SOURCE
Lewis Research Center, Cleveland, OH.

TITLE → **EXPERIMENTAL INVESTIGATION OF COUNTER-ROTATING PROPFAN FLUTTER AT CRUISE CONDITIONS**

AUTHORS → ORAL MEHMED NASA Lewis Research Center, Cleveland, OH and ← AUTHOR'S AFFILIATION
ANATOLE P. KURKOV *Journal of Propulsion and Power* (ISSN ← JOURNAL TITLE

PUBLICATION DATE → 0748-4658) vol. 10, no. 3 May-June 1994 p. 343-347 refs

REPORT NUMBER → (BTN-94-EIX94321333310) Copyright

This article presents wind-tunnel experimental flutter results, at transonic relative flows, for a 0.62-m-diam composite propfan model. A blade row that fluttered was tested alone, and with a stable aft counter-rotating blade row. The major objectives of the experiment were to study the effect of the second blade row on the row in flutter, and to investigate the flutter. Results show that the second row had a small stabilizing effect. Two distinct flutter modes were found within the operating regime of the rotor: both apparently single-degree-of-freedom instabilities, associated respectively with the first and second natural blade modes. For both flutter modes, flutter boundary, frequency, nodal diameter, and blade displacement data are given. The blade displacement data, obtained with an optical method, gives an indication of the flutter mode shape at a span near the blade tip. Author (EI)

ABSTRACTS

01 AERONAUTICS (GENERAL)

A94-60015

STRUCTURE OF LOCAL PRESSURE-DRIVEN THREE-DIMENSIONAL TRANSIENT BOUNDARY-LAYER SEPARATION

LAURA L. PAULEY Pennsylvania State Univ., University Park *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 997-1005 refs

(BTN-94-EIX94301315979) Copyright

The separation of a flat-plate, laminar boundary layer under the influence of a suddenly imposed three-dimensional external adverse pressure gradient was studied computationally by time-accurate numerical solution of the incompressible Navier-Stokes equations. The separation decay was then investigated by impulsively removing the pressure gradient. The development and decay of the separation structure were compared with experimental results reported by other investigators for the same geometry. The periodic vortex shedding of the three-dimensional separation was described in terms of a Strouhal number based on the freestream velocity and Blasius boundary-layer momentum thickness at the location where separation occurs. The characteristic Strouhal number of 0.0136 during the separation development from the computation compared favorably with 0.0134 from the experiment. When the adverse pressure gradient was impulsively removed, the boundary layer returned to an attached boundary layer much faster than the time required for the separation development. Author (EI)

A94-60016

REATTACHMENT STUDIES OF AN OSCILLATING AIRFOIL DYNAMIC STALL FLOWFIELD

S. AHMEDMCAT Inst., San Jose, CA and M. S. CHANDRASEKHARA *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1006-1012 refs

(BTN-94-EIX94301315980) Copyright

The reattaching flow over an oscillating airfoil executing large-amplitude sinusoidal motion around a mean angle of attack of 10 deg has been studied using the techniques of stroboscopic schlieren, two-component laser Doppler velocimetry, and point diffraction interferometry, for a freestream Mach number of 0.3 and a reduced frequency of 0.05. The results show that the dynamically stalled flow reattaches in a process that begins when the airfoil is very close to the static stall angle on its downward stroke and progresses over the airfoil through a large range of angles of attack as the airfoil angle decreases to about 6 deg. The airfoil suction peak shows a dramatic rise as the static stall angle is approached, and the velocity profiles develop such that the flow near the surface is accelerated. The process completes through the disappearance of a separation bubble that forms over the airfoil. Author (EI)

A94-60025

ARTIFICIAL NEURAL NETWORKS FOR PREDICTING NONLINEAR DYNAMIC HELICOPTER LOADS

A. B. COOK Virginia Polytechnic Inst. and State Univ., Blacksburg, C. R. FULLER, W. F. O'BRIEN, and R. H. CABELL *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1072-1077 refs

(BTN-94-EIX94301315989) Copyright

The fatigue life of dynamic helicopter components is highly dependent on the history of loads experienced by the components during flight. However, practical methods of monitoring the loads on individual components during flight have not been developed. Current maintenance programs are characterized by frequent inspections and sometimes premature retirement of safety-critical components. This paper proposes using an artificial neural network (ANN) to predict the loads in critical components based on flight variable information that can be easily measured. The artificial neural network learns the relationship between flight variables and component loads through exposure to a database of flight variable records and corresponding load histories taken from an instrumented military helicopter undergoing standard maneuvers. Eight standard flight variables are used as inputs for predicting the time-varying mean and oscillatory components of the tailboom bending load and the pitch link load for seven flight maneuvers. The ANN predicts the mean and oscillatory components with accuracy ranging from 90.7% to 97.7% correct. Author (EI)

A94-60026

EXPLICIT KUTTA CONDITION FOR AN UNSTEADY TWO-DIMENSIONAL CONSTANT POTENTIAL PANEL METHOD

NEIL BOSE Memorial Univ. of Newfoundland, Saint Johns *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1078-1080 refs

(BTN-94-EIX94301315990) Copyright

Described is an explicit Kutta condition that was implemented in a time-domain constant potential panel method for two dimensional airfoils in unsteady motion. To calculate thrust and propulsive efficiency from oscillating hydrofoils with chordwise flexibility, this panel method was written. EI

A94-60029

CROSSFLOW TOPOLOGY OF VORTICAL FLOWS

MIGUEL R. VISBAL Wright Lab, Wright-Patterson Air Force Base, OH and RAYMOND E. GORDNIER *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1085-1087 refs

(BTN-94-EIX94301315993) Copyright

The aim of this paper is to demonstrate that a number of distinct topologies of crossflow separation are possible using critical-point theory and computational results for delta wing flows. The present results confirm and extend recent experimental findings for the instantaneous crossflow topology on pitching delta wings. EI

A94-60031

PRECISION REQUIREMENT FOR POTENTIAL-BASED PANEL METHODS

JAMES K. NATHMAN Analytical Methods Inc., Redmond, WA *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1089-1090 refs

(BTN-94-EIX94301315995) Copyright

Good numerical results were obtained from a potential-based panel method for very thin wings. But small panel number while recognizing their matrix equation was nearly singular. Through the precision of the method then, the diverse behavior described can be explained. EI

A94-60035

SURFACE INTERFERENCE IN RAYLEIGH SCATTERING MEASUREMENTS NEAR FOREBODIES

ZAIDI B. ZAKARIA Purdue Univ., West Lafayette, IN and STEVEN H. COLLICOTT *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1098-1100 refs

(BTN-94-EIX94301315999) Copyright

Determined is the closest proximity for use of direct Rayleigh scattering near representative aerodynamic forebodies. The aim of this experiment is to provide data that will serve as guidelines for selection of nonintrusive diagnostic methods for experiments in high-speed forebody flows. EI

A94-60037

VANE-BLADE INTERACTION IN A TRANSONIC TURBINE. PART 1: AERODYNAMICS

K. V. RAO Allison Gas Turbine Div, Indianapolis, IN, R. A. DELANEY, and M. G. DUNN *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 305-311 refs

(BTN-94-EIX94321333305) Copyright

Part 1 of this article presents results of a computational investigation of the effects of blade row interaction on the aerodynamics of a transonic turbine stage. The predictions are obtained using a two-dimensional unsteady Navier-Stokes code based on an explicit Runge-Kutta algorithm and an overlapping O-H grid system. This code simulates the flow in time-accurate fashion using nonreflective stage inflow and outflow boundary conditions and phase-lagging procedures for modeling arbitrary airfoil counts in the vane and blade rows. The O-H grid provides high spatial resolution of the high gradient regions near the airfoil surfaces and allows for arbitrary placement of stage inflow and outflow boundaries. Unsteady and time-averaged airfoil surface pressure predictions are compared with those from an older version of the code based on the explicit hopscotch algorithm and an O-grid system, and experimental data obtained in a short-duration shock tunnel facility. Author (EI)

A94-60042* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

EXPERIMENTAL INVESTIGATION OF COUNTER-ROTATING PROPFAN FLUTTER AT CRUISE CONDITIONS

ORAL MEHMED NASA Lewis Research Center, Cleveland, OH and ANATOLE P. KURKOV *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 343-347 refs

(BTN-94-EIX94321333310) Copyright

This article presents wind-tunnel experimental flutter results, at transonic relative flows, for a 0.62-m-diam composite propfan model. A blade row that fluttered was tested alone, and with a stable aft counter-rotating blade row. The major objectives of the experiment were to study the effect of the second blade row on the row in flutter, and to investigate the flutter. Results show that the second row had a small stabilizing effect. Two distinct flutter modes were found within the operating regime of the rotor: both apparently single-degree-of-freedom instabilities, associated respectively with the first and second natural blade modes. For both flutter modes, flutter boundary, frequency, nodal diameter, and blade displacement data are given. The blade displacement data, obtained with an optical method, gives an indication of the flutter mode shape at a span near the blade tip. Author (EI)

A94-60092

HYPERSONIC FIN AERODYNAMICS

R.-J. YANG Rockwell International, Canoga Park, CA *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 2 March-April 1994 p. 339-341 refs

(BTN-94-EIX94311330699) Copyright

A shock-expansion theory is applied to a 2-dimensional airfoil strip to obtain the expressions for various aerodynamic coefficients of a fin with the combined effects of the dihedral angle, cant angle, angle of attack, rolling rate, and the shape of a fin. This attempt has the following major assumptions: the flow is hypersonic, the airfoil has sharp leading edge, the flow behind the leading-edge shock is the same as an isentropic Prandtl-Meyer expansion, and the reflections of the Mach waves from the curved shock and those from the streamlines are weak. EI

A94-60113

APPLICATIONS OF COMPUTATIONAL FLUID DYNAMICS TO THE AERODYNAMICS OF ARMY PROJECTILES

WALTER B. STUREK Army Research Lab, MD, CHARLES J. NIETUBICZ, JUBARAJ SAHU, and PAUL WEINACHT *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 2 March-April 1994 p. 186-199 refs

(BTN-94-EIX94311330678) Copyright

The ability to predict the complete set of aerodynamic performance parameters for projectile configurations is the goal of the computational aerodynamicists at the U.S. Army Research Laboratory. To achieve this goal, predictive capabilities that use Navier-Stokes computational techniques have been developed and applied to an extensive number of projectile configurations. A summary of code validation efforts and applications for both spin-stabilized and fin-stabilized projectile configurations are described. Significant progress in the predictive capability for projectile aerodynamics has been achieved through the availability of substantial supercomputer resources and modern computational techniques. Current and future research areas of interest are described and provide an indication of computer resources and code enhancements needed to continue the progress in projectile computational aerodynamics. Author (EI)

A94-60141

COMBUSTION SHOCK TUNNEL AND INTERFACE COMPRESSION TO INCREASE RESERVOIR PRESSURE AND ENTHALPY

M. A. S. MINUCCI Instituto de Estudos Avancados, Sao Jose dos Campos (Brazil), H. T. NAGAMATSU, and L. N. MYRABO *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 8, no. 2 April-June 1994 p. 259-266 refs

(BTN-94-EIX94311330650) Copyright

This article discusses the production of hypervelocity-hypersonic flows in a combustion shock tunnel operating in the equilibrium interface mode. In this mode of operation, the additional compression provided by the approaching interface is used to obtain higher pressures and temperatures, as opposed to the reflected method. A computer code was developed to model the operation of a shock tunnel in the equilibrium interface condition. In this article, all the calculations were made for the Rensselaer Polytechnic Institute (RPI) 1.22-m-diam Combustion Driver Hypersonic Shock Tunnel. The major drawback of the interface compression technique, which is the contamination of the driven gas by the driver gas, was overcome through the utilization of a small volume region separating the two gases. Numerical results indicate that the RPI facility will be able to generate reservoir temperatures of the order of 20,000 K and reservoir pressures of the order of 30,000 psi. These reservoir conditions can be used to produce test section Mach numbers of 35. Author (EI)

A94-60151

PRESSURE MEASUREMENTS ON A FORWARD-SWEPT WING-CANARD CONFIGURATION

GIOVANNI LOMBARDI Univ. of Pisa, Pisa, Italy and MAURO MORELLI *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 469-472 refs

(BTN-94-EIX94311329149) Copyright

Through nonlinear potential numerical methods, the study of the canard-wing configurations, for low angles of attack and low subsonic flows can be performed. The canard effects are significantly dependent on canard position. EI

A94-60152
TAIL LOAD CALCULATIONS FOR LIGHT AIRPLANES
E. V. LAITONE Univ. of California, Berkeley, CA *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 466-469 refs
(BTN-94-EIX94311329148) Copyright

For the typical light airplane, a nearly rectangular wing planform with an aspect ratio A of at least five, very simple relations can be developed. In this paper, calculations for the tail load on a typical light airplane are given. EI

A94-60153
WAKE CURVATURE AND AIRFOIL LIFT
LUCIEN Z. DUMITRESCU Provence Univ., Marseille, France *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 465-466 refs
(BTN-94-EIX94311329147) Copyright

The aim of this paper is to discuss, in the light of some previous results, the physics of the phenomena, which are obscured by emphasis on numerics. In this context, an analogy with the jet-flap will be put forward. EI

A94-60154
AERODYNAMIC PROPERTIES OF CRESCENT WING PLANFORMS
P. L. ARDONCEAU Ecole Nationale Superieure de Mecanique et d' Aerotechnique, Poitiers, France *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 462-465 refs
(BTN-94-EIX94311329146) Copyright

To investigate the crescent planforms, and to determine if any advantage can be drawn for aeronautical purposes, the aerodynamic properties of four different wing planforms have been measured. These planforms are analytically defined with the same chord/span low on each model, and a variable sweep/span law varying from zero sweep to a 22.3 deg aerodynamic mean sweep. EI

A94-60155
SCHEDULED MAINTENANCE OPTIMIZATION SYSTEM
RAYMOND J. ANDERSON McDonnell-Douglas Corp., Saint Louis, MO Journal of Aircraft (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 459-462
(BTN-94-EIX94311329145) Copyright

Ongoing development is currently being done in an integrated software package composed of a FMECA module, a RCM module, a SMID, a SMIC module and an ICT module. These said modules will provide an integrated consolidated process for rapid assessment of previous aircraft scheduled maintenance requirements, combat turnaround times, and the necessary tools to provide future scheduled maintenance requirements and optimum elapsed time for ICT's. EI

A94-60157* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECTS OF MODEL SCALE ON FLIGHT CHARACTERISTICS AND DESIGN PARAMETERS
WILLIAM H. PHILLIPS NASA. Langley Research Center, Hampton, VA *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 454-457 refs
(BTN-94-EIX94311329143) Copyright

Presented in this paper is a simple way of examining the effects of scaling on a wide range of parameters. In this analysis, the main variables considered are namely, the scale and mass of the vehicle and the density of the flight medium. EI

A94-60158
PARAMETER ESTIMATES OF AN AEROELASTIC AIRCRAFT AS AFFECTED BY MODEL SIMPLIFICATIONS
A. K. GHOSH Indian Inst. of Tech., Kanpur, India and S. C. RAISINGHANI *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 452-454 refs
(BTN-94-EIX94311329142) Copyright

In this paper, a preliminary study has been initiated to investigate how estimation model may be simplified to reduce the number of unknown parameters, and how are the resulting parameter estimates affected by such approximate models. Given special attention is the extreme case of using rigid body model in the estimation algorithm, and proposed is an analytical method to predict approximations to parameter estimates. EI

A94-60159
JOINED-WING MODEL VIBRATIONS USING PC-BASED MODAL TESTING AND FINITE ELEMENT ANALYSIS
BENHE QU Auburn Univ., Auburn, AL and MALCOLM A. CUTCHINS *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 449-452 refs
(BTN-94-EIX94311329141) Copyright

For the joined-wing model, the COMPAQ PORTABLE 386 is the modal testing system that is convenient to use. Finite element analysis results show good agreement with the test results for the first four modes in terms of the frequency values and mode shapes. EI

A94-60162
BOUNDARY-LAYER INFLUENCES ON THE SUBSONIC NEAR-WAKE OF BLUFF BODIES
COLIN P. BRITCHER Old Dominion Univ., Norfolk, VA and CHARLES W. ALCORN *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 443-444 refs
(BTN-94-EIX94311329138) Copyright

In this paper, studied is the wake of a family of slanted-base bluff bodies. The incoming boundary-layer momentum thickness influence the base pressure and wake stagnation point locations. EI

A94-60163* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
BUFFET-INDUCED STRUCTURAL/FLIGHT-CONTROL SYSTEM INTERACTION OF THE X-29A AIRCRAFT
DAVID F. VORACEK NASA. Dryden Flight Research Facility, Edwards, CA and ROBERT CLARKE *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 441-443
(BTN-94-EIX94311329137) Copyright

Observed in the lateral-directional axis of the flight-control system is an aeroservoelastic interaction during the high angle-of-attack flight envelope expansion of the X-29A forward-swept wing aircraft. This interaction consists of structural modes that result in commands to the control surface actuators. EI

A94-60164
DETERMINATION OF TIRE-WHEEL INTERFACE LOADS FOR AIRCRAFT WHEELS
S. KANDARPA Notre Dame Univ., Notre Dame, IN, B. F. SPENCER, JR., and D. J. KIRKNER *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 433-440 refs
(BTN-94-EIX94311329136) Copyright

A numerical tool is developed for determining the pressure distribution at the tire-wheel interface of an aircraft-wheel from experimentally obtained strains. The methodology employs an axisymmetric finite element model which is subjected to a general loading. The loading is represented as a double Fourier series, and the components are determined by a least squares fit using the experimentally determined strains. A finite element code based on linear elasticity for an isotropic material was developed to perform this analysis. Sample experiments are presented to illustrate the validity and the robustness of the algorithm. Finally, the limitations of this type of analysis are discussed and future directions are indicated. Author (EI)

A94-60166
AIRCRAFT FLEET MAINTENANCE BASED ON STRUCTURAL RELIABILITY ANALYSIS

J. N. YANG California Univ., Irvine, CA and S. D. MANNING *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 419-425 refs
(BTN-94-EIX94311329134) Copyright

A stochastic crack growth analysis methodology, based on the lognormal random variable model, is described and demonstrated for two practical aircraft structural maintenance applications. In the first application, a reliability centered maintenance analysis for evaluating aircraft structural maintenance and supportability requirements and options in terms of risk or reliability is demonstrated. The sensitivity of initial and reinspection intervals to variations in analysis variables is investigated using a cutout in an aluminum-lithium cheek frame. The second application is the maintenance scheduling for a fleet of aircraft on a calendar year basis in terms of risk or reliability. The crack growth life dispersion due to material, service usage severity, and aircraft utilization rate on the fleet maintenance schedule are accounted for. Aircraft fleet tracking data are used and the sensitivity of fleet maintenance requirements to variations in the design stress levels and other variables are investigated and presented. Author (EI)

A94-60168
TIME SIMULATION OF FLUTTER WITH LARGE STIFFNESS CHANGES
M. KARPEL Technion - Israel Inst. of Tech., Haifa, Israel and C. D. WIESEMAN *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 404-410 refs
(BTN-94-EIX94311329132) Copyright

Time simulation of flutter, involving large local structural changes, is formulated with a state-space model that is based on a relatively small number of constant generalized coordinates. Vibration modes are first calculated for a nominal finite element model with relatively large fictitious masses located at the area of structural changes. A low-frequency subset of these modes is then transformed into a set of structural modal coordinates with which the entire simulation is performed. These generalized coordinates and the associated oscillatory aerodynamic force coefficient matrices are used to construct an efficient time-domain, state-space model for a basic aeroelastic case. The time simulation can then be performed by simply changing the mass, stiffness, and damping coupling terms when structural changes occur. It is shown that the size of the aeroelastic model required for time simulation with large structural changes at a few a priori known locations is similar to that required for direct analysis of a single structural case. The method is applied to the simulation of an aeroelastic wind-tunnel model. The diverging oscillations are followed by the activation of a tip-ballast decoupling mechanism that stabilizes the system, but may cause significant transient overshoots. Author (EI)

A94-60169
MODAL COORDINATES FOR AEROELASTIC ANALYSIS WITH LARGE LOCAL STRUCTURAL VARIATIONS
M. KARPEL Technion - Israel Inst. of Tech., Haifa, Israel and C. D. WIESEMAN *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 396-403 refs
(BTN-94-EIX94311329131) Copyright

Time domain aeroelastic equations of motion are formulated in a way that allows large local structural variations with a state-space model that is based on a relatively small number of generalized coordinates. Free-free or restrained vibration modes are first calculated for a nominal finite element model loaded with relatively large fictitious masses located at the area of structural variations. These modes and the associated oscillatory aerodynamic force coefficient matrices are used to construct a time-domain model for a basic aeroelastic case where the fictitious mass contribution to the generalized mass matrix is removed. High-accuracy aeroelastic investigations of the effects of structural variations can then be performed by simply introducing mass, stiffness, and damping coupling terms. It is shown that the number of modes required for the investigation of large stiffness variations is substantially lower than that required when fictitious masses are not used, and only slightly larger than the number of modes required for direct aeroelastic analysis of a single structural case. Author (EI)

A94-60171
AIRCRAFT ACCIDENT FLIGHT PATH SIMULATION AND ANIMATION
D. E. CALKINS Washington Univ., Seattle, WA *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 376-386 refs
(BTN-94-EIX94311329129) Copyright

During 1987, Northwest Airlines Flight 255 crashed in Detroit in the summer, and Continental Airlines Flight 1713 crashed in Denver in the winter. This article will describe the reconstruction, simulation, and animation of the time dependent flight path for each accident through a process known as forensic engineering. Forensic engineering is the application of scientific and engineering knowledge to legal matters, such as accident reconstruction. The flight paths were reconstructed as an aid in visualizing the sequence of events and the factors involved in each accident. Author (EI)

A94-60173
EFFECTS OF THRUST LINE OFFSET ON NEUTRAL POINT DETERMINATION IN FLIGHT TESTING
U. P. SOLIES Tennessee Univ. Space Inst., Tullahoma, TN *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 362-366 refs
(BTN-94-EIX94311329127) Copyright

On aircraft with high or low thrust lines, conventional stability flight test methods result in shifted neutral points, which do not correspond to the actual pitch stability neutral points of the aircraft. Specifically, e.g., an 'elevator-position neutral point' extrapolated from flight test data of an aircraft with a high thrust line, may be significantly behind the actual 'stick-fixed neutral point,' causing a potential hazard. This implies that 'stable' slopes of elevator position and stick force vs velocity diagrams do not necessarily mean that the aircraft is stable in pitch. Author (EI)

A94-60177* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC TRANSPORT WING MINIMUM WEIGHT DESIGN INTEGRATING AERODYNAMICS AND STRUCTURES
J.-F. M. BARTHELEMY NASA Langley Research Center, Hampton, VA, G. A. WRENN, A. R. DOVI, P. G. COEN, and L. E. HALL *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 330-338 refs
(BTN-94-EIX94311329123) Copyright

An approach is presented for determining the minimum weight design of aircraft wing models. The approach takes into consideration aerodynamics-structure coupling when calculating the zeroth-order information that is needed for analysis and the first-order information that is needed for optimization. When performing sensitivity analysis coupling is accounted for by using a generalized sensitivity formulation. The results presented show that the aeroelastic effects are calculated properly and noticeably reduce constraint approximation errors. However, for the particular example selected, the error introduced by ignoring aeroelastic effects are not sufficient to significantly affect the convergence of the optimization process. Trade studies are reported that consider different structural materials, internal spar layouts, and panel buckling lengths. For the formulation, model, and materials used in this study, an advanced aluminum material produced the lightest design while satisfying the problem constraints. Also, shorter panel buckling lengths resulted in lower weights by permitting smaller panel thicknesses and generally, unloading the wing skins and loading the spar caps. Finally, straight spars required slightly lower wing weights than angled spars. Author (EI)

A94-60178
EXPERIMENTAL STUDIES OF VORTEX FLAPS AND VORTEX PLATES
K. RINOIE Cranfield Inst. of Tech., Bedford (England) and J. L.

STOLLERY *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 322-329 refs
(BTN-94-EIX94311329122) Copyright

Low-speed wind-tunnel tests were made on a number of vortex flap and vortex plate configurations at the Cranfield Institute of Technology. The objectives of the experiment are to assess the benefits of these devices on the lift/drag ratio improvement of delta wings. The force and surface pressure measurements were made on a 1.15-m span, 60 deg delta wing model. The results indicate that the vortex flap deflection angle, which causes the flow to attach on the flap surface without any large separation, shows a much higher lift/drag ratio than the flap deflection angle which forms a leading-edge separation vortex over the flap surface. The performance of a vortex plate protruding from the leading edge of the datum delta wing is comparable to that of the vortex flap. However, when the vortex plate is used with the vortex flap deflected, it showed no benefit in these tests. Author (EI)

A94-60179* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

VORTEX-WING INTERACTION OF A CLOSE-COUPLED CANARD CONFIGURATION

EUGENE L. TU NASA Ames Research Center, Moffett Field, CA *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 314-321 refs
(BTN-94-EIX94311329121) Copyright

The thin-layer Navier-Stokes equations are solved numerically to investigate the effects of canard vertical position on a close-coupled, canard-wing-body configuration at a transonic Mach number of 0.90 and angles of attack ranging from -2 to 12 deg. Canard-wing interactions are investigated for the canard positioned above, coplanar with, and below the wing (high-, mid- and low-canard positions, respectively). The computational results show favorable canard-wing interactions for the high- and mid-canard configurations. The unfavorable lift and drag characteristics for the low-canard configuration are examined by analyses of the low-canard flowfield structure and found to be directly attributed to the interaction between the canard vortex and the wing surface. At relatively low angles of attack, the low-canard vortex passes under the wing surface and induces low pressures on the wing lower surface. As the angle of attack is increased, the low-canard vortex impacts the wing surface and is split into two distinct vortices. Author (EI)

A94-60180* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

PROPULSION-INDUCED AERODYNAMIC EFFECTS MEASURED WITH A FULL-SCALE STOVL MODEL

BRIAN E. SMITH NASA Ames Research Center, Moffett Field, CA, WILLIAM A. POPPEN, and J. DAVID LYE *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 306-313 refs
(BTN-94-EIX94311329120) Copyright

Propulsion-induced aerodynamic interference effects are presented for a full-scale, powered, STOVL fighter aircraft model. The ejector-lift/vectored thrust configuration, designated the E-7A, was tested at low speed in the 40- by 80-ft and the 80- by 120-ft wind tunnels of the National Full-Scale Aerodynamics Complex located at NASA ARC. Aerodynamic effects on vehicle lift, drag, and pitching moment are presented over a range of effective velocities for simultaneous operation of all lifting jets. The jet/airframe interactions for separate operation of the lifting ejector system and vectorable ventral nozzle are also presented. Ejector and engine inlet momentum effects were fully simulated in these full-scale, powered tests. The jet thrust vector angle of the ventral nozzle was varied to simulate transition from hover to wingborne flight modes. When the lifting ejector system and ventral nozzle are operated simultaneously, the induced effects on lift decrease as the thrust vector angle of the ventral nozzle approaches the horizontal. A negative increment in drag is produced over a narrow portion of the transition speed range when the ejectors and ventral nozzle are operated together. Aerodynamic induced effects of the ejector system measured at full-scale compare well with the small-scale data. Changes in lift and pitching moment due to ventral nozzle operation are smaller at full scale. Author (EI)

A94-60182

UNSTEADY LIFT OF A FLAPPED AIRFOIL BY INDICIAL CONCEPTS

J. GORDON LEISHMAN Maryland Univ., College Park, MD *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 288-297 refs
(BTN-94-EIX94311329118) Copyright

A practical method is described for computing the unsteady lift on an airfoil due to the arbitrary motion of a trailing-edge flap. The result for the incompressible case is obtained in state-space form by means of Duhamel superposition and employing an improved exponential approximation to Wagner's indicial lift function. For subsonic compressible flow, the indicial lift at small values of time due to impulsive trailing-edge flap deflection is obtained from linear theory in conjunction with the aerodynamic reciprocal theorems. These results are used with experimental results for the oscillating case to obtain complete exponential approximations for the indicial response due to impulsive flap deflection. The final result for the unsteady lift due to an arbitrary flap motion in subsonic flow is obtained in state-space form. Numerical results and comparisons with experimental data are shown. Author (EI)

A94-60185* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PREDICTION OF ICE SHAPES AND THEIR EFFECT ON AIRFOIL DRAG

JAIWON SHIN National Aeronautice and Space Administration, Cleveland, OH, BRIAN BERKOWITZ, HSUN H. CHEN, and TUNCER CEBECI *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 263-270 refs
(BTN-94-EIX94311329115) Copyright

Calculation of ice shapes and the resulting drag increases are presented for a NACA 0012 airfoil. The calculations were made using a combination of modified LEWICE and interactive boundary-layer codes for a wide range of values of parameters such as airspeed and temperature, the droplet size and liquid water content of the cloud, and the angle of attack of the airfoil. Based on experimental data, an improved correlation of equivalent sand-grain roughness was developed. Calculated ice shapes are in good agreement with experimental data for rime ice, but some differences are shown between predictions and experimental data for glaze ice. Calculated drag coefficients generally follow trends shown by the experimental data. Author (EI)

A94-60186

COMPUTATIONAL ANALYSIS OF A SINGLE JET IMPINGEMENT GROUND EFFECT LIFT LOSS

XIN ZHANG Southampton Univ. (England) and DAN N. ING *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 256-262 refs
(BTN-94-EIX94311329114) Copyright

A study was carried out on single-round-jet, ground effect lift loss. The jet exit Mach number and velocity were 0.71 and 240 m/s, respectively. The effects of ground height, baffle plate edge, and jet exit turbulent intensity were assessed, and Navier-Stokes equations were solved using computational fluid dynamics. Turbulence closure was achieved using a k-epsilon model, and the result was compared with calculations obtained with a differential stress model. Three baffle plate edges were tested (rounded, squared, and chamfered), and the ground heights varied from eta = 0.15 to 0.8. It was found that flow mechanisms varied significantly with ground heights. A coherent vortex existed between the baffle plate and the ground at the low ground heights (eta less than 0.25), which suppressed and/or delayed separation at the baffle plate edge and induced high lift loss. At the high ground heights (eta greater than/equivalent to 0.25), the vortex disappeared and separation at the plate edge played an important part in determining the lift loss. The baffle plate edge was found to account for as much as 14% of the ground effect lift loss. The stress model was found to improve the accuracy of the prediction. Author (EI)

A94-60187
QUANTITATIVE LOW-SPEED WAKE SURVEYS
G. W. BRUNE Boeing Commercial Airplane Co., Seattle, WA *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 249-255 refs
(BTN-94-EIX94311329113) Copyright

Theoretical and practical aspects of conducting three-dimensional wake measurements in large wind tunnels are reviewed with emphasis on applications in low-speed aerodynamics. Such quantitative wake surveys furnish separate values for the components of drag such as profile drag and induced drag but also measure lift without the use of a balance. In addition to global data, details of the wake flowfield as well as spanwise distributions of lift and drag are obtained. This article demonstrates the value of this measurement technique using data from wake measurements conducted on a variety of low-speed configurations including the complex high-lift system of a transport aircraft. Author (EI)

A94-60193
EFFECTS OF THE ROLL ANGLE ON CRUCIFORM WING-BODY CONFIGURATIONS AT HIGH INCIDENCES
J. MEYER Israel Inst. of Tech., Haifa (Israel) *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 1 January-February 1994 p. 113-122 refs
(BTN-94-EIX94311322903) Copyright

Three cruciform wings were tested on a body at five roll angles, up to three longitudinal positions, and angles of attack of up to alpha = 90 degin a low-speed wind tunnel. The roll angle affects, in a significant manner, the fin normal force coefficient. The normal force on the upper fins decreases to zero, at alpha greater than 40 deg, possibly because the vortex breakdown on the lower fins induces separated flow over the upper fins. As a consequence, a strong rolling moment is induced at these incidences at asymmetric roll angles. EI

A94-60196
DRAG REDUCTION FOR TURBULENT FLOW OVER A PROJECTILE, PART 2
SHEN-MIN LIANG National Cheng Kung Univ., Tainan (Taiwan) and JAN-KUANG FU *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 1 January-February 1994 p. 93-98 refs
(BTN-94-EIX94311322900) Copyright

The performance of a secant-ogive-cylinder-boattail projectile in the transonic regime in terms of drag is numerically investigated. To improve the projectile performance, a drag reduction method, passive control of shock/boundary-layer interaction on the boattail, is applied. The present results show that the passive control method applied on the boattail not only can reduce the boattail drag but also can reduce the base drag, and an additional 7% (approximately) total drag reduction is obtained compared with that without the passive control. The passive control effect on total drag reduction is found to be insensitive to Reynolds number. EI

A94-60205* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TECHNOLOGY AND STAGING EFFECTS ON TWO-STAGE-TO-ORBIT SYSTEMS
ALAN W. WILHITE National Aeronautics and Space Agency, Langley Research Center, Hampton, VA, WALTER C. ENGELUND, DOUGLAS O. STANLEY, CHRISTOPHER MAFTEL, ROGER A. LEPSCH, LANCE B. BUSH, and KATHRYN E. BURSTER *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 1 January-February 1994 p. 31-38 refs
(BTN-94-EIX94311322891) Copyright

Horizontal takeoff and landing two-stage systems with an airbreathing first stage and rocket second stage are evaluated for staging Mach numbers that range from 5 to 14. With advanced technologies, the two-stage systems are heavier than the single stage. Using a rocket on the first stage to accelerate from the turboramjet limit of Mach 6-Mach 10 significantly decreases by weight as compared to the Mach 6 staged system. With current technology, the scramjet two-stage systems are half the weight of the single stage, but still require substantial technology development in the areas of inlets, nozzles, ramjet propulsion, active cooling, and high-temperature structures. EI

A94-60208*
CHARACTERISTICS OF THE SHUTTLE ORBITER LEESIDE FLOW DURING A RE-ENTRY CONDITION
WILLIAM L. KLEB National Aeronautices and Space Administration, Langley Research Center, Hampton, VA and JAMES WEILMUENSTER *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 1 January-February 1994 p. 8-16 refs
(BTN-94-EIX94311322888) Copyright

A study of the leeside flow characteristics of the Shuttle Orbiter is presented for a re-entry flight condition. The flow is computed using a point-implicit, finite-volume scheme known as the Langley aerothermodynamic upwind relaxation algorithm (LAIRA). LAIRA is a second-order-accurate, laminar Navier-Stokes solver incorporating finite-rate chemistry with a radiative equilibrium wall temperature distribution and finite-rate wall catalysis. The computational results are compared with measured inflight surface pressure and surface heating from several Shuttle Orbiter flights. EI

A94-60266
PLANAR KRF LASER-INDUCED OH FLUORESCENCE IMAGING IN A SUPERSONIC COMBUSTION TUNNEL
T. M. QUAGLIAROLI Univ of Virginia, Charlottesville, VA, G. LAUFER, S. D. HOLLO, R. H. KRAUSS, R. B. WHITEHURST, III, and J. C. JR. MCDANIEL *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 377-381 refs
(BTN-94-EIX94321333315) Copyright

Planar fluorescence images of OH were obtained in a continuous-flow, electrically heated, high enthalpy, hydrogen-air combustion tunnel, using a tunable KrF laser. These images were compared to previously recorded fluorescence images produced using a doubled-dye laser under similar conditions. For the detection configuration used, the images of doubled-dye laser-induced fluorescence demonstrated a severe distortion as a result of laser beam absorption and fluorescence trapping. By contrast, images of the fluorescence induced by the tunable KrF laser retained the symmetry properties of the flow. Based on signal-to-noise ratio measurements, the yield of the fluorescence obtained with the doubled-dye laser is considerably larger than the fluorescence yield induced by the KrF laser. The measurement uncertainties in the present facility of OH fluorescence induced by the KrF laser were primarily controlled by photon-statistical noise. Based on these results, tunable KrF laser systems are recommended for quantitative OH imaging in facilities where the product of the optical path length for either fluorescence excitation or collection and the average OH concentration along that path is greater than 10(exp 16) cm/cm-(exp 3). Author (EI)

A94-60267
INJECTION OF BUBBLING LIQUID JETS FROM MULTIPLE INJECTORS INTO A SUPERSONIC STREAM
TAKAKAGE ARAI Virginia Polytechnic Inst and State Univ, Blacksburg, VA and JOSEPH A. SCHETZ *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 382-386 refs
(BTN-94-EIX94321333316) Copyright

Multiple (12 injectors) bubbling liquid jets (helium microbubbles in water) were injected transverse to a M = 2.4 airflow. Penetration and spray plume spreading angle were measured directly using nanoshadowgraphs and front-lighted pictures, respectively. The experiments were performed at two conditions, i.e., the constant supply pressure condition and the constant liquid mass flow rate condition. For the case of a parallel arrangement of the injector orifices to the airflow, the penetration of the jet array increased steadily from front to back. The last jet (12th jet) has over 5 times the penetration of the first jet for the water only case. The usual similarity law for the penetration, h varies directly as q exp -0.5, was approximately valid also for the multiple water-only jets. For the bubbling jet case, the penetration of the first jet doesn't change with increasing gas concentration gamma, but the rear jets have less penetration height than that of liquid-only jets at the constant injection pressure condition. For the constant injection pressure condition, the resulting penetration of the jet plume decreased with increasing gamma. On the other hand, for the constant liquid mass flow rate condition, the penetration of the multiple bubbling jets increased a little with increasing gamma. Straight coherent jets just coming out of orifice were observed for the gamma = 0 case. Conical jet plumes were obtained for the bubbling jet case. Therefore, the width of the jet plume increased by using the bubbling jet. The effects of the angle between the orifice array and the freestream direction and the surfactant concentration on the penetration and mixing of multiple bubbling jets were also clarified. Author (EI)

A94-60334
ORNITHOPTER WING DESIGN
JAMES D. DELAURIER Univ. of Toronto *Canadian Aeronautics and Space Journal* (ISSN 0008-2821) vol. 40, no. 1 March 1994 p. 10-18 refs
(BTN-94-EIX94331337499) Copyright

The physics of flapping-wing flight has been studied in order to gain insights on how animals fly and to assess the possibility of achieving this with a flapping-wing airplane (ornithopter). To this end, the major focus of this work has been the proof-of-concept flight tests of a remotely-piloted, engine-powered ornithopter. The level of sophistication of the analyses and laboratory experiments, which determined the design changes to the ornithopter, was driven by the results from these flight tests. Ultimately, successful sustained flight required the development of a comprehensive unsteady-aerodynamic/aeroelastic analysis complemented with wind tunnel experiments. Author (EI)

A94-60427
THREE-DIMENSIONAL UPWIND PARABOLIZED NAVIER-STOKES CODE FOR SUPERSONIC COMBUSTION FLOWFIELDS
GANESH WADAWADIGI Iowa State Univ., Ames, IA, JOHN C. TANNEHILL, and PHILIP E. BUELOW *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 7, no. 4 October-December 1993 p. 661-667 refs
(BTN-94-EIX94351142134) Copyright

A new upwind, parabolized Navier-Stokes (PNS) code has been developed to compute the three-dimensional chemically reacting flow in scramjet (supersonic combustion ramjet) engines. The code is a modification of the three-dimensional upwind PNS (UPS) airflow code which has been extended in the present study to permit internal flow calculations with hydrogen-air chemistry. With these additions, the new code has the capability of computing both aerodynamic and propulsive flowfields. The algorithm solves the PNS equations using a finite-volume, upwind TVD method based on Roe's approximate Riemann solver that has been modified to account for nonequilibrium effects. The fluid medium is assumed to be a chemically reacting mixture of thermally perfect (but calorically imperfect) gases in thermal equilibrium. The new code has been applied to two test cases. These include the Burrows-Kurkov supersonic combustion experiment and a three-dimensional shock-induced combustion flowfield. The computed results compare favorably with the available experimental data. Author (EI)

A94-60428
COMPUTATION OF NONEQUILIBRIUM HYPERSONIC FLOWFIELDS AROUND HEMISPHERE CYLINDERS
ESWAR JOSYULA Wright Lab., Wright-Patterson AFB, OH and JOSEPH S. SHANG *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 7, no. 4 October-December 1993 p. 668-679 refs
(BTN-94-EIX94351142135) Copyright

Hypersonic flows past hemisphere cylinders at zero incidence in chemical and thermal nonequilibrium are investigated for a range of Mach numbers from 10 to 18. The numerical code shows excellent comparison for surface pressure and heat transfer prediction with recent experiments conducted in a shock tunnel. The numerical code also compares well for stagnation point heat flux predictions at altitudes of 22 and 37 km with a set of earlier experiments. Numerical solutions with the vibrational equilibrium model are compared with those of multitemperature nonequilibrium. The stagnation point heat transfer is 10 to 23 percent higher for the nonequilibrium solutions in the Mach number range of 12-18. The importance of a multitemperature model for accurate prediction of stagnation properties, particularly the heat transfer, is noted. The variation in computed shock-standoff distance substantiates that the Mach number independence principle applicable to ideal gases does not hold for dissociating flows. Over the range of Mach numbers, the noticeable influence of vibrational relaxation on the temperature distributions and mass concentrations in the vicinity of shocks is shown in the present study. Author (EI)

A94-60429
DIRECT SIMULATION WITH VIBRATION-DISSOCIATION COUPLING
DAVID B. HAS North Carolina State Univ., Raleigh, NC and H. A. HASSAN *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 7, no. 4 October-December 1993 p. 680-686 refs
(BTN-94-EIX94351142136) Copyright

In the investigation of hypersonic rarefied flows, it is important to consider the effects of thermal nonequilibrium on the dissociation rates. Because the vibrational mode requires a finite time to relax, vibrational energy may not be available for dissociation immediately behind the shock. In this way, the dissociation of the preshock species can be delayed for a significant portion of the hypersonic shock layer. The majority of implementations of the direct simulation Monte Carlo (DSMC) method of bird do not account for vibration-dissociation coupling. Haas and Boyd have proposed the vibrationally favored dissociation (VFD) model to accomplish this task. Their model made use of measurements of induction distance to determine model constants. A more general expression has been derived that does not require any experimental input. The model is used to calculate one-dimensional shock waves in nitrogen and the flow past a lunar transfer vehicle (LTV). For the conditions considered in the simulation, the influence of vibration-dissociation coupling on heat transfer in the stagnation region of the LTV can be important. Author (EI)

A94-60436* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CALCULATION OF REAL-GAS EFFECTS ON AIRFOIL AERODYNAMIC CHARACTERISTICS
CHUL PARK NASA. Ames Research Center, Moffett Field, CA and SEOKKWAN YOON *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 7, no. 4 October-December 1993 p. 727-729 refs
(BTN-94-EIX94351142143) Copyright

Employing the CENS2H and the CENS2D computer codes, this technical note calculates the effects of two-dimensional, chemically reacting flowfields on the airfoil for the wings of the Space Shuttle Orbiter. Ellipses of thickness ratio vary from five to fifteen percent. EI

A94-60624
SYSTEMATIC COMPUTATION SCHEME OF PAR-WIG CRUISING PERFORMANCE
SHIGENORI ANDO Tokushima Bunri Univ., Kagawa (Japan) *Transactions of the Japan Society for Aeronautical and Space Sciences* (ISSN 0549-3811) vol. 36, no. 112 August 1993 p. 92-106 refs

(BTN-94-EIX94361135427) Copyright

A systematic computation scheme is presented for PAR-WIG cruising performance, on a FORTRAN program. It is suitable to be executed on personal computers. Effect of many parameters on the transportation efficiency is explored. Two concepts are presented in three views and artist impressions. One is a smallest single-crewman vehicle for experiment, sports or pleasure. The other is a large vehicle for civil transportation. Both have twin hulls, which are quite suitable to install 'SMALL-TAIL-WIG' or 'WIG-let' to establish longitudinal attitude stability. Author (EI)

A94-60625

STATIC AND DYNAMIC FLIGHT-PATH STABILITY OF AIRPLANES

OSAMU KOBAYASHI Kawasaki Heavy Industries Ltd., Gifu (Japan) *Transactions of the Japan Society for Aeronautical and Space Sciences* (ISSN 0549-3811) vol. 36, no. 112 August 1993 p. 107-120 refs

(BTN-94-EIX94361135428) Copyright

The concept of flight-path stability, which is today in use, is based on the characteristics of airplanes in equilibrium, or steady unaccelerated flight conditions, and so can be called 'static flight-path stability'. After summarizing the studies on the static flight-path stability from several points of view, the concept of 'dynamic flight-path stability' for accelerated/decelerated flight conditions is introduced, and the elevator compensation necessary to provide an airplane with a desired dynamic flight-path stability is obtained. Furthermore, through the study on the time history and the root-locus characteristics of airplane's motion, it is shown that the airplane with the compensation can stably control the flight-path by the elevator in the backside region. Author (EI)

N94-35394*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLIGHT TESTING OF A LUMINESCENT SURFACE PRESSURE SENSOR

B. G. MCLACHLAN, J. H. BELL, J. ESPINA, J. GALLERY, M. GOUTERMAN, C. G. N. DEMANDANTE, and L. BJARKE Oct. 1992 28 p

(Contract RTOP 537-03-23)

(NASA-TM-103970; A-92175; NAS 1.15:103970) Avail: CASI HC A03/MF A01

NASA ARC has conducted flight tests of a new type of aerodynamic pressure sensor based on a luminescent surface coating. Flights were conducted at the NASA ARC-Dryden Flight Research Facility. The luminescent pressure sensor is based on a surface coating which, when illuminated with ultraviolet light, emits visible light with an intensity dependent on the local air pressure on the surface. This technique makes it possible to obtain pressure data over the entire surface of an aircraft, as opposed to conventional instrumentation, which can only make measurements at pre-selected points. The objective of the flight tests was to evaluate the effectiveness and practicality of a luminescent pressure sensor in the actual flight environment. A luminescent pressure sensor was installed on a fin, the Flight Test Fixture (FTF), that is attached to the underside of an F-104 aircraft. The response of one particular surface coating was evaluated at low supersonic Mach numbers (M = 1.0-1.6) in order to provide an initial estimate of the sensor's capabilities. This memo describes the test approach, the techniques used, and the pressure sensor's behavior under flight conditions. A direct comparison between data provided by the luminescent pressure sensor and that produced by conventional pressure instrumentation shows that the luminescent sensor can provide quantitative data under flight conditions. However, the test results also show that the sensor has a number of limitations which must be addressed if this technique is to prove useful in the flight environment. Author (revised)

02 AERODYNAMICS

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

A94-60354

INCIPIENT TORSIONAL STALL FLUTTER AERODYNAMIC EXPERIMENTS ON THREE-DIMENSIONAL WINGS

PETER F. LORBER United Technologies Research Center, East Hartford, CT and FRANKLIN O. CARTA *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 2 March-April 1994 p. 217-224 refs

(BTN-94-EIX94341338362) Copyright

The aerodynamics of small amplitude pitching motions near stall have been studied experimentally in order to improve understanding of torsional stall flutter. A model wing was oscillated in pitch at several small amplitudes over a wide range of conditions. Unsteady surface pressures were measured and integrated to determine the aerodynamic damping at five spanwise stations. Attached flow damping was positive and, for moderate Mach number and frequencies, in good agreement with thin airfoil theory. Strong negative damping was found for motions centered near static stall for all studied reduced frequencies, Mach number, and sweep angles. The 30-degrees swept-back configuration was found to become negatively damped over the entire span nearly simultaneously, while the unswept model exhibited local regions of negative damping that moved toward the wingtip as the mean angle of attack was increased. Author (EI)

N94-34612# Dassault Aviation, Saint-Cloud (France).

HIGH INCIDENCE FLOW ANALYSIS OVER THE RAFALE A [ANALYSE THEORIQUE DE L'ECOULEMENT AUTOUR D'UN RAFALE A A GRANDE INCIDENCE]

JEAN-DENIS MARION *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 7 p Mar. 1994 In FRENCH

Copyright Avail: CASI HC A02/MF A03

A good high angle of attack (AoA) behavior is a requisite for any new combat aircraft. In order to gain a better knowledge of the flow at high AoA, computation over the 'RAFALE A' has been conducted. The aircraft is in a full nose down controls configuration: low speed, low altitude, high AoA, and large control surfaces deflection. Moreover, sideslip is considered so as to assess the lateral behavior of the aircraft in this high AoA regime. The computational domain around the complete aircraft is discretized into an unstructured mesh and the flow is computed with a 3D inviscid (Euler) approach in finite elements. Aerodynamic coefficients have been analyzed together with the topology of the flow in these high AoA configurations. Results have been found to yield a promising agreement concerning the flow features (loss of weathercock stability at high AoA) although absolute values of coefficients are still beyond reach of this basic methodology. In an attempt to get insight into nonsymmetric flow as it can be found experimentally at high AoA, a modification of the boundary conditions which create a source of vorticity has been implemented. This leads to the existence of large amplitude side forces agreeing with experiments. Author (revised)

N94-34704*# Rice Univ., Houston, TX.

ANALYSIS OF WAVELET TECHNOLOGY FOR NASA APPLICATIONS Final Report

R. O. WELLS, JR. 31 May 1994 19 p

(Contract NAG9-681)

(NASA-CR-195929; NAS 1.26:195929) Avail: CASI HC A03/MF A01

The purpose of this grant was to introduce a broad group of NASA researchers and administrators to wavelet technology and to determine its future role in research and development at NASA JSC. The activities of several briefings held between NASA JSC scientists and Rice University researchers are discussed. An attached paper, 'Recent

Advances in Wavelet Technology', summarizes some aspects of these briefings. Two proposals submitted to NASA reflect the primary areas of common interest. They are image analysis and numerical solutions of partial differential equations arising in computational fluid dynamics and structural mechanics. CASI

N94-34948*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN EXAMINATION OF THE AERODYNAMIC MOMENT ON ROTOR BLADE TIPS USING FLIGHT TEST DATA AND ANALYSIS
THOMAS H. MAIER and WILLIAM G. BOUSMAN Oct. 1993 20 p
See also A94-12064
(Contract RTOP 505-59-52)
(NASA-TM-104006; A-93047; NAS 1.15:104006; USAATCOM-TR-92-A-014) Avail: CASI HC A03/MF A01

The analysis CAMRAD/JA is used to model two aircraft, a Puma with a swept-tip blade and a UH-60A Black Hawk. The accuracy of the analysis in predicting the torsion loads is assessed by comparing the predicted loads with measurements from flight tests. The influence of assumptions in the analytical model is examined by varying model parameters and comparing the predicted results to baseline values for the torsion loads. Flight test data from a research Puma are used to identify the source of torsion loads. These data indicate that the aerodynamic section moment in the region of the blade tip dominates torsion loading in high-speed flight. Both the aerodynamic section moment at the blade tip and the pitch-link loads are characterized by large positive (nose-up) moments in the first quadrant with rapid reversal of load so that the moment is negative in the second quadrant. Both the character and magnitude of this loading are missed by the CAMRAD/JA analysis. Author

N94-34964*# Calspan-State Univ. of New York Joint Venture, Buffalo, NY. Research Center.
EXPERIMENTAL STUDIES OF SHOCK-WAVE/WALL-JET INTERACTION IN HYPERSONIC FLOW, PART A Final Report
MICHAEL S. HOLDEN and KATHLEEN RODRIGUEZ May 1994 226 p
(Contract NAG1-790)
(NASA-CR-195957; NAS 1.26:195957) Avail: CASI HC A11/MF A03

Experimental studies have been conducted to examine slot film cooling effectiveness and the interaction between the cooling film and an incident planar shock wave in turbulent hypersonic flow. The experimental studies were conducted in the 48-inch shock tunnel at Calspan at a freestream Mach number of close to 6.4 and at a Reynolds number of 35 x 10(exp 6) based on the length of the model at the injection point. The Mach 2.3 planar wall jet was generated from 40 transverse nozzles (with heights of both 0.080 inch and 0.120 inch), producing a film that extended the full width of the model. The nozzles were operated at pressures and velocities close to matching the freestream, as well as at conditions where the nozzle flows were over- and under-expanded. A two-dimensional shock generator was used to generate oblique shocks that deflected the flow through total turnings of 11, 16, and 21 degrees; the flows impinged downstream of the nozzle exits. Detailed measurements of heat transfer and pressure were made both ahead and downstream of the injection station, with the greatest concentration of measurements in the regions of shock-wave/boundary layer interaction. The major objectives of these experimental studies were to explore the effectiveness of film cooling in the presence of regions of shock-wave/boundary layer interaction and, more specifically, to determine how boundary layer separation and the large recompression heating rates were modified by film cooling. Detailed distributions of heat transfer and pressure were obtained in the incident-shock/wall-jet interaction region for a series of shock strengths and impingement positions for each of the two nozzle heights. Measurements were also made to examine the effects of nozzle lip thickness on cooling effectiveness. The major conclusion from these studies was that the effect of the cooling film could be readily dispersed by relatively weak incident shocks, so the peak heating in the recompression region was not significantly reduced by even the largest levels of film cooling. For the case studies in the absence of film cooling, the interaction regions were unseparated. However, adding film cooling resulted in regions of boundary layer separation induced in the film cooling layer, the size of which regions first increased and then decreased with increased film cooling. Surprisingly, the size of the separated regions and the magnitude of the recompression heating were not strongly influenced by the thickness of the cooling film, nor by the point of shock impingement relative to the exit plane of the nozzles. The lip thickness was found to have little effect on cooling effectiveness. Measurements with and in the absence of shock interaction were compared with the results of earlier experimental studies and correlated in terms of the major parameters controlling these flows. Author

N94-34965*# Calspan-State Univ. of New York Joint Venture, Buffalo, NY. Research Center.
EXPERIMENTAL STUDIES OF TRANSPIRATION COOLING WITH SHOCK INTERACTION IN HYPERSONIC FLOW, PART B Final Report
MICHAEL S. HOLDEN May 1994 267 p
(Contract NAG1-790)
(NASA-CR-195958; NAS 1.26:195958) Avail: CASI HC A12/MF A03

This report describes the result of experimental studies conducted to examine the effects of the impingement of an oblique shock on the flowfield and surface characteristics of a transpiration-cooled wall in turbulent hypersonic flow. The principal objective of this work was to determine whether the interaction between the oblique shock and the low-momentum region of the transpiration-cooled boundary layer created a highly distorted flowfield and resulted in a significant reduction in the cooling effectiveness of the transpiration-cooled surface. As a part of this program, we also sought to determine the effectiveness of transpiration cooling with nitrogen and helium injectants for a wide range of blowing rates under constant-pressure conditions in the absence of shock interaction. This experimental program was conducted in the Calspan 48-inch Shock Tunnel at nominal Mach numbers of 6 and 8, for a Reynolds number of 7.5 x 10(exp 6). For these test conditions, we obtained fully turbulent boundary layers upstream of the interaction regions over the transpiration-cooled segment of the flat plate. The experimental program was conducted in two phases. In the first phase, we examined the effects of mass-addition level and coolant properties on the cooling effectiveness of transpiration-cooled surfaces in the absence of shock interaction. In the second phase of the program, we examined the effects of oblique shock impingement on the flowfield and surface characteristics of a transpiration-cooled surface. The studies were conducted for a range of shock strengths with nitrogen and helium coolants to examine how the distribution of heat transfer and pressure and the characteristics of the flowfield in the interaction region varied with shock strength and the level of mass addition from the transpiration-cooled section of the model. The effects of the distribution of the blowing rate along the interaction regions were also examined for a range of blowing rates through the transpiration-cooled panels. The regions of shockwave/boundary layer interaction examined in these studies were induced by oblique shocks generated with a sharp, flat plate, inclined to the freestream at angles of 5 degrees, 7.5 degrees, and 10 degrees. It was found that, in the absence of an incident shock, transpiration cooling was a very effective method for reducing both the heat transfer and the skin friction loads on the surface. The helium coolant was found to be significantly more effective than nitrogen, because of its low molecular weight and high specific heat. The studies of shock-wave/transpiration-cooled surface interaction demonstrated that the interaction region between the incident shock and the low-momentum transpiration-cooled boundary layer did not result in a significant increase in the size of attached or separated interaction regions, and did not result in significant flowfield distortions above the interaction region. The increase in heating downstream of the shock-impingement point could easily be reduced to the values without shock impingement by a relatively small increase in the transpiration cooling in this region. Surprisingly, this increase in cooling rate did not result in a significant increase in size of the region ahead of the incident shock or create a significantly enlarged interaction region with a resultant increase in the distortion level in the inviscid flow. Thus, transpiration cooling appears to be a very effective technique to cool the internal surfaces of scramjet engines, where shocks in the engine would induce large local increases in wall heating and create viscous/inviscid interactions that could significantly disturb the smooth flow through the combustor. However, if hydrogen is used as the coolant, burning upstream of shock impingement might result in localized hot spots. Clearly, further research is needed in this area. Author

N94-34967*# United Technologies Corp., East Hartford, CT.
UNSTEADY SEPARATION EXPERIMENTS ON 2-D AIRFOILS, 3-D WINGS, AND MODEL HELICOPTER ROTORS
PETER F. LORBER and FRANKLIN O. CARTA *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 1-22 Mar. 1992
Avail: CASI HC A03/MF A03

Information on unsteady separation and dynamic stall is being obtained from two experimental programs that have been underway at United Technologies Research Center since 1984. The first program is designed to obtain detailed surface pressure and boundary layer condition information during high amplitude pitching oscillations of a large (17.3 in. chord) model wing in a wind tunnel. The second program involves the construction and testing of a pressure-instrumented model helicopter rotor. This presentation describes some of the results of these experiments, and in particular compares the detailed dynamic stall inception information obtained from the oscillating wing with the unsteady separation and reverse flow results measured on the retreating blade side of the model rotor during wind tunnel testing. Derived from text

N94-34969*# Florida Agricultural and Mechanical Univ., Tallahassee, FL. Coll. of Engineering.
UNSTEADY FLOW PAST AN AIRFOIL PITCHED AT CONSTANT RATE
L. LOURENCO, L. VANDOMMELEN, C. SHIB, and A. KROTHAPALLI *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 35-59 Mar. 1992 Sponsored by AFOSR Prepared in cooperation with Florida State Univ., Tallahassee
Avail: CASI HC A03/MF A03

The unsteady flow past a NACA 0012 airfoil that is undertaking a constant-rate pitching up motion is investigated experimentally by the PIDV technique in a water towing tank. The Reynolds number is 5000, based upon the airfoil's chord and the free-stream velocity. The airfoil is pitching impulsively from 0 to 30 deg. with a dimensionless pitch rate alpha of 0.131. Instantaneous velocity and associated vorticity data have been acquired over the entire flow field. The primary vortex dominates the flow behavior after it separates from the leading edge of the airfoil. Complete stall emerges after this vortex detaches from the airfoil and triggers the shedding of a counter-rotating vortex near the trailing edge. A parallel computational study using the discrete vortex, random walk approximation has also been conducted. In general, the computational results agree very well with the experiment. Author

N94-34970*# University of Southern California, Los Angeles, CA. Dept. of Aerospace Engineering.
UNSTEADY SEPARATION PROCESS AND VORTICITY BALANCE ON UNSTEADY AIRFOILS
CHIH-MING HO, ISMET GURSUL, CHIANG SHIH, and HANK LIN *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 61-77 Mar. 1992
(Contract F49620-88-C-0061)
Avail: CASI HC A03/MF A03

Low momentum fluid erupts at the unsteady separation region and forms a local shear layer at the viscous-inviscid interface. At the shear layer, the vorticity lumps into a vortex and protrudes into the inviscid region. This process initiates the separation process. The response of airfoils in unsteady free stream was investigated based on this vortex generation and convection concept. This approach enabled us to understand the complicated unsteady aerodynamics from a fundamental point of view. Author

N94-34971*# Lehigh Univ., Bethlehem, PA.
CONTROL OF LEADING-EDGE VORTICES ON A DELTA WING
C. MAGNESS, O. ROBINSON, and D. ROCKWELL *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 79-100 Mar. 1992 Sponsored by AFOSR
Avail: CASI HC A03/MF A03

The unsteady flow structure of leading-edge vortices on a delta wing has been investigated using new types of experimental techniques, in order to provide insight into the consequences of various forms of active control. These investigations involve global control of the entire wing and local control applied at crucial locations on or adjacent to the wing. Transient control having long and short time-scales, relative to the convective time-scale C/U(sub infinity), allows substantial modification of the unsteady and time-mean flow structure. Global control at long time-scale involves pitching the wing at rates an order of magnitude lower than the convective time-scale C/U(sub infinity), but at large amplitudes. The functional form of the pitching maneuver exerts a predominant influence on the trajectory of the feeding sheet, the instantaneous vorticity distribution, and the instantaneous location of vortex breakdown. Global control at short time-scales of the order of the inherent frequency of the shear layer separating from the leading-edge and the natural frequency of vortex breakdown shows that 'resonant' response of the excited shear layer-vortex breakdown system is attainable. The spectral content of the induced disturbance is preserved not only across the entire core of the vortex, but also along the axis of the vortex into the region of vortex breakdown. This unsteady modification results in time-mean alteration of the axial and swirl velocity fields and the location of vortex breakdown. Localized control at long and short time-scales involves application of various transient forms of suction and blowing using small probes upstream and downstream of the location of vortex breakdown, as well as distributed suction and blowing along the leading-edge of the wing applied in a direction tangential to the feeding sheet. These local control techniques can result in substantial alteration of the location of vortex breakdown; in some cases, it is possible to accomplish this without net mass addition to the flow field. Derived from text

N94-34972*# Illinois Inst. of Tech., Chicago, IL. Fluid Dynamics Research Center.
THE UNSTEADY PRESSURE FIELD AND VORTICITY PRODUCTIION AT THE SUCTION SURFACE OF A PITCHING AIRFOIL
MUKUND ACHARYA and METWALLY H. METWALLY *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 101-118 Mar. 1992
Avail: CASI HC A03/MF A03

The objective of this work is to develop techniques for the control and management of separated flows over airfoils, particularly under unsteady operating conditions. The results are expected to help achieve the ultimate goal, which is flow management for highly maneuverable aircraft. Author

N94-34974*# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Engineering Mechanics.
CHARACTERIZATION OF DYNAMIC STALL PHENOMENON USING TWO-DIMENSIONAL UNSTEADY NAVIER-STOKES EQUATIONS
K. N. GHIA, U. GHIA, and G. A. OSSWALD *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 129-147 Mar. 1992
(Contract AF-AFOSR-0074-87; AF-AFOSR-0249-90)
Avail: CASI HC A03/MF A03

Among the new significant aspects of the present work are: (1) the treatment of the far-field boundary; (2) the use of C-grid topology, with the branch-cut singularity treated analytically; (3) evaluation of the effect of the envelope of prevailing initial states, and finally; (4) the ability to employ streakline/pathline 'visualization' to probe the unsteady features prevailing in vortex-dominated flows. The far-field boundary is placed at infinity, using appropriate grid stretching. This contributes to the accuracy of the solutions, but raised a number of important issues which needed to be resolved; this includes determining the equivalent time-dependent circulation for the pitching airfoil. A secondary counter-clockwise vortex erupts from within the boundary layer and immediately pinches off the energetic leading-edge shear layer which then, through hydrodynamic instability, rolls up into the dynamic stall vortex. The streakline/pathline visualization serves to provide information for insight into the physics of the unsteady separated flow. Author

N94-34975*# Arizona Univ., Tucson, AZ.

COMPUTED UNSTEADY FLOWS OF AIRFOILS AT HIGH INCIDENCE

K.-Y. FUNG, JEFFREY CURRIER, and S. O. MAN *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 149-162 Mar. 1992

Avail: CASI HC A03/MF A03

The flow over an airfoil at an angle of attack above the static stall angle would ordinarily be massively separated. Under dynamic conditions, the onset of stall can be delayed to an angle, depending on the type of unsteadiness, much higher than that for static stall. The stall onset mechanisms under dynamic conditions are unclear. Due to extreme difficulties involved, experimental investigations, so far, have provided insufficient information about the flow field for the identification of the onset mechanisms. A course of classical boundary layer analysis augmented with numerical experiments and measured data is chosen here instead, with the hope that the identification of onset mechanisms can be more systematic and quantitative. Author

N94-34977*# Naval Postgraduate School, Monterey, CA. Dept. of Aeronautics and Astronautics.

COMPUTATION OF UNSTEADY FLOWS OVER AIRFOILS

J. A. EKATERINARIS and M. F. PLATZER *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 177-185 Mar. 1992 Sponsored by Naval Air Systems Command

Avail: CASI HC A02/MF A03

Two methods are described for calculating unsteady flows over rapidly pitching airfoils. The first method is based on an interactive scheme in which the inviscid flow is obtained by a panel method. The boundary layer flow is computed by an interactive method that makes use of the Hilbert integral to couple the solutions of the inviscid and viscous flow equations. The second method is based on the solution of the compressible Navier-Stokes equations. The solution of these equations is obtained with an approximately factorized numerical algorithm, and with single block or multiple grids which enable grid embedding to enhance the resolution at isolated flow regions. In addition, the attached flow region can be computed by the numerical solution of compressible boundary layer equations. Unsteady pressure distributions obtained with both methods are compared with available experimental data. Derived from text

N94-34978*# California State Univ., Long Beach, CA. Dept. of Aerospace Engineering.

PREDICTION OF UNSTEADY AIRFOIL FLOWS AT LARGE ANGLES OF INCIDENCE

TUNCER CEBECI, H. M. JANG, and H. H. CHEN *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 187-201 Mar. 1992

Avail: CASI HC A03/MF A03

The effect of the unsteady motion of an airfoil on its stall behavior is of considerable interest to many practical applications including the blades of helicopter rotors and of axial compressors and turbines. Experiments with oscillating airfoils, for example, have shown that the flow can remain attached for angles of attack greater than those which would cause stall to occur in a stationary system. This result appears to stem from the formation of a vortex close to the surface of the airfoil which continues to provide lift. It is also evident that the onset of dynamic stall depends strongly on the airfoil section, and as a result, great care is required in the development of a calculation method which will accurately predict this behavior. Author (revised)

N94-34979*# Lehigh Univ., Bethlehem, PA. Dept. of Mechanical Engineering and Mechanics.

SOME ASPECTS OF UNSTEADY SEPARATION

C. R. SMITH and J. D. A. WALKER *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 203-208 Mar. 1992

Avail: CASI HC A02/MF A03

Unsteady separation can be forced in a variety of ways and in this presentation two fundamental means will be considered: (1) the introduction of convected vorticular disturbances into the flow; and (2) the influence of a specific type of three-dimensional geometry. In both situations a response of the viscous flow near the wall is provoked wherein the fluid near the surface abruptly focuses into a narrow region that erupts from the surface into the mainstream. In two-dimensional flows, the eruption takes the form of a narrow, explosively-growing spike, while in three-dimensional situations, examples are presented which indicate that the eruption is along a narrow zone in the shape of a crescent-shaped plume. The nature of the three-dimensional flow near a circular cylinder, which is mounted normal to a flat plate, is also examined in this study. Here the three-dimensional geometry induces complex three-dimensional separations periodically. The dynamics of the generation process is studied experimentally in a water channel using hydrogen bubble wires and a laser sheet, and the main features of the laminar regime through to transition are documented. Author (revised)

N94-34986*# Army Aviation Systems Command, Moffett Field, CA. Aeroflightdynamics Directorate.

THE QUEST FOR STALL-FREE DYNAMIC LIFT

C. TUNG, K. W. MCALISTER, LAWRENCE W. CARR, E. DUQUE, and R. ZINNER *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 277-295 Mar. 1992

Avail: CASI HC A03/MF A03

During the past decade, numerous major effects have addressed the question of how to control or alleviate dynamic stall effects on helicopter rotors, but little concrete evidence of any significant reduction of the adverse characteristics of the dynamic stall phenomenon has been demonstrated. Nevertheless, it is important to remember that the control of dynamic stall is an achievable goal. Experiments performed at the US Army Aeroflight-dynamics Directorate more than a decade ago demonstrated that dynamic stall is not an unavoidable penalty of high amplitude motion, and that airfoils can indeed operate dynamically at angles far above the static-stall angle without necessarily forming a stall vortex. These experiments, one of them featuring a slat that was designed from static airfoil considerations, showed that unsteadiness can be a very beneficial factor in the development of high-lift devices for helicopter rotors. The experience drawn from these early experiments is now being focused on a program for the alleviation of dynamic-stall effects on helicopter rotors. The purpose of this effort is to demonstrate that rotor stall can be controlled through an improved understanding of the unsteady effects on airfoil stall and to document the role of specific means that lead to stall alleviation in the three dimensional unsteady environment of helicopter rotors in forward flight. The first concept to be addressed in this program will be a slatted airfoil. A two dimensional unsteady Navier-Stokes code has been modified to compute the flow around a two-element airfoil. Derived from text

N94-34987*# Illinois Inst. of Tech., Chicago, IL. Fluid Dynamics Research Center.

MECHANISMS OF FLOW CONTROL WITH THE UNSTEADY BLEED TECHNIQUE

D. R. WILLIAMS, M. ACHARYA, and J. BERNHARDT *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 297-307 Mar. 1992
(Contract F49620-86-C-0133)
Avail: CASI HC A03/MF A03

The unsteady bleed technique (a.k.a. internal acoustic forcing) has been shown to be an effective method for control of separation on low Reynolds number airfoils, blunt-end cylinders aligned axially with the flow, cylinders aligned perpendicular to the flow, and forebody geometries at high angles of attack. In many of these investigations, the mechanism for the control has been attributed to enhancement of the shear layer (Kelvin-Helmholtz) instability by the unsteady component of the forcing. However, this is not the only possible mechanism, nor may it be the dominant mechanism under some conditions. In this work it is demonstrated that at least two other mechanisms for flow control are present, and depending on the location and the amplitude of the forcing, these may have significant impact on the flow behavior. Experiments were conducted on a right-circular cylinder with a single unsteady bleed slot aligned along the axis of the cylinder. The effects of forcing frequency, forcing amplitude, and slot location on the azimuthal pressure distribution were studied. The results suggest that a strong vortical structure forms near the unsteady bleed slot when the slot location is upstream of the boundary layer separation point. The structure is unsteady, since it is created by the unsteady forcing. The 'vortex' generates a sizeable pressure spike (C(sub p) = -3.0) in the time-averaged pressure field immediately downstream of the slot. In addition to the pressure spike, the boundary layer separation location moves farther downstream when the forcing is activated. Delay of the separation is believed to be a result of enhancing the Kelvin-Helmholtz instability. When forcing is applied in a quiescent wind tunnel, a weak low-pressure region forms near the slot that is purely the result of the second-order streaming effect. Derived from text

N94-34989*# Michigan State Univ., East Lansing, MI.
EFFECT OF INITIAL ACCELERATION ON THE DEVELOPMENT OF THE FLOW FIELD OF AN AIRFOIL PITCHING AT CONSTANT RATE
M. M. KOOCHESFAHANI, V. SMILJANOVSKI, and T. A. BROWN *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 317-332 Mar. 1992
Avail: CASI HC A03/MF A03

We present results from a series of experiments where an airfoil is pitched at constant rate from 0 to 60 degrees angle of attack. It is well documented that the dynamic stall behavior of such an airfoil strongly depends on the nondimensional pitch rate K = dot-alpha C/(2U(sub infinity)), where C is the chord, dot-alpha the constant pitch rate, and U(sub infinity) the free stream speed. In reality, the actual motion of the airfoil deviates from the ideal ramp due to the finite acceleration and deceleration periods imposed by the damping of drive system and response characteristics of the airfoil. It is possible that the pitch rate alone may not suffice in describing the flow and that the details of the motion trajectory before achieving a desired constant pitch rate may also affect the processes involved in the dynamic stall phenomenon. The effects of acceleration and deceleration periods are investigated by systematically varing the acceleration magnitude and its duration through the initial acceleration phase to constant pitch rate. The magnitude and duration of deceleration needed to bring the airfoil motion to rest is similarly controlled. Derived from text

N94-35246*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LANGLEY 14- BY 22-FOOT SUBSONIC TUNNEL TEST ENGINEER'S DATA ACQUISITION AND REDUCTION MANUAL
P. FRANK QUINTO and NETTIE M. ORIE Jun. 1994 63 p
(Contract RTOP 535-03-10-02)
(NASA-TM-4563; L-17263; NAS 1.15:4563) Avail: CASI HC A04/MF A01

The Langley 14- by 22-Foot Subsonic Tunnel is used to test a large variety of aircraft and nonaircraft models. To support these investigations, a data acquisition system has been developed that has both static and dynamic capabilities. The static data acquisition and reduction system is described; the hardware and software of this system are explained. The theory and equations used to reduce the data obtained in the wind tunnel are presented; the computer code is not included. Author

N94-35360# Sandia National Labs., Albuquerque, NM.
A REVIEW AND DEVELOPMENT OF CORRELATIONS FOR BASE PRESSURE AND BASE HEATING IN SUPERSONIC FLOW
J. PARKER LAMB (Texas Univ., Austin, TX.) and WILLIAM L. OBERKAMPF Nov. 1993 79 p
(Contract DE-AC04-94AL-85000)
(SAND93-0280; UC-706) Avail: CASI HC A05/MF A01

A comprehensive review of experimental base pressure and base heating data related to supersonic and hypersonic flight vehicles has been completed. Particular attention was paid to free-flight data as well as wind tunnel data for models without rear sting support. Using theoretically based correlation parameters, a series of internally consistent, empirical prediction equations was developed for planar and axisymmetric geometries (wedges, cones, and cylinders). These equations encompass the speed range from low supersonic to hypersonic flow and laminar and turbulent forebody boundary layers. A wide range of cone and wedge angles and cone bluntness ratios was included in the data base used to develop the correlations. The present investigation also included preliminary studies of the effect of angle of attack and specific-heat ratio of the gas. Author (revised)

N94-35498*# Eloret Corp., Palo Alto, CA.
DEVELOPMENT AND APPLICATION OF COMPUTATIONAL AEROTHERMODYNAMICS FLOWFIELD COMPUTER CODES Final Technical Report, 1 Sep. 1986 - 31 Jan. 1994
ETHIRAJ VENKATAPATHY 14 Jul. 1994 124 p
(Contract NCC2-420)
(NASA-CR-196136; NAS 1.26:196136) Avail: CASI HC A06/MF A02

Research was performed in the area of computational modeling and application of hypersonic, high-enthalpy, thermo-chemical nonequilibrium flow (Aerothermodynamics) problems. A number of computational fluid dynamic (CFD) codes were developed and applied to simulate high altitude rocket-plume, the Aeroassist Flight Experiment (AFE), hypersonic base flow for planetary probes, the single expansion ramp model (SERN) connected with the National Aerospace Plane, hypersonic drag devices, hypersonic ramp flows, ballistic range models, shock tunnel facility nozzles, transient and steady flows in the shock tunnel facility, arc-jet flows, thermochemical nonequilibrium flows around simple and complex bodies, axisymmetric ionized flows of interest to re-entry, unsteady shock induced combustion phenomena, high enthalpy pulsed facility simulations, and unsteady shock boundary layer interactions in shock tunnels. Computational modeling involved developing appropriate numerical schemes for the flows on interest and developing, applying, and validating appropriate thermochemical processes. As part of improving the accuracy of the numerical predictions, adaptive grid algorithms were explored, and a user-friendly, self-adaptive code (SAGE) was developed. Aerothermodynamic flows of interest included energy transfer due to strong radiation, and a significant level of effort was spent in developing computational codes for calculating radiation and radiation modeling. In addition, computational tools were developed and applied to predict the radiative heat flux and spectra that reach the model surface. Author

N94-35529 Lehigh Univ., Bethlehem, PA. Dept. of Mechanical Engineering and Mechanics.
UNSTEADY STRUCTURE OF LEADING-EDGE VORTICES ON A DELTA WING Final Report, 1 Nov. 1990 - 31 Oct. 1992
DONALD O. ROCKWELL 22 Mar. 1994 8 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality

(Contract AF-AFOSR-0005-91)
(AD-A278988; AFOSR-94-0269TR) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The overall objective of this research program was to characterize the unsteady flow structure on wings having swept edges. Wings were subjected to global control, involving motion of the entire wing and local control, involving perturbations at specified locations on the surface of the wing. New types of experimental facilities and image acquisition and processing techniques have allowed determination of the instantaneous vorticity distributions and streamline patterns of the flow. The occurrence of vortex breakdown and stall and their phase shifts relative to the wing motion and to control at the leading-edges have been interpreted in terms of new flow mechanisms. DTIC

N94-35717 Stanford Univ., CA. Dept. of Aeronautics and Astronautics.
INVESTIGATION OF BURNETT EQUATIONS FOR TWO-DIMENSIONAL HYPERSONIC FLOW Final Report, 1 Nov. 1992 - 31 Oct. 1993
DEAN R. CHAPMAN and ROBERT W. MACCORMACK Apr. 1994 16 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract F49620-92-J-0012)
(AD-A278942; AFOSR-94-0278TR) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Two separate areas of investigation are explored of two dimensional flow fields computed from the Burnett and Navier-Stokes equations: evaluation of various forms of Burnett equations from computations of one dimensional hypersonic shock structure and two dimensional flow over a flat plate at zero incidence, and investigation of the interaction at high altitudes of a hypersonic oblique shock impinging on a cowl lip. Among five different formulations of Burnett equations, two were found to exhibit in shock structure a small region of flow wherein the heat flux is physically unreal. Preliminary computations with the three other formulations are made for flow over a flat plate. It is found that the well-known severe overheating, due to oblique shock impingement on a leading edge, decreases significantly as altitude increases disappearing at Knudsen numbers above about 0.1. DTIC

N94-35826 Naval Postgraduate School, Monterey, CA. Dept. of Mechanical Engineering.
DATA REDUCTION, ANALYSIS AND RESULTS OF LACV-30-07 AIR CUSHION VEHICLE TESTS, FORT STORY, VA, AUGUST - SEPTEMBER 1993
YOUNG S. SHIN and ERIC HOY Feb. 1994 521 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A278859; NPS-ME-94-002) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The LACV-30-07 Air Cushion Vehicle was instrumented and tested at Fort Story, VA during the months of August-September 1993 by Ed. Thomas, NSWC-Cardrock Division, Annapolis Detachment, Annapolis, MD. The tests include 27 cuts with vehicle speed ranging from 0 to 42 knots and approximate wave height of 0 to 2.5 feet. Two triaxial accelerometers, and a pitch and roll transducer were installed to measure axial, transverse and vertical accelerations and pitch and roll (in degree) of the vehicle. The test results clearly show that the vibration g-amplitude is extremely low (fraction of 1-g level) for air cushion vehicle and air cushion vehicle itself is acting as a super-damper to reduce the wave-induced vibration response amplitude. The vibration amplitude in terms of g-level may not be the controlling factor, but the combined vehicle dominant frequencies, vibration g-level, and duration may be the definite factors that the superconductor magnet must persist. DTIC

N94-35855*# Southampton Univ. (England).
THE SIMULATION OF A PROPULSIVE JET AND FORCE MEASUREMENT USING A MAGNETICALLY SUSPENDED WIND TUNNEL MODEL
K. S. GARBUTT and M. J. GOODYER *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 1 p 291-305 May 1994
Avail: CASI HC A03/MF A04

Models featuring the simulation of exhaust jets were developed for magnetic levitation in a wind tunnel. The exhaust gas was stored internally producing a discharge of sufficient duration to allow nominal steady state to be reached. The gas was stored in the form of compressed gas or a solid rocket propellant. Testing was performed with the levitated models although deficiencies prevented the detection of jet-induced aerodynamic effects. Difficulties with data reduction led to the development of a new force calibration technique, used in conjunction with an exhaust simulator and also in separate high incidence aerodynamic tests. Author

N94-35864*# California Univ., San Diego, La Jolla, CA. Dept. of Applied Mechanics and Engineering Sciences.
ON THE VARIOUS FORMS OF THE ENERGY EQUATION FOR A DILUTE, MONATOMIC MIXTURE OF NONREACTING GASES Final Report
CHRISTOPHER A. KENNEDY Jul. 1994 19 p
(Contract NAG1-1193; RTOP 505-59-50-05)
(NASA-CR-4612; NAS 1.26:4612) Avail: CASI HC A03/MF A01

In the case of gas mixtures, the governing equations become rather formidable and a complete listing of the equations in their various forms and methods to evaluate the transport coefficients is difficult to find. This paper seeks to compile common, as well as less well known, results in a single document. Various relationships between equations describing conservation of energy for a dilute, monatomic, nonreacting gas in local equilibrium are provided. The gas is treated as nonrelativistic, not subject to magnetic or electric fields, or radiative effects. Author

N94-35950 Ohio State Univ., Columbus. Dept. of Mechanical Engineering.
EXPANSION EFFECTS ON SUPERSONIC TURBULENT BOUNDARY LAYERS Final Report, 1 Sep. 1991 - 31 Dec. 1993
STEPHEN A. ARNETTE, MO SAMIMY, and GREGORY S. ELLIOTT Feb. 1994 190 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract AF-AFOSR-0412-91)
(AD-A278989; MEMS-94-101; AFOSR-94-0268TR) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The effects of various expansion regions on the large scale structure of a Mach 3 fully-developed-turbulent boundary layer are investigated. Five cases are studied: 7 deg and 14 deg centered expansions, 7 deg and 14 deg gradual expansions, and the flat plate. Multi-point surface pressure measurements, filtered Rayleigh scattering visualizations, and double-pulse visualizations were employed. Plan view images of the flat plate boundary layer reveal the presence of structures of a very large streamwise, and limited spanwise, extent. These structures were found well above the inner layer, nominally at n/delta = 0.5-1.0. The structures were also found in the expanded boundary layers. Across the expansion, the large scale structures of the outer layer undergo an increase in scale and structure angle. The small scale turbulent motions of the incoming boundary layer are quenched by the expansion, while the large scale structures respond more gradually. Convection velocities from the pressure correlations are reasonable in the incoming boundary layer, but unreasonably high in the expanded boundary layers. Convection velocities from correlations of double-pulse images appear reasonable. The discrepancy between the two results suggests the relationship between the large scale structures and the convecting pressure field is severely altered by the expansions. DTIC

N94-35965*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
WIND TUNNEL MEASUREMENTS ON A FULL-SCALE F/A-18 WITH A TANGENTIALLY BLOWING SLOT
WENDY R. LANSER *In its* 1993 Technical Paper Contest for Women. Gear Up 2000: Women in Motion p 27-36 Feb. 1994

Avail: CASI HC A02/MF A02

A full-scale F/A-18 was tested in the 80 by 120-Foot Wind Tunnel at NASA Ames Research Center to measure the effectiveness of a tangentially blowing slot in generating significant yawing moments while minimizing coupling in the pitch and roll axes. Various slot configurations were tested to determine the optimum configuration. The test was conducted for angles of attack from 25 to 50 deg, angles of sideslip from -15 to +15 deg, and freestream velocities from 67 ft/sec to 168 ft/sec. By altering the forebody vortex flow, yaw control was maintained for angles of attack up to 50 deg. Of particular interest was the result that blowing very close to the radome apex was not as effective as blowing slightly farther aft on the radome, that a 16-inch slot was more efficient, and that yawing moments were generated without inducing significant rolling or pitching moments. Author

N94-35991*# Eidetics International, Inc., Torrance, CA.
F/A-18 FOREBODY VORTEX CONTROL. VOLUME 1: STATIC TESTS
BRIAN R. KRAMER, CARLOS J. SUAREZ, GERALD N. MALCOLM, and BERT F. AYERS Mar. 1994 183 p
(Contract NAS2-13383)
(NASA-CR-4582; A-94056; NAS 1.26:4582) Avail: CASI HC A09/MF A02

A wind tunnel test was conducted on a six percent model of the F/A-18 at the NASA Ames 7 X 10-Foot Low Speed Wind Tunnel. The primary objective of the test was to evaluate several forebody vortex control configurations at high angles of attack in order to determine the most effective method of obtaining well behaved yawing moments, in preparation for the rotary balance test. Both mechanical and pneumatic systems were tested. Single and dual rotating nose tip strakes and a vertical nose strake were tested at different sizes and deflections. A series of jet blowing configurations were located at various fuselage stations, azimuth angles, and pointing angles ranging from straight aft to 60 deg canted inboard. Slot blowing was investigated for several slot lengths and fuselage stations. The effect of blowing rate was tested for both of these pneumatic systems. The most effective configurations were then further tested with a variation of both sideslip angle and Reynolds number over a range of angles of attack from 0 to 60 deg. It was found that a very robust system can be developed that provides yawing moments at angles of attack up to 60 deg that significantly exceeds that available from 30 deg of rudder deflection (F/A-18 maximum) at 0 deg angle of attack. Author

N94-35994*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
A THREE DIMENSIONAL MULTIGRID REYNOLDS-AVERAGED NAVIER-STOKES SOLVER FOR UNSTRUCTURED MESHES Final Report
D. J. MAVRIPLIS May 1994 28 p Submitted for publication
(Contract NAS1-19480; RTOP 505-90-52-01)
(NASA-CR-194908; NAS 1.26:194908; ICASE-94-29) Avail: CASI HC A03/MF A01

A three-dimensional unstructured mesh Reynolds averaged Navier-Stokes solver is described. Turbulence is simulated using a single field-equation model. Computational overheads are minimized through the use of a single edge-based data-structure, and efficient multigrid solution technique, and the use of multi-tasking on shared memory multi-processors. The accuracy and efficiency of the code are evaluated by computing two-dimensional flows in three dimensions and comparing with results from a previously validated two-dimensional code which employs the same solution algorithm. The feasibility of computing three-dimensional flows on grids of several million points in less than two hours of wall clock time is demonstrated. Author

03
AIR TRANSPORTATION AND SAFETY

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

N94-34915*# Western Aerospace Labs., Inc., Monte Sereno, CA.
EFFECTS OF CHECKLIST INTERFACE ON NON-VERBAL CREW COMMUNICATIONS
LEON D. SEGAL May 1994 95 p
(Contract NCC2-486)
(NASA-CR-177639; A-94079; NAS 1.26:177639) Avail: CASI HC A05/MF A01

The investigation looked at the effects of the spatial layout and functionality of cockpit displays and controls on crew communication. Specifically, the study focused on the intra-cockpit crew interaction, and subsequent task performance, of airline pilots flying different configurations of a new electronic checklist, designed and tested in a high-fidelity simulator at NASA Ames Research Center. The first part of this proposal establishes the theoretical background for the assumptions underlying the research, suggesting that in the context of the interaction between a multi-operator crew and a machine, the design and configuration of the interface will affect interactions between individual operators and the machine, and subsequently, the interaction between operators. In view of the latest trends in cockpit interface design and flight-deck technology, in particular, the centralization of displays and controls, the introduction identifies certain problems associated with these modern designs and suggests specific design issues to which the expected results could be applied. A detailed research program and methodology is outlined and the results are described and discussed. Overall, differences in cockpit design were shown to impact the activity within the cockpit, including interactions between pilots and aircraft and the cooperative interactions between pilots. Author

N94-34991# National Transportation Safety Board, Washington, DC. Office of Research and Engineering.
ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA: US GENERAL AVIATION CALENDAR YEAR 1991
4 Apr. 1994 84 p
(PB94-127982; NTSB/ARG-94/01) Avail: CASI HC A05/MF A01

This report presents a statistical compilation and review of general aviation accidents which occurred in 1991 in the United States, its territories and possessions, and in international waters. The accidents reported are all those involving U.S. registered aircraft not conducting operations under 14 CFR 121, 14 CFR 125, 14 CFR 127, or 14 CFR 135. This report is divided into five sections: all accidents, fatal accidents, serious injury accidents, property damage accidents, and midair collision accidents. Several tables present accident parameters for 1991 accidents only, and each section includes tabulations which present comparative statistics for 1991 and for the five-year period 1986-1990. Author (revised)

N94-35236# Federal Aviation Administration, Oklahoma City, OK. Civil Aeromedical Inst.
A REVIEW OF COMPUTER EVACUATION MODELS AND THEIR DATA NEEDS Final Report
JEFFREY H. MARCUS May 1994 14 p
(DOT/FAA/AM-94/11) Avail: CASI HC A03/MF A01

This document reviews the history and current status of computer models of the evacuation of an airliner cabin. Basic concepts upon which evacuation models are based are discussed, followed by a review of the Civil Aeromedical Institute's efforts during the 1970's. A comparison is made of the three models available today (GA Model, AIREVAC, and EXODUS). The report then reviews parameters common to all models, and discusses literature available as a basis for these parameters. Finally, the report briefly discusses validation exercises for evacuation models. Author

N94-35482# National Transportation Safety Board, Washington, DC.
SAFETY STUDY: A REVIEW OF FLIGHTCREW-INVOLVED, MAJOR ACCIDENTS OF US AIR CARRIERS, 1978 THROUGH 1990
Jan. 1994 105 p
(PB94-917001; NTSB/SS-94/01) Avail: CASI HC A06/MF A02

U.S. air carrier operations are extremely safe, and the accident rate has declined in recent years. However, among the wide array of factors cited by the National Transportation Safety Board as causal or contributing to airplane accidents, actions or inactions by the flight crew have been cited in the majority of fatal air carrier accidents. Recognizing that deficiencies in various aspects of the aviation system may adversely influence flight crew performance, the safety board conducted this study to learn more about flight crew performance by evaluating characteristics of the operating environments, crew members, and errors made in major accidents of U.S. air carriers between 1978 and 1990 in which the flight crew was cited by the board. Characteristics of the operating environments and flight crews were identified from information derived from major investigations of 36 accidents and 1 incident (for convenience, referred to as an accident). The errors identified in the accidents were evaluated in light of the contexts in which they occurred. The safety board aggregated the information examined in this study from its records of individual accident investigations. Although the data were not analyzed for the purpose of determining trends over time, the board did identify patterns in the data. In evaluating the results of the study, the board recognized that major accidents are rare events and that flight crew performance during accidents is subject to the simultaneous influences of many operational context variables. Results of this study need to be viewed from this perspective. Author (revised)

N94-35496# National Transportation Safety Board, Washington, DC. Office of Research and Engineering.
ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA. US GENERAL AVIATION, CALENDAR YEAR 1992
15 Jun. 1994 85 p
(PB94-181054; NTSB/ARG-94/02) Avail: CASI HC A05/MF A01

This report presents a statistical compilation and review of general aviation accidents which occurred in 1992 in the United States, its territories and possessions, and in international waters. The accidents reported are all those involving U.S. registered aircraft not conducting operations under 14 CFR 121, 14 CFR 127, or 14 CFR 135. This report is divided into five sections: All Accidents; Fatal Accidents: Serious Injury Accidents; Property Damage Accidents; and Midair Collision Accidents. Several tables present accident parameters for 1992 accidents only, and each section includes tabulations which present comparative statistics for 1992 and for the five-year period 1987-1991. Author

N94-35521# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORT: UNCONTROLLED COLLISION WITH TERRAIN, AMERICAN INTERNATIONAL AIRWAYS FLIGHT 808, DOUGLAS DC-8-61, N814CK, US NAVAL AIR STATION, GUANTANAMO BAY, CUBA, 18 AUGUST 1993
1994 148 p
(PB94-910406; NTSB/AAR-94/04) Avail: CASI HC A07/MF A02

This report explains the crash of American International Airways Flight 808, a DC-8-61, about 1/4 mile from the approach end of runway 10 at Leeward Point Airfield, U.S. Naval Air Station, Guantanamo Bay, Cuba, on August 18, 1993. The safety issues discussed in the report include flightcrew scheduling, the effects of fatigue on flightcrew performance, training on special airports, and the dissemination of information about special airports. Safety recommendations concerning these issues were made to the Federal Aviation Administration, American International Airways, Inc., and the Department of Defense. Author

N94-35522*# North Carolina State Univ., Raleigh, NC. Dept. of Marine, Earth and Atmospheric Sciences.
NUMERICAL MODELING STUDIES OF WAKE VORTEX TRANSPORT AND EVOLUTION WITHIN THE PLANETARY BOUNDARY LAYER Semiannual Report, FY 1994
YUH-LANG LIN, S. PAL ARYA, and MICHAEL L. KAPLAN 1994 17 p
(Contract NCC1-188)
(NASA-CR-196078; NAS 1.26:196078) Avail: CASI HC A03/MF A01

The proposed research involves four tasks. The first of these is to simulate accurately the turbulent processes in the atmospheric boundary layer. TASS was originally developed to study meso-gamma scale phenomena, such as tornadic storms, microbursts and windshear effects in terminal areas. Simulation of wake vortex evolution, however, will rely on appropriate representation of the physical processes in the surface layer and mixed layer. This involves two parts. First, a specified heat flux boundary condition must be implemented at the surface. Using this boundary condition, simulation results will be compared to experimental data and to other model results for validation. At this point, any necessary changes to the model will be implemented. Next, a surface energy budget parameterization will be added to the model. This will enable calculation of the surface fluxes by accounting for the radiative heat transfer to and from the ground and heat loss to the soil rather than simple specification of the fluxes. The second task involves running TASS with prescribed wake vortices in the initial condition. The vortex models will be supplied by NASA Langley Research Center. Sensitivity tests will be performed on different meteorological environments in the atmospheric boundary layer, which include stable, neutral, and unstable stratifications, calm and severe wind conditions, and dry and wet conditions. Vortex strength may be varied as well. Relevant nondimensional parameters will include the following: Richardson number or Froude number, Bowen ratio, and height to length scale ratios. The model output will be analyzed and visualized to better understand the transport, decay, and growth rates of the wake vortices. The third task involves running simulations using observed data. MIT Lincoln Labs is currently planning field experiments at the Memphis airport to measure both meteorological conditions and wake vortex characteristics. Once this data becomes available, it can be used to validate the model for vortex behavior under different atmospheric conditions. The fourth task will be to simulate the wake in a more realistic environment covering a wider area. This will involve grid nesting, since high resolution will be required in the wake region but a larger total domain will be used. During the first allocation year, most of the first task will be accomplished. Derived from text

N94-36048*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FINAL-APPROACH SPACING AIDS (FASA) EVALUATION FOR TERMINAL-AREA, TIME-BASED AIR TRAFFIC CONTROL
LEONARD CREDEUR, WILLIAM R. CAPRON, GARY W. LOHR, DANIEL J. CRAWFORD, DERSHUEN A. TANG, and WILLIAM G. RODGERS, JR. Dec. 1993 193 p
(Contract RTOP 505-64-13-01)
(NASA-TP-3399; L-17260; NAS 1.60:3399) Avail: CASI HC A09/MF A03

A jointly funded (NASA/FAA) real-time simulation study was conducted at NASA Langley Research Center to gather comparative performance data among three candidate final-approach spacing aid (FASA) display formats. Several objective measures of controller performance and their display eye-scan behavior as well as subjective workload and rating questionnaires were used. For each of two representative pattern-speed procedures (a 170-knot procedure and a 210-knot procedure with speed control aiding), data were gathered, via twelve FAA controllers, using four final-controller display format conditions (manual/ARTS 3, graphic marker, DICE countdown, and centerline slot marker). Measured runway separations were more precise with both the graphic marker and DICE countdown formats than with the centerline slot marker and both (graphic and DICE) improved precision relative to the manual/ARTS 3 format. For three separate rating criteria, the subject controllers ranked the FASA formats in the same order: graphic marker, DICE countdown, and centerline slot marker. The increased precision measured with the 210-knot pattern-speed procedure may indicate the potential for the application of speed-control aiding where higher pattern speeds are practical after the base-to-final turn. Also presented are key FASA issues, a rationale for the formats selected for testing, and their description. Author

N94-36184 Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

AN ANALYSIS OF OPERATIONAL SUITABILITY FOR TEST AND EVALUATION OF HIGHLY RELIABLE SYSTEMS M.S. Thesis

JAMES N. SERPA Mar. 1994 52 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A278573; AFIT/GOR/ENS/94M-13) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The purpose of this research was to develop a quantitative measure of operational suitability (OS) and determine its applicability in making the test length decision prior to Initial Operational Test and Evaluation (IOT&E). The current approach used by the Air Force Operational Test and Evaluation Center (AFOTEC) was presented and used to establish the relationships of the test measures. It was established that OS could be represented by a function of operational availability (A(sub O)) and built-in test effectiveness (BE). BE was defined and measures proposed based on the method of data collection. A proposal for predicting A(sub O), BE, and OS to determine the proper test length and sample size was analyzed for several examples of prior information. Multiplicative and additive utility functions were proposed as possible ways to calculate OS. It was shown that probability statements could be made about BE, A(sub O), and OS from the prior information; this analysis revealed the reliance of the results on the prior information. DTIC

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A94-60181

FOREBODY VORTEX CONTROL FOR WING ROCK SUPPRESSION

T. T. NG Toledo Univ., OH, C. J. SUAREZ, B. R. KRAMER, L. Y. ONG, B. AYERS, and G. N. MALCOLM *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 298-305 refs
(BTN-94-EIX94311329119) Copyright

Static and free-to-roll tests were conducted in a water tunnel and a wind tunnel with a configuration that consisted of a highly slender forebody and 78 deg-swept delta wings. The mechanisms governing the wing rock of this configuration are the interactions between the forebody and the wing vortices. Means of suppressing wing rock by controlling the forebody vortices using small blowing jets were explored. Steady blowing, tangentially aft from leeward nozzles near the forebody tips was found to be capable of suppressing wing rock. The wing rock motion was attenuated at low blowing rates and eliminated at high blowing rates. At high blowing rates, however, significant vortex asymmetries were also induced. On the other hand, alternating pulsed blowing on the left and right sides of the forebody was demonstrated to potentially be an effective means of suppressing wing rock without creating, on a time-average basis, large flow asymmetries. Author (EI)

A94-60211

TACTICAL COCKPITS: THE COMING REVOLUTION

EUGENE C. ADAM McDonnell Aircraft, St. Louis, MO *IEEE Aerospace and Electronic Systems Magazine* (ISSN 0885-8985) vol. 9, no. 3 March 1994 p. 20-26
(BTN-94-EIX94331335530) Copyright

A cockpit revolution is in the making. Many of the much ballyhooed, much promised, but little delivered technologies of the 70's and 80's will finally come of age in the 90's just in time to complement the data explosion coming from sensor and processing advances. Technologies such as helmet systems, large flat panel displays, speech recognition, color graphics, decision aiding, and stereopsis are simultaneously reaching technology maturities that promise big payoffs for the third generation cockpit and beyond. The first generation cockpit used round dials to help the pilot keep the airplane flying right side up. The second generation cockpit used multifunction displays and the HUD to interface the pilot with sensors and weapons. What might the third generation cockpit look like? How might it integrate many of these technologies to simplify the pilot's life? Most of all, what is the payoff? This paper will examine tactical cockpit problems and the technology needed to solve them and recommend three generations of solutions. Author (EI)

A94-60214

ATM AND FIS DATA LINK SERVICES

CHRISTINA R. BAUHOF Mitre Corp., McLean, VA *IEEE Aerospace and Electronic Systems Magazine* (ISSN 0885-8985) vol. 9, no. 3 March 1994 p. 38-42 refs
(BTN-94-EIX94331335533) Copyright

The Federal Aviation Administration (FAA) currently has under development data link services for air traffic management (ATM), flight information service (FIS), and communication, navigation, and surveillance (CNS). These services will be provided over the aeronautical telecommunications network (ATN), a worldwide data network intended to provide data communications connectivity among mobile aircraft, airlines, and civil aviation authorities. The ATM and FIS services currently under development are part of an evolutionary process that will begin, for the most part, with duplication of voice services. In the future, services will facilitate a common source of data for pilots, controllers, and flight planners, as well as computer-to-computer communication systems between ground based and airborne automation systems. These future services will provide benefits such as the use of optimum aircraft and flight profiles. Author (EI)

A94-60336

F-16 UNCOMMANDED PITCH OSCILLATION

W. A. FLYNN Air Force Flight Test Center, Edwards AFB, CA and K. L. KELLER *Canadian Aeronautics and Space Journal* (ISSN 0008-2821) vol. 40, no. 1 March 1994 p. 27-31
(BTN-94-EIX94331337501) Copyright

The Air Force Flight Test Center (AFFTC) consistently uses simulation prior to and in conjunction with flight test to identify aircraft flight control problems and also to develop, test, and validate solutions to these problems. This paper discusses how ground simulation was vital in developing an effective software modification to eliminate a potentially dangerous aircraft flight control anomaly. Through simulation, an in-flight uncommanded pitch oscillation incident was investigated and the source of the problem was identified. A potential solution was tested and validated by using the simulator prior to flight test. Additional benefits were gained due to simulation studies. The project pilots were able to practice test maneuvers and emergency procedures essential to the flight test program. The preliminary work, accomplished with ground simulation, correctly predicted the effectiveness of the software modification and ensured the success of an efficient and valid flight test program. Author (EI)

A94-60337

EVALUATION OF THE DYNAMICS AND HANDLING QUALITY CHARACTERISTICS OF THE BELL 412 HP HELICOPTER

STEWART W. BAILLIE Inst. for Aerospace Research,

STANKERELIUK, J. MURRAY-MORGAN, and KEN HUI *Canadian Aeronautics and Space Journal* (ISSN 0008-2821) vol. 40, no. 1 March 1994 p. 32-46 refs
(BTN-94-EIX94331337502) Copyright

A flight test program to determine if the Bell 412 HP would be suitable for use as NRC's Advanced Systems Research Aircraft (ASRA) is described. As a replacement to the NRC Bell 205 Airborne Simulator, the ASRA characteristics should include high control power and a minimum of control cross-coupling. Using both frequency and time domain parameter identification techniques, the Bell 412 HP control response was assessed. Other characteristics, such as vehicle vibration and handling qualities, both with the stability augmentation system (SAS) on and off, were also evaluated. From considerations of handling quality and the measured values of control response to both step and frequency sweep inputs, the Bell 412 HP is shown clearly to have airborne simulation potential far in excess of the current NRC Bell 205 Airborne Simulator. Author (EI)

N94-34591# Aeronautical Research Inst. of Sweden, Bromma.
FATIGUE MANAGEMENT AND VERIFICATION OF AIRFRAMES
A. F. BLOM and HANS ANSELL *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 25 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

The methodology currently used in Sweden for fatigue management and verification of airframes is described. Applications from the new fighter aircraft JAS39 Gripen are included in order to illustrate the various concepts being considered. Additional experience from recent work on the older fighter 37Viggen is also included to highlight certain differences in the detail analyses, stemming from rather different nominal stress levels in the two aircraft. The present paper discusses the handling of load sequences and load spectra development, stress analyses and fracture mechanics analyses, fatigue crack growth modelling, component and full scale testing, service load monitoring regarding both the dedicated test aircraft, which is used to verify basic load assumptions, and also the individual load tracking program developed for the new fighter. Author

N94-34592# Lockheed Aeronautical Systems Co., Marietta, GA.
RISK ANALYSIS OF THE C-141 WS405 INNER-TO-OUTER WING JOINT
R. E. ALFORD, R. P. BELL, J. B. COCHRAN, and D. O. HAMMOND *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 10 p Mar. 1994 Presented at the Structural Integrity Program Conference, San Antonio, TX, 2-5 Dec. 1991; sponsored by USAF
Copyright Avail: CASI HC A02/MF A03

It is evident that weapon system management benefits greatly from the use of probabilistic risk assessment methods. The C-141 WS 405 inner-to-outer wing joint provides an actual case of how this technology was implemented by Lockheed and USAF engineers to determine conditions of inspection and repair for the C-141 fleet. Author

N94-34593# Dassault-Breguet Aviation, Saint Cloud (France).
ASSESSMENT OF IN-SERVICE AIRCRAFT FATIGUE MONITORING PROCESS
R. J. CAZES *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 8 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

Maintaining the structural integrity of aircraft depends on the initial definition of an inspection program to detect structural damage that may occur in service. Prediction of possible fatigue damage due to the applied loads and conditions of use encountered in service is based on an analysis of the probability of incipient cracks and on an evaluation of the development of undetectable faults assumed to exist between two inspections. The validity of evaluation models is generally demonstrated based on comparisons with results obtained on elementary test pieces subjected to predicted local load conditions in service and used to identify the influence of events such as rare overloads or frequent repetitive small loads. This paper presents the principles for processing in flight signals collected in order to predict structural damage by making in flight integrated calculations, considering influences such as: load signals precision (frequency of points taken); elimination of low amplitude variations; and cycle counting methods for the damage calculation. Author (revised)

N94-34594# Deutsche Aerospace A.G., Munich (Germany). Military Aircraft Div.
THE ROLE OF FATIGUE ANALYSIS FOR DESIGN OF MILITARY AIRCRAFT
R. BOCHMANN and D. WEISGERBER *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 7 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

A brief overview of the fatigue design method employed at DASA (Deutsche Aerospace AG) for combat aircraft is presented. The efficiency of the fatigue analysis—as embedded in the overall design process—is discussed and compared with full scale testing. Furthermore, possible improvements in the method are suggested. Author (revised)

N94-34595# Wright Lab., Wright-Patterson AFB, OH.
DAMAGE TOLERANCE MANAGEMENT OF THE X-29 VERTICAL TAIL
J. HARTER *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 8 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

During high angle-of-attack (aoa), less than 25 deg, the X-29 experienced severe vertical tail buffet. Fin tip accelerometer data exceeded 110 g's at approximately 16 Hz. The U.S. Air Force Flight Dynamics Directorate was asked to provide technical support to ensure that the entire X-29 flight test program could be safely conducted. The Flight Dynamics Directorate transitioned an in-house developed crack growth life prediction program to the X-29 program office and NASA/Dryden as well as extensive technical support. Three dimensional crack growth analyses were conducted between flight days to track possible damage growth based on actual strain data collected at critical areas of the vertical tail. The entire high aoa flight test program was completed as planned using MODGRO to predict damage accumulation. The data was used to manage flight maneuvers to maximize useful flight data and minimize structural risk. A follow-on flight test program was conducted with the X-29 to assess Vortex Flow Control. Repair to the tail was required to complete this mission. Analysis and verification testing of the repair was performed by the Flight Dynamics Directorate. At the end of that flight test program, less than 10 percent of the repair life was used. Author (revised)

N94-34596# British Aerospace Defence Ltd., Farnborough (England). Military Aircraft Div.
HARRIER 2: A COMPARISON OF US AND UK APPROACHES TO FATIGUE CLEARANCE
F. S. PERRY *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 27 p Mar. 1994
Copyright Avail: CASI HC A03/MF A01

The different approaches adopted for the fatigue clearance of the Harrier 2 in United States Marine Corps and Royal Air Force usage are discussed. Brief accounts are given of the impact differing analysis methodologies and national airworthiness requirements have had on fatigue design, test, and monitoring of the airframe. Author (revised)

N94-34597# British Aerospace Defence Ltd., Brough (England). Structures Unit.
FATIGUE DESIGN, TEST AND IN-SERVICE EXPERIENCE OF THE BAE HAWK
JOHN OHARA *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 10 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

The BAe Hawk family is designed primarily to UK regulations, including the safe life S-N fatigue philosophy. S-N data pertinent to key structural features was assembled at the design stage, and fatigue coupon/element tests were conducted in confirmation. The Hawk TMk.1 full scale fatigue test (FSFT) has continued to lead the RAF fleet, and the test loading has been validated by a major operational loads measurement (OLM) exercise. Incidents arising on the FSFT or in-service are handled by several approaches including S-N and fracture mechanics calculations, testing, statistical analysis, and modifications and/or routine inspections are introduced when necessary. The development of the fatigue life clearances of the BAe Hawk family is discussed with particular emphasis on the confirmatory testing and in-service loads measurement necessary to ensure and maintain fleet aircraft fatigue life clearance. Author

N94-34598# National Aerospace Lab., Amsterdam (Netherlands).
REDUCTION OF FATIGUE LOAD EXPERIENCE AS PART OF THE FATIGUE MANAGEMENT PROGRAM FOR F-16 AIRCRAFT OF THE RNLAF
D. J. SPIEKHOUT *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 11 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

Load monitoring of the F-16 fleet of the RNLAF is carried out by NLR using an electronic device capable of analyzing the signal of a strain gage bridge on one of the main carry through bulkheads. This is done on a sample of the fleet. By making use of the information stored in a large centralized data base system, 'individual airplane tracking' is done. Six times per year, the fatigue damage experience of the fleet is reported to the air staff, expressed in the so called 'crack severity index.' From the measurements it is known that the RNLAF is operating its F-16 fleet in a very damaging way. For this reason, it was decided to investigate the possibilities of how to decrease the severity of flying. In this program much attention has been given to the 'stress per G' relation during a flight. In particular the influence of flying with favorite take off store configurations has been studied. Author (revised)

N94-34599# Lockheed Corp., Fort Worth, TX.
AN OVERVIEW OF THE F-16 SERVICE LIFE APPROACH
J. W. MORROW and G. T. HERRICK *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 9 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

The F-16 airframe was designed according to the latest USAF philosophy adopted in the 1970s. It has a modular structural arrangement and maximum use has been made of aluminum. It was designed with fracture requirements in mind from its inception. Presented in viewgraph format are F-16 requirements for airframe structural durability and safety, F-16 design approach, metals crack growth analysis methodology, fatigue/fracture bulkhead web analysis, test policy comparisons, fatigue and fracture control plan, F-16 force management approach, F-16 fleet management recording systems, and lessons learned. CASI

N94-34605# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
TECHNOLOGIES FOR HIGHLY MANOEUVRABLE AIRCRAFT [LES TECHNOLOGIES POUR LES AERONEFS A HAUTE MANOEUVRABILITE]
Mar. 1994 339 p In ENGLISH and FRENCH Symposium held in Annapolis, MD, 18-21 Oct. 1993
(AGARD-CP-548; ISBN-92-835-0740-1) Copyright Avail: CASI HC A15/MF A03

The new generation of combat aircraft incorporate significant advances in maneuver capability, especially in such areas as post-stall control and sustained supersonic maneuver. These technologies expand the operational capabilities, and are essential for survival in a sophisticated threat scenario, and also to obtain favorable exchange ratios against an opponent using the current generation of fighters. The aim of this symposium was to review the various technologies, which combine to give this increased operational capability, and the techniques which are available or being developed, to overcome the design problems associated with the attainment of these goals. The symposium was divided into six sessions covering propulsion and integrated flight control, aerodynamics and control at high angles of attack, post-stall flight and control, flying qualities applied criteria, agility and simulation.

N94-34606# Calspan Corp., Arnold AFS, TN.
USAF/AEDC AERODYNAMIC AND PROPULSION GROUND TEST AND EVALUATION TECHNIQUES FOR HIGHLY MANEUVERABLE AIRCRAFT: CAPABILITIES AND CHALLENGES
EDWARD M. KRAFT, GLEN R. LAZALIER, and M. L. LASTER *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 15 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

The simulation of highly agile aircraft during the development phase presents a significant challenge to aerodynamic and propulsion ground test and evaluation methodologies. The primary simulation challenges are caused by the inherent unsteady, separated nature of the flow phenomena associated with maneuvering aircraft that cause dynamic effects on the airframe and engine. In general, ground test techniques are quasi-steady and transient effects are represented by linearized superposition of steady-state data and unsteady small disturbances. Current trends in the design of tactical fighter aircraft require close coupling between the airframe, avionics, and propulsion systems. In addition, the extreme attitudes and high angular rate motions of this new breed of vehicle causes a strong nonlinear coupling between components. In the current paper, several aerodynamic and propulsion ground test and evaluation methodologies applicable to maneuvering aircraft are summarized, challenges associated with current techniques are identified, and an emerging integrated test and evaluation concept that can significantly impact the quality, time, and cost of developing a new flight vehicle is introduced. Author

N94-34609# British Aerospace Defence Ltd., Warton (England). Aerodynamics Dept.
DESIGN OF INTEGRATED FLIGHT AND POWERPLANT CONTROL SYSTEMS
C. FIELDING *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 12 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

This paper describes the work being undertaken by British Aerospace on both of these projects, as a continuation of the flight control and technology demonstration research successfully completed on earlier projects such as the Jaguar Fly-By-Wire and the Experimental Aircraft Programme (EAP). Derived from text

N94-34611# Wright Lab., Wright-Patterson AFB, OH.
RESULTS FROM THE STOL AND MANEUVER TECHNOLOGY DEMONSTRATION PROGRAM
DAVID J. MOORHOUSE *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 8 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

The S/MTD program has generated flight test data to validate four specific technologies: 2-D thrust vectoring & reversing nozzle; integrated flight/propulsion control; advanced pilot/vehicle interface including autonomous landing guidance; and rough field/high sink rate landing gear. These technologies have been integrated into an F-15B to provide mission benefits across the complete flight envelope from on-board guidance to a bad weather short landing, through significantly enhanced maneuvering benefits to supersonic performance. These technologies are either transitioning on to other aircraft, or can be considered viable design options for future aircraft. Derived from text

N94-34614# Institut de Mecanique des Fluides de Marseille (France).
TECHNIQUES FOR AERODYNAMIC CHARACTERIZATION AND PERFORMANCE EVALUATION AT HIGH ANGLE OF ATTACK [OUTILS POUR LA CARACTERISATION AERODYNAMIQUE ET L'EVALUATION DES PERFORMANCES A HAUTE INCIDENCE]
O. RENIER *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 13 p Mar. 1994 In FRENCH
Copyright Avail: CASI HC A03/MF A03

ONERA-IMFL develops techniques for high AOA maneuvering aircraft behavior studies. Specific wind-tunnels test coning and oscillatory coning motions, and constant pitch rate tests provide information about steady and unsteady, low speed aerodynamics. Specific software facilitates data analysis and aerodynamic modelling. Application of nonlinear dynamic systems analysis techniques allows stabilities calculations and performance evaluation. For some maneuvers, behavior predictions can be validated with model flight tests in vertical wind-tunnel or in laboratory. These techniques have been used for forebody yaw control studies. Sensitivity of strakes efficiency to aircraft dynamic motions was measured in wind-tunnel facilities. Model flight tests confirm expected behaviors. Author (revised)

N94-34617# Tsentralni Aerogidrodinamicheskii Inst., Moscow (USSR).
AERODYNAMIC DESIGN OF SUPER MANEUVERABLE AIRCRAFT
R. D. IRODOV and A. V. PETROV *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 6 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

The main peculiarities of aerodynamic design of highly maneuverable aircraft are examined. The possibilities of improving the aerodynamic characteristics of aircraft at high angles of attack by use of high-lift devices and powered-lift systems (boundary layer control, blowing over wing, engine thrust vectoring) are shown. The conditions of controllable maneuver at high post-stalled angles of attack (alpha is less than or equal to 90 degrees) are established. Results of experimental investigations on the influence of wing planform and locations of aircraft components (wing, empennage) on the longitudinal stability and controllability at high angles of attack are presented. A comparative analysis of aerodynamic and maneuver performance of aircraft of various configurations (conventional, three-surface, canard) is performed. Author (revised)

N94-34620# Naval Air Warfare Center, Patuxent River, MD. Strike Aircraft Test Directorate.
X-31 TACTICAL UTILITY: INITIAL RESULTS
DAVID E. CANTER and ALLEN W. GROVES *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 15 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

The X-31 is a research aircraft built to explore the tactical benefits of the enhanced fighter maneuverability that is possible through the use of thrust vectoring. This paper gives background information on the program and on the aircraft. The high angle of attack envelope expansion phase is covered. This section details aircraft modifications that were required. The tactical utility phase of testing, including simulation and flight testing, is discussed. Helmet mounted display and supersonic thrust vectoring tests planned for the near future are briefly discussed. Author (revised)

N94-34621# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. of Flight Mechanics.
EFA FLYING QUALITIES SPECIFICATION AND ITS UTILISATION
M. MARCHAND, R. KOEHLER, H. DUDA, E. BUCHACKER, and K. ELBEL *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 18 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

The European Fighter Aircraft (EFA) was designed as a highly augmented, basically unstable aircraft. Its Stability and Control System (FCS) is of a much higher complexity than that used in earlier aircraft, e.g., the Tornado. To ensure that safe operation and optimum performance are not degraded due to possible handling quality deficiencies, new methods had to be used for both the development and the assessment of the aircraft. This paper describes the specifications and the methods used in customer assessment prior to first flight. An overview of these methods is provided. Author (revised)

N94-34622# Naval Air Warfare Center, Warminster, PA. Air Vehicle and Crew Systems Technology Dept.
APPLICATION OF CURRENT DEPARTURE RESISTANCE CRITERIA TO THE POST-STALL MANOEUVERING ENVELOPE
ROBERT M. SELTZER and JEFFREY F. CALVERT *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 17 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

This paper presents an analysis of current departure resistance and high angle of attack (HAOA) flying quality parameters with respect to applicability and utility in the design and assessment of today's enhanced maneuverability aircraft. Modern fighter/attack aircraft possess extremely nonlinear aerodynamic databases and highly complex flight control systems. In addition, these aircraft require both departure resistance and mission effective HAOA maneuvering capability. The limitations of using traditional departure susceptibility parameters such as C(sub n(beta (sub DYN))) and LCDP to address departure resistance and agility design and analysis issues are analyzed and presented herein. Discussion includes the design philosophy and tradeoffs of improving static versus dynamic departure resistance. In addition, the utility of open or closed-loop departure parameters derived from linear and/or decoupled equations of motion representing highly nonlinear aircraft is addressed. Finally, a general methodology outlining the application and validity of current departure susceptibility parameters to the modern aircraft HAOA flight regime is provided with recommendations. Author (revised)

N94-34623# Wright Lab., Wright-Patterson AFB, OH. Flight Dynamics Directorate.
FLYING QUALITIES EVALUATION MANEUVERS
THOMAS J. CORD, DAVID B. LEGGETT, DAVID J. WILSON, DAVID R. RILEY, and KEVIN D. CITURS *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 8 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

An initial set of aircraft maneuvers has been defined to augment the evaluation methods currently used by the flying qualities and flight test communities. These maneuvers are meant to employ the full range of available aircraft dynamics and to be applied over the full aircraft flight envelope. They include several closed-loop tasks and are the start of a set of demonstration maneuvers (of the type now used in the rotorcraft flying quality specification) for aircraft requirements. A primary goal was to establish a tie between design parameters, aircraft attributes, and the operational usage environment while maintaining control of the evaluation process. The approach was to concentrate on aircraft dynamics which occur in daily operations and to create pilot tasks which use those conditions to relate to important aircraft characteristics. Existing evaluation methods concentrate on comparing quantitative data to charts in MIL-Standards which predict flying qualities. The maneuvers discussed here directly measure the ability of the pilot to perform the tasks of interest and at the same time maintain a tie to the design community. Author (revised)

N94-34624# Army Aviation Systems Command, Moffett Field, CA.
STUDY FINDINGS ON THE INFLUENCE OF MANEUVERABILITY AND AGILITY ON HELICOPTER HANDLING QUALITIES
MATTHEW S. WHALLEY *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 10 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

Three piloted simulation studies were performed by the U.S. Army Aeroflightdynamics Directorate to examine the influence of maneuver-

ability and agility on helicopter handling qualities and to provide an expanded basis for the dynamic response requirements in Aeronautical Design Standard 33C, Handling Qualities Requirements for Military Rotorcraft. The experiments focused on aggressive tasks such as air-to-air combat and target acquisition and tracking. The first experiment focused on yaw agility requirements in the form of attitude quickness and bandwidth. The second experiment focused on pitch and roll agility and maneuverability requirements in the form of bandwidth, angular rate, and attitude quickness. The third experiment focused on maneuverability requirements in the form of normal and longitudinal load factor envelope for both conventional and compound helicopters. Findings from the three studies are presented in the form of Cooper-Harper handling qualities ratings, pilot commentary, and task performance.
Author

N94-34625# British Aerospace Defence Ltd., Preston (England).
OPERATIONAL AGILITY: AN OVERVIEW OF AGARD WORKING GROUP 19
K. MCKAY *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 11 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

The environment in which a fighter pilot is required to operate is subject to continual change. This change arises from advances in technology and the altering world political situation. The only prediction that can be made with any confidence is that this change process is bound to continue with an unpredictable rate. In dealing with change, it is easy to prescribe a process but extremely difficult to implement the process with success. Success requires anticipation, reaction, reevaluation and modification of tactics and processes. The need for change must be recognized and accommodated. Such an approach, whether applied to fighter airplanes or any field of human endeavor, translates to agility. In undertaking this work, the group encountered many definitions of agility, some of which represented widely differing viewpoints. Often, in the past, protagonists of the varying ideas have fallen into heated arguments as to who is right. Fortunately, within the group, we have been able to stand back and examine the arguments with a dispassionate approach which has enabled us to understand the various arguments and see the common ground, rather than the differences. From our deliberations and discussions, the answer has emerged that no one was wrong, that all were right, at least in part. However, few had taken the time to stand back and take an all embracing view. Had they done so, then the message that all were trying to put forward might have had a wider and more sympathetic audience. All of the agility concepts that have been put forward have some merit. What was required was a way to relate the ideas and be able to apply them in a manner that is both reasonable and logical from both the viewpoints of the designer/supplier of aircraft and the customer/user of the vehicles that result. In defining a weapon system, it is essential to examine the component parts and their interaction, whether this be airframe, propulsion system, sensors, cockpit and avionics, or the weapons themselves and establish balance and synergistic integration between all of the components appropriate to the intended role and missions of the aircraft. It is the need to achieve balance and integration that is the prime driver for understanding operational agility as a set of concepts, supported by metrics which fit into a generalized framework, capable of evaluating a complex combat aircraft design with a view to maximizing the effectiveness of that design within affordable cost limits. The activities of the group have produced such a framework, derived from the various flight mechanics based concepts, but which would appear to be generalizable to cover the other systems, either as individual systems, or as a total weapon system. There is further work required to confirm that this framework will stand, but our initial investigations are very promising. This points the way forward for future aircraft. Achievement of this design balance requires all of the weapon system attributes to be studied, evaluated, and weighed against each other, together with the cost implications, to determine the optimum solutions. This may imply significant compromises if the roles and perceived threats are too diverse. A consequence is that future design specifications and requirements will need to be prepared in a different way from that traditionally used.
Author (revised)

N94-34626# Alenia, Turin (Italy).
OPERATIONAL AGILITY ASSESSMENT WITH THE AM-X AIRCRAFT
RENZO BAVA, UGO ROSSI, and SERGIO PALONI *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 19 p Mar. 1994
Copyright

Relating to the activities performed by WG 19 a common area of interest was individuated by Aermacchi, Alenia, and the Flight Test Center of the Italian Air Force to investigate the application of the agility concept to conventional aircraft. Agility metrics and maneuvers have been developed to evaluate the operational effectiveness of a modern fighter in the new combat scenarios that evolved following the introduction of advanced technologies. Agility metrics and maneuvers, however, may be effectively adopted to evaluate also operational effectiveness of a conventional aircraft since those metrics have been developed to reproduce synthetically the new operational scenarios. The AM-X ground attack aircraft was hence chosen as a testbed to verify the applicability of the agility concept to conventional aircraft and to assess the possible benefits for operational training. The research activity is being carried out by simulator and flight tests to compare simulator cueing effectiveness against the real A/C and to investigate simulator effectiveness for agility training. Single axis agility maneuvers performed by simulator will be validated through upcoming flight tests. Results from this activity will be used to plan and perform further simulation test with complex multiaxis closed loop agility tasks. This activity proved that agility metrics and maneuvers are applicable also to conventional A/C as well, and are effective in evaluating it within a highly dynamic combat environment. Operational agility may be improved with adequate pilot training and simulator may be used as an effective tool for it. Anyway, particular attention must be paid to the definition of the training program to overcome shortcomings of the simulator cueing system.
Author (revised)

N94-34628# Defence Research Agency, Bedford (England).
THE INFLUENCE OF FLYING QUALITIES ON OPERATIONAL AGILITY
GARETH D. PADFIELD and JOHN HODGKINSON *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 14 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

Flying qualities standards are formally set to ensure safe flight and therefore to reflect minimum, rather than optimum, requirements. Agility is a flying quality but relates to operations at high, if not maximum, performance. While the quality metrics and test procedures for flying, as covered for example in MIL-STD-1797 or ADS33, may provide an adequate structure to encompass agility, they do not currently address flight at high performance. A current concern in both the fixed and rotary wing communities is the absence of substantiated agility criteria and the possible conflicts between flying qualities and high performance, i.e., more may not always be better. This paper addresses these concerns and suggests an agility factor that quantifies performance margins in flying qualities terms. The attitude quickness, from the latest rotary-wing handling requirements, provides an ideal agility measure and links handling with agility. A new parameter, based on maneuver acceleration, is introduced as a potential candidate for defining upper limits to flying qualities. These concepts are introduced within a framework aimed at unifying flying qualities and performance requirements. Finally, a probabilistic analysis of pilot handling qualities ratings is presented that suggests a powerful relationship between inherent airframe flying qualities and operational agility.
Author (revised)

N94-34629# Aerospace Engineering Test Establishment, Cold Lake (Alberta).
AN AGILITY METRIC STRUCTURE FOR OPERATIONAL AGILITY

ANDREW REIF *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 15 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

This paper summarizes how an agility metric organizational structure was developed by the Flight Mechanics Panel Working Group 19. The structure was developed from existing concepts and was generalized for application to both fixed and rotary wing aircraft. The approach was based on time domain analysis concepts focusing on the 'time to complete' a specific operational task as the primary metric. From this metric a hierarchy of smaller time scale metrics were developed to emphasize the desired transient response dependent on the mission. The metric structure was developed for organizing the concepts of airframe agility as these were the most mature. The metric scheme is comprised of transient, experimental, and operational metrics. The transient metrics were defined as those time dependent parameters that characterize instantaneous airframe state changes. Experimental metrics were defined by discrete small task elements with compound properties that were optimized for evaluation purposes but were not necessarily recognizable as a mission related maneuver. Operational metrics were defined as complete mission task elements including the total vehicle response in multiple degrees of freedom. The structure was also found to be applicable to other aspects of agility through the evolving concept of operational agility. This entailed the limited study of possible systems, pilot/vehicle interface, and weapon system time based agility metrics. Finally, the working group identified areas which required further study. Author (revised)

N94-34703*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

DEVELOPING AND FLIGHT TESTING THE HL-10 LIFTING BODY: A PRECURSOR TO THE SPACE SHUTTLE

ROBERT W. KEMPEL (PRC Kentron, Inc., Edwards, CA.), WENETH D. PAINTER (National Test Pilot School, Mojave, CA.), and MILTON O. THOMPSON Apr. 1994 56 p
(Contract RTOP 505-68-50)
(NASA-RP-1332; H-1942; NAS 1.61:1332) Avail: CASI HC A04/MF A01

The origins of the lifting-body idea are traced back to the mid-1950's, when the concept of a manned satellite reentering the Earth's atmosphere in the form of a wingless lifting body was first proposed. The advantages of low reentry deceleration loads, range capability, and horizontal landing of a lifting reentry vehicle (as compared with the high deceleration loads and parachute landing of a capsule) are presented. The evolution of the hypersonic HL-10 lifting body is reviewed from the theoretical design and development process to its selection as one of two low-speed flight vehicles for fabrication and piloted flight testing. The design, development, and flight testing of the low-speed, air-launched, rocket-powered HL-10 was part of an unprecedented NASA and contractor effort. NASA Langley Research Center conceived and developed the vehicle shape and conducted numerous theoretical, experimental, and wind-tunnel studies. NASA Flight Research Center (now NASA Dryden Flight Research Center) was responsible for final low-speed (Mach numbers less than 2.0) aerodynamic analysis, piloted simulation, control law development, and flight tests. The prime contractor, Northrop Corp., was responsible for hardware design, fabrication, and integration. Interesting and unusual events in the flight testing are presented with a review of significant problems encountered in the first flight and how they were solved. Impressions by the pilots who flew the HL-10 are included. The HL-10 completed a successful 37-flight program, achieved the highest Mach number and altitude of this class vehicle, and contributed to the technology base used to develop the space shuttle and future generations of lifting bodies. Author

N94-34968*# Naval Postgraduate School, Monterey, CA. Dept. of Aeronautics and Astronautics.

COMPARISON OF PITCH RATE HISTORY EFFECTS ON DYNAMIC STALL

M. S. CHANDRASEKHARA, LAWRENCE W. CARR, and S. AHMED *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 23-34 Mar. 1992
Avail: CASI HC A03/MF A03

Dynamic stall of an airfoil is a classic case of forced unsteady separated flow. Flow separation is brought about by large incidences introduced by the large amplitude unsteady pitching motion of an airfoil. One of the parameters that affects the dynamic stall process is the history of the unsteady motion. In addition, the problem is complicated by the effects of compressibility that rapidly appear over the airfoil even at low Mach numbers at moderately high angles of attack. Consequently, it is of interest to know the effects of pitch rate history on the dynamic stall process. This abstract compares the results of a flow visualization study of the problem with two different pitch rate histories, namely, oscillating airfoil motion and a linear change in the angle of attack due to a transient pitching motion. Derived from text

N94-34988*# Colorado Univ., Boulder, CO.

CONCEPTS AND APPLICATION OF DYNAMIC SEPARATION FOR AGILITY AND SUPER-MANEUVERABILITY OF AIRCRAFT: AN ASSESSMENT

PETER FREYMUTH *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 309-316 Mar. 1992
Avail: CASI HC A02/MF A03

Aims for improvement of fighter aircraft pursued by the unsteady flow community are high agility (the ability of the aircraft to make close turns in a low-speed regime) and super maneuverability (the ability of the aircraft to operate at high angles of attack in a post stall regime during quick maneuvers in a more extended speed range). High agility requires high lift coefficients at low speeds in a dynamic situation and this requirement can be met by dynamically forced separation or by quasistatic stall control. The competing methods will be assessed based on the known physics. Maneuvering into the post stall regime also involves dynamic separation but because even fast maneuvers involving the entire aircraft are 'aerodynamically slow' the resulting dynamic vortex structures should be considered 'elicited' rather than 'forced.' More work seems to be needed in this area of elicited dynamic separation. Derived from text

N94-35241*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

EVALUATING THE DYNAMIC RESPONSE OF IN-FLIGHT THRUST CALCULATION TECHNIQUES DURING THROTTLE TRANSIENTS

RONALD J. RAY Jun. 1994 27 p Presented at the 7th Biennial Flight Test Conference, Colorado Springs, CO, 20-23 Jun. 1994
(Contract RTOP 505-68-00)
(NASA-TM-4591; H-1990; NAS 1.15:4591; AIAA PAPER 94-2115)
Copyright Avail: CASI HC A03/MF A01

New flight test maneuvers and analysis techniques for evaluating the dynamic response of in-flight thrust models during throttle transients have been developed and validated. The approach is based on the aircraft and engine performance relationship between thrust and drag. Two flight test maneuvers, a throttle step and a throttle frequency sweep, were developed and used in the study. Graphical analysis techniques, including a frequency domain analysis method, were also developed and evaluated. They provide quantitative and qualitative results. Four thrust calculation methods were used to demonstrate and validate the test technique. Flight test applications on two high-performance aircraft confirmed the test methods as valid and accurate. These maneuvers and analysis techniques were easy to implement and use. Flight test results indicate the analysis techniques can identify the combined effects of model error and instrumentation response limitations on the calculated thrust value. The methods developed in this report provide an accurate approach for evaluating, validating, or comparing thrust calculation methods for dynamic flight applications. Author

N94-35969*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
IN-FLIGHT SIMULATION STUDIES AT THE NASA DRYDEN FLIGHT RESEARCH FACILITY
MARY F. SHAFER *In* NASA. Ames Research Center, 1993 Technical Paper Contest for Women. Gear Up 2000: Women in Motion p 77-97 Feb. 1994
Avail: CASI HC A03/MF A02

Since the late 1950's the National Aeronautics and Space Administration's Dryden Flight Research Facility has found in-flight simulation to be an invaluable tool. In-flight simulation has been used to address a wide variety of flying qualities questions, including low lift-to-drag ratio approach characteristics for vehicles like the X-15, the lifting bodies, and the space shuttle; the effects of time delays on controllability of aircraft with digital flight control systems; the causes and cures of pilot-induced oscillation in a variety of aircraft; and flight control systems for such diverse aircraft as the X-15 and the X-29. In-flight simulation has also been used to anticipate problems, avoid them, and solve problems once they appear. This paper presents an account of the in-flight simulation at the Dryden Flight Research Facility and some discussion. An extensive bibliography is included. Author

06
AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A94-60160
AIRCRAFT LANDING GEAR POSITIONING CONCERNING ABNORMAL LANDING CASES
HSING-JUIN LEE National Chung Hsing Univ., Taichung, Taiwan and CHENG-YI CHIOU *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 446-449 refs
(BTN-94-EIX94311329140) Copyright

Addressed in this paper is the search for dynamically superior positioning of aircraft landing gears. For assessing the amount of sinking energy absorbed by nose landing gear for normal and abnormal landing cases, the percussion theory and lumping mass concept are merged. EI

A94-60170
ANALYSIS OF AERODYNAMICS OF AIRFOILS MOVING OVER A WAVY WALL
KYOKO NITTA Nagoya Univ, Aichi, Japan *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 387-395 refs
(BTN-94-EIX94311329130) Copyright

The aerodynamic characteristics and the motion of a two-dimensional flat plate airfoil flying over a wavy wall surface are calculated. The used computational scheme is a finite difference method (ADI scheme), which was developed to improve the Ames code LTRAN2 and to expand the computable reduced frequency region up to 0.8. Modifications of the grid generating system is the major point for applying the LTRAN2 version to the current problem. Weak compressibility (M(sub x) = 0.1-0.3) is considered, but nonlinearity is neglected in current calculations. Numerical computations include cases of a flat plate flying over a flat solid wall in addition to the cases of a moving wavy wall. The flat plate is fixed in the freestream at first, and after some research of its aerodynamic characteristics, aeroelastic analysis is added allowing 3 DOFs. The calculated results are compared with those obtained by the lifting surface theory. The agreement is satisfactory. Author (EI)

A94-60172
INVESTIGATION OF MONTE CARLO SIMULATION IN FAA PROGRAM KRASH
HOWARD J. FLEISHER Galaxy Scientific Corp., Pleasantville, NJ and HAYM BENAROYA *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 367-375 refs
(BTN-94-EIX94311329128) Copyright

In 1971, the U.S. Army first supported the development of computer code KRASH to model the impact dynamics and mechanics of airframes. The Federal Aviation Administration continued this support in 1975. Many enhancements have been added to the initial code, and the current official release version is KRASH 85. The next step in the ongoing advancement of KRASH includes uncertainties in modeling capabilities, which is the contribution of this work. In particular, a Monte Carlo simulation framework has been utilized here to permit the input of parameter uncertainties, and thus allow the output variables to be bound with a degree of statistical confidence. An airframe model was selected and preliminary sensitivity tests were performed on four parameters, specifically the impact surface coefficient of dynamic friction, the internal beam damping constant, the external crushing spring damping ratio, and the material properties, including yield stresses. Results from these preliminary tests showed the model was sensitive to variation in the first three parameters, while it was insensitive to changes in the material properties. Accelerations and impulses were plotted for two of the masses in the model. The means and standard deviations at each time step were calculated and incorporated into the plots. Finally, verification whether the simulation yielded statistically significant results, and confidence bounds for results with large uncertainty are presented. The techniques outlined here are completely extendable to as general a KRASH model as desired. Author (EI)

A94-60174* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ALLEVIATION OF SIDE FORCE ON TANGENT-OGIVE FOREBODIES USING PASSIVE POROSITY
STEVEN X. S. BAUER NASA. Langley Research Center, Hampton, VA and MICHAEL J. HEMSCH *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 354-361 refs
(BTN-94-EIX94311329126) Copyright

An experimental investigation to determine the effectiveness of passive porosity for alleviating side forces on forebodies was conducted in the NASA Langley Research Center 7-ft by 10-ft high-speed wind tunnel. Force, moment, and surface pressure data were obtained on solid and porous (22% porosity, 0.020-in. hole diam) tangent-ogive forebodies of fineness ratios 2.5 and 5.0. The solid forebodies were tested with transition grit to simulate fully turbulent conditions, and without transition grit to simulate free transition conditions. The extent of porosity on the forebodies was varied to determine the extent of porosity needed to alleviate side forces. Static longitudinal and lateral-directional stability and surface pressure data were obtained at Mach numbers of 0.2, 0.5, and 0.8, angles of attack from -5 to 45 deg, and roll angles from -90 to 180 deg. The solid forebodies exhibited large asymmetric pressure loads at moderate to high angles of attack causing large side forces and yawing moments; the transition grit had minimal effect on the asymmetric characteristics, but had a large effect on the longitudinal characteristics. The porous forebodies exhibited no significant side forces or yawing moments at any angle of attack tested. Author (EI)

A94-60183
DRAG REDUCTION OF AIRPLANE FUSELAGES THROUGH SHAPING BY THE INVERSE METHOD
M. F. ZEDAN King Saud Univ, Riyadh (Saudi Arabia), A. A. SEIF, and S. AL-MOUFADI *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 279-287 refs
(BTN-94-EIX94311329117) Copyright

The axial singularity solution for the axisymmetric inverse problem was extended to utilize doublet elements with linear intensity distribution. The solution converges faster than the source-based method and is therefore quite promising. A procedure based on this solution was used to design low-drag laminar fuselage shapes for small aircraft applications with a volumetric Reynolds number range of 10-30 million. A profile with a fineness ratio of 6, transition at 40% of body length, and volumetric drag coefficient of 0.012 at a nominal R(sub qq) of 15 million, was developed. The present inverse procedure was shown to be a powerful alternative to optimization methods. Several transition criteria were investigated in the course of the study. The Crabtree criterion appears to be the most consistent. Experimental transition data for axisymmetric bodies at high (flight) Reynolds numbers are urgently needed. Author (EI)

A94-60623

EFFECTS OF PROPELLER ON THE TURNING OF OLD FIGHTERS

TADASHI SATO Iwate Univ., Morioka (Japan), HIROBUMI OHTA, SHOKICHI KANNO, and TATSUO CHUBACHI *Transactions of the Japan Society for Aeronautical and Space Sciences* (ISSN 0549-3811) vol. 36, no. 112 August 1993 p. 72-91 refs (BTN-94-EIX94361135426) Copyright

This paper is concerned with the effects of propeller on the turning flight of old fighters. The effects of propeller are composed of three elements. One of them is the aerodynamic moments induced by the vortex. The second is the gyro moments and the third is the torque reaction due to propeller. The curves of trailing vortices are spiral. Exact analysis is very difficult. Therefore the vortices are decomposed into the axial and circumferential components in this paper. The latter gives almost no effect. Approximate analyses of aerodynamic moments and stability derivatives were performed. The results were applied to the simulations of turning flight of old fighters. Considerable effects are shown in the figures. Author (EI)

N94-35055*# Pennsylvania State Univ., University Park, PA. Dept. of Computer Science and Engineering.

ACCURATE ESTIMATION OF OBJECT LOCATION IN AN IMAGE SEQUENCE USING HELICOPTER FLIGHT DATA

YUAN-LIANG TANG and RANGACHAR KASTURI *In* NASA. Goddard Space Flight Center, The 1994 Goddard Conference on Space Applications of Artificial Intelligence p 147-157 May 1994 (Contract NAG1-1371)

Avail: CASI HC A03/MF A03

In autonomous navigation, it is essential to obtain a three-dimensional (3D) description of the static environment in which the vehicle is traveling. For a rotorcraft conducting low-latitude flight, this description is particularly useful for obstacle detection and avoidance. In this paper, we address the problem of 3D position estimation for static objects from a monocular sequence of images captured from a low-latitude flying helicopter. Since the environment is static, it is well known that the optical flow in the image will produce a radiating pattern from the focus of expansion. We propose a motion analysis system which utilizes the epipolar constraint to accurately estimate 3D positions of scene objects in a real world image sequence taken from a low-altitude flying helicopter. Results show that this approach gives good estimates of object positions near the rotorcraft's intended flight-path. Author (revised)

N94-35344# Radio Technical Commission for Aeronautics, Washington, DC.

MINIMUM PERFORMANCE STANDARDS: AIRBORNE LOW-RANGE RADAR ALTIMETERS

1 Nov. 1974 64 p Supersedes RTCA Paper No. 96-63/DO-123 (RTCA-DO-155)

Avail: CASI HC A04/MF A01

Minimum performance standards are set forth for those characteristics of the airborne low-range radar altimeter which are essential for its operation in applications which provide measured height above terrain for clearance and landing data. The potentially diverse range of applications for this equipment precludes the precise definition of the term 'low-range.' It should be recognized that very limited capabilities may suffice in some installations while other installations may require a broader range of altitude (height) data. The maximum range envisioned by system designers at the date of this document is of the order of 2500 feet. The term 'altitude' shall be defined for the purposes of this document as height or distance from the terrain to the altimeter antennas. Compliance with these standards is recommended as a means of assuring that the equipment will satisfactorily perform its intended functions over all conditions normally encountered in routine aeronautical operations. Inasmuch as measured values of radio equipment performance characteristics may be a function of the method of measurement, standard test conditions and methods of tests are also recommended. Derived from text

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.

A94-60426

NUMERICAL METHOD FOR SIMULATING FLUID-DYNAMIC AND HEAT-TRANSFER CHANGES IN JET-ENGINE INJECTOR FEED-ARM DUE TO FOULING

V. R. KATTA Systems Research Laboratories, Inc., Dayton, OH and W. M. ROQUEMORE *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 7, no. 4 October-December 1993 p. 651-660 (BTN-94-EIX94351142133) Copyright

A computational method for integrating fluid-dynamic simulations and heat-transfer calculations in different segments of solid boundaries has been developed to predict deposition inside tubes. The fuel thermal-degradation mechanism is treated mathematically using a four-step global-chemistry model. Deposits are allowed to grow on the wall surface, and the resulting fluid-dynamic and heat-transfer changes are implicitly computed using a time-dependent formulation. Turbulent-flow simulations for the fuel flow bounded by the fuel-deposit interface are made on a body-oriented coordinate system. The induction period, which is associated with the slower deposition during the initial hours of exposure, is modeled by introducing a wall-reaction-type mechanism for the surface sticking phenomenon. Calculations are made for full-scale and half-scale gas-turbine injector feed-arm rigs. The temperature at the deposit-tube interface is found to increase with deposition. Computed accumulated deposit weight and changes in the tube-inner-wall temperature with time are compared with the experimental data. The effects of fouling on heat transfer and blockage to the fuel flow are discussed. Author (EI)

A94-60447

EXPERIMENTAL INVESTIGATION ON SUPERSONIC COMBUSTION (2)

XINGZHOU LIU The 31st Research Inst., Ministry of Aeronautics and Astronautics, Beijing (China), JINGHUA LIU, YUREN WANG, YUNQI GE, LIXING YANG, and YULI HU *Journal of Propulsion Technology* (ISSN 1001-4055) no. 4 August 1993 p. 1-7 In CHINESE refs (BTN-94-EIX94351144985) Copyright

An experimental investigation was carried out on two model supersonic combustors of differing lengths. The combustors both had a rearward-facing step and a diverging duct. Both of the combustors use electric arc-heated air to simulate the working conditions associated with incoming flow that varied from Ma = 2.1 to 3.0. Comparisons were made between the two combustors of different length: each burns kerosene or hydrogen fuel; and each has fuel injected either parallel or perpendicular to the airstream. EI

A94-60449

COMPUTATION AND DISCUSSION OF A NEARLY CONSTANT DEGREE OF REACTION TURBINE STAGE

JIYA CUI Beijing Univ. of Aeronautics and Astronautics, Beijing

(China) *Journal of Propulsion Technology* (ISSN 1001-4055) no. 4 August 1993 p. 14-17 In CHINESE refs
(BTN-94-EIX94351144987) Copyright

The tension spline streamline curvature method was used. The nozzle vanes' leading edge positive lean angle is increased to 18 deg, and their reverse to conventional exit angle twist increased to 22.5 deg. The variations of main gas dynamic parameters, total pressure loss coefficients, and stage efficiencies along the blade height were shown together with the corresponding conventional stage of the same flow path for comparison. A reaction difference of only 0.032 was achieved; however, owing to a stage exit pressure that is at its highest at the shroud, the nozzle exit pressure is still highest at shroud. It seems apparent that in order to minimize nozzle vane secondary flow and shroud clearance leakage losses, an optimum pressure gradient along nozzle vane exit is decisive in future study. EI

A94-60454
COMBUSTION PERFORMANCE OF DUMP COMBUSTOR IN RAMJET ENGINE USING LIQUID HYDROGEN FUEL
SHAOQING WANG The 31st Research Inst., Ministry of Aeronautics and Astronautics, Beijing (China) *Journal of Propulsion Technology* (ISSN 1001-4055) no. 4 August 1993 p. 42-46 In CHINESE refs
(BTN-94-EIX94351144992) Copyright

The ramjet characteristics associated with using liquid hydrogen were calculated and analyzed. The results showed that the ramjet's performance meet the required demands in the range of M = 1.50-6.00 and H = 40 km. The calculated results for dump and normal combustors were compared. At low altitude and small M number, the results showed that the performance of dump combustor is better than normal combustor, i.e. the thrust is increased and the resistance of overflow is decreased. At higher altitude and higher M number, the differences between the two are very small. Additionally, the problem of flow matching is also partially solved by using dump combustor. EI

N94-34607# Wright Lab., Wright-Patterson AFB, OH. Turbine Engine Div.
PROGRESS AND PURPOSE OF IHPTET PROGRAM
RICHARD J. HILL *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 8 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

IHPTET is the Integrated High Performance Turbine Engine Technology initiative. This paper discusses the purpose (background goals and applications) and the progress of IHPTET. IHPTET is 30 percent complete and achieving significant success in advancing turbine engine technology levels. The future of IHPTET is bright. IHPTET developed technologies are being applied to both military and commercial turbine engines — both new engines and fleet modernization's. IHPTET is the technology base for all future military systems and the springboard for many new commercial engines. Author

N94-34608# Rolls-Royce Ltd., Bristol (England).
ENGINE CHARACTERISTICS FOR AGILE AIRCRAFT
K. R. GARWOOD, G. S. HODGES, and H. E. ROGERS *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 8 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

A number of different factors drive and constrain the development of future technology. This paper looks at the current perspective on the development of agile aircraft systems and more specifically, the engine characteristics these demand. Having identified the desirable engine characteristics, the key technologies required to enable them are discussed. It is proposed that the optimum agile aircraft system will be achieved given these technologies by considering the best way in which the engine should be 'rated' to fulfill the operational requirements envisaged. Author

N94-34679*# General Motors Corp., Indianapolis, IN. Gas Turbine Div.
COMPOSITE MATRIX EXPERIMENTAL COMBUSTOR Final Technical Report
MARC D. PASKIN Apr. 1994 181 p
(Contract NAS3-24226)
(NASA-CR-194446; EDR-16346; NAS 1.26:194446; ARL-TR-334) Avail: CASI HC A09/MF A02

A joint Army/NASA program was conducted to design, fabricate, and test an advanced, reverse-flow, small gas turbine combustor utilizing a compliant metal/ceramic (CMC) wall cooling concept. The objectives of this effort were to develop a design method (basic design data base and analysis) for the CMC cooling technique and then demonstrate its application to an advanced cycle, small, reverse-flow combustor with 3000 F burner outlet temperature (BOT). The CMC concept offers significant improvements in wall cooling effectiveness resulting in a large reduction in cooling air requirements. Therefore more air is available for control of burner outlet temperature pattern in addition to the benefits of improved efficiency, reduced emissions, and smoke levels. Task 1 of the program defined component materials and localized design of the composite wall structure in conjunction with development of basic design models for analysis of flow and heat transfer through the wall. Task 2 required implementation of the selected materials and validated design models during combustor preliminary design. Detail design of the selected combustor concept and its refinement with 3-D aerothermal analysis were completed in Task 3. Task 4 covered detail drawings, process development and fabrication, and a series of burner rig tests. Burner rig tests covered characterization of cold flow pressure drop, lean blowout and ignition mapping steady-state performance throughout the operating range including the milestone 3000 F BOT as well as two series of simulated cyclic thermal shock tests at high point BOT conditions of 2700 F (32 total cycles) and 3000 F (68 total cycles). Rig test results have demonstrated the benefits and viability of the CMC concept, meeting or exceeding the aerothermal performance and liner wall temperature characteristics of similar lower temperature combustors, achieving 0.15 pattern factor at 3000 F BOT while utilizing approximately 80 percent less cooling air than conventional, film-cooled combustion systems. Author

N94-34993*# Coltec Industries, West Hartford, CT. Control Systems Div.
HOT GAS INGESTION EFFECTS ON FUEL CONTROL SURGE RECOVERY AND AH-1 ROTOR DRIVE TRAIN TORQUE SPIKES Final Report, Sep. - Oct. 1992
FRANK TOKARSKI, MIHIR DESAI, MARTIN BOOKS, and RAYMOND ZAGRANSKI Apr. 1994 54 p
(Contract NAS3-26075; DA PROJ. 1L1-62211-A-47)
(NASA-CR-191047; E-8638; NAS 1.26:191047; ARL-CR-13) Avail: CASI HC A04/MF A01

This report summarizes the work accomplished through computer simulation to understand the impact of the hydromechanical turbine assembly (TA) fuel control on rocket gas ingestion induced engine surges on the AH-1 (Cobra) helicopter. These surges excite the lightly damped torsional modes of the Cobra rotor drive train and can cause overtorqueing of the tail rotor shaft. The simulation studies show that the hydromechanical TA control has a negligible effect on drive train resonances because its response is sufficiently attenuated at the resonant frequencies. However, a digital electronic control working through the TA control's separate, emergency fuel metering system has been identified as a solution to the overtorqueing problem. State-of-the-art software within the electronic control can provide active damping of the rotor drive train to eliminate excessive torque spikes due to any disturbances including engine surges and aggressive helicopter maneuvers. Modifications to the existing TA hydromechanical control are relatively minor, and existing engine sensors can be utilized by the electronic control. Therefore, it is concluded that the combination of full authority digital electronic control (FADEC) with hydromechanical backup using the existing TA control enhances flight safety, improves helicopter performance, reduces pilot workload, and provides a substantial payback for very little investment. Author

N94-35352*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COMPUTATIONAL METHODS FOR HSCT-INLET CONTROLS/ CFD INTERDISCIPLINARY RESEARCH
GARY L. COLE, KEVIN J. MELCHER, AMY K. CHICATELLI, TOM T. HARTLEY, and JOONGKEE CHUNG May 1994 13 p Presented at the 30th Joint Propulsion Conference, Indianapolis, IN, 27-29 Jun. 1994; sponsored by AIAA, ASME, SAE, and ASEE
(Contract NCC3-233; NAG3-1450; RTOP 505-62-52)
(NASA-TM-106618; ICOMP-94-10; E-8903; NAS 1.15:106618; AIAA PAPER 94-3209) Copyright Avail: CASI HC A03/MF A01

A program aimed at facilitating the use of computational fluid dynamics (CFD) simulations by the controls discipline is presented. The objective is to reduce the development time and cost for propulsion system controls by using CFD simulations to obtain high-fidelity system models for control design and as numerical test beds for control system testing and validation. An interdisciplinary team has been formed to develop analytical and computational tools in three discipline areas: controls, CFD, and computational technology. The controls effort has focused on specifying requirements for an interface between the controls specialist and CFD simulations and a new method for extracting linear, reduced-order control models from CFD simulations. Existing CFD codes are being modified to permit time accurate execution and provide realistic boundary conditions for controls studies. Parallel processing and distributed computing techniques, along with existing system integration software, are being used to reduce CFD execution times and to support the development of an integrated analysis/design system. This paper describes: the initial application for the technology being developed, the high speed civil transport (HSCT) inlet control problem; activities being pursued in each discipline area; and a prototype analysis/design system in place for interactive operation and visualization of a time-accurate HSCT-inlet simulation. Author

N94-35746 Air Force Office of Scientific Research, Bolling AFB, Washington, DC.
AFOSR CONTRACTORS PROPULSION MEETING
M. A. BIRKAN and J. M. TISHKOFF 20 Apr. 1994 338 p Meeting held in Atlantic City, NJ, 14-18 Jun. 1993 Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract AF PROJ. 2308)
(AD-A279028; AFOSR-TR-94-0275) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Abstracts are given for research in airbreathing combustion, rocket propulsion, and diagnostics in reacting media supported by the Air Force Office of Scientific Research. DTIC

08
AIRCRAFT STABILITY AND CONTROL

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

N94-34613# Defence Research Agency, Farnborough, Hampshire (England). Aerodynamics and Propulsion Dept.
DYNAMIC TESTS TO DEMONSTRATE LATERAL CONTROL USING FOREBODY SUCTION ON LARGE SCALE MODELS IN THE DRA 24 FOOT WIND TUNNEL
GERALDINE F. EDWARDS, A. JEAN ROSS, EDWARD B. JEFFERIES, and CHARLES O. OLEARY *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 14 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

The concept of applying suction at the nose of forebodies at high angles of attack to control the vortex flow was tested in two dynamic wind-tunnel experiments on large scale versions of the Defence Research Agency (DRA) High Incidence Research Model (HIRM1) in the DRA 24ft wind tunnel. The first experiment with a HIRM1 wind tunnel model mounted on a free-to-yaw rig used an analog control system. The model was controlled at angles of attack of 28 degrees and 32.5 degrees by applying differential suction through small holes near the nose apex to minimize the error between demanded and measured angle of sideslip. The second experiment used a free-flight version of HIRM1 with a digital Departure Prevention System (DPS) which was flown successfully in previous experiments. A nose suction control law, designed to maintain roll about the wind axis, was added to the DPS. The model was mounted on a rig which allowed freedom in yaw, roll, and pitch, the tailplanes could move symmetrically and differentially, and the rudder was used to augment directional stability. The model could be flown at angles of attack up to about 30 degrees, with the suction control law active, but would diverge in yaw and roll if the suction was turned off. Author (revised)

N94-34615# Bath Univ. (England). School of Mechanical Engineering.
YAW CONTROL BY TANGENTIAL FOREBODY BLOWING
N. J. WOOD and W. J. CROWTHER *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 10 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

Aircraft yaw control at high angles of attack by tangential forebody blowing has been investigated experimentally. Tests were performed in the University of Bath 2.1 m X 2.5 m low speed wind tunnel using an approximately 6 percent scale generic combat aircraft model fitted with blowing slots in the nose cone. Six component strain gauge balance force and moment data was measured for angles of attack up to 90 degrees for various slot geometries and locations. The effect of slot azimuthal location is demonstrated and a slot stall phenomenon described. A geometry dependent forebody/wing flow-field coupling has been identified which can lead to unexpected yawing and rolling moments. The primary source of yawing moment is shown to be the enhanced area of attached flow on the blown side of the forebody rather than direct vortex influence. The optimum slot extent and location depend on the angle of attack range over which control is required. For regions where steady vortex asymmetry is present, slots near the apex of the forebody produce severe control reversals at low blowing rates which can be minimized by placing the slots away from the apex. For control in regions where the flow is dominated by periodic vortex shedding, long slots offer efficient control to 90 degree angle of attack. The most suitable compromise for wide range control would appear to be a short slot placed away from the apex of the forebody. Author (revised)

N94-34616# Defence Research Agency, Bedford (England).
CONTROL OF LEADING-EDGE SEPARATION ON A CAMBERED DELTA WING
P. R. ASHILL and G. L. RIDDLE *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 13 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

Wind tunnel studies of flows over a cambered delta wing of 60 degrees leading-edge sweep at low speed have shown that the flow separates on a forward part of the curved upper surface. Although not apparent in surface pressure distributions, this separation strongly influences the position of the onset of leading-edge separation. The present paper describes a wind-tunnel study into the use of sub boundary-layer vortex generators, in the form of thin wires, to control the flow along and toward the upper-surface separation line. The control is effective because it shifts the position of the onset of leading-edge separation downstream, ensuring increased leading-edge thrust, mainly through a reorganization of the separated flow further downstream. The flow mechanisms are described, as well as the effects of wire number. Multiple wires can provide a reduction of about 16% in the lift-dependent drag factor. The implications of the study for the subsonic flight characteristics of supersonic combat aircraft are described and suggest that the vortex generators offer genuine improvements in subsonic maneuver performance. Author (revised)

N94-34618# Deutsche Aerospace A.G., Munich (Germany). Military Aircraft Group.
X-31A CONTROL LAW DESIGN
H. BEH and G. HOFINGER *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 9 p Mar. 1994
Copyright Avail: CASI HC A02/MF A03

This paper presents an overview on the X-31A flight control law design philosophy and the technical realization of the design. After an introduction to the FCS hardware configuration, the basic control law structure and the method used for feedback gain calculation are presented. Several elements, such as the feedforward path, gravity effect compensation, inertial and gyroscopic coupling compensation, and the pilot command system, are discussed in more detail. Simplified block diagrams of the basic flight control mode in the longitudinal and lateral/directional axis follow. Finally, the implementation of the thrust vectoring system including engagement and disengagement procedure is shown. Author (revised)

N94-34619# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugmechanik.
X-31A SYSTEM IDENTIFICATION APPLIED TO POST-STALL FLIGHT: AERODYNAMICS AND THRUST VECTORING
D. ROHLF, E. PLASTSCHKE, and S. WEISS *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 12 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

Flight testing of the X-31A post-stall experimental aircraft started in Oct. 1990. By the end of 1992, the X-31A flight regime had been expanded to 70 deg angle of attack, and a significant number of flight tests with dynamic post-stall maneuvers had been performed. Within the international 'Combined X-31A Flight Test Team,' DLR (the German Aerospace Research Establishment) contributes its system identification experience and capabilities to the determination of aerodynamic parameters and thrust vector control effectiveness from flight test data. After a brief description of the applied hardware and software, this paper presents recent results from flight test data compatibility checking. The identification models used for the separated evaluation of longitudinal and lateral-directional motion are introduced. This emphasizes the model reductions necessary for X-31A high angle of attack applications. Identification results of selected aerodynamic parameters are shown in comparison to wind-tunnel predictions. The identification of the X-31A thrust vector control effectiveness is addressed, and preliminary results are presented as well. An overview of future identification activities with respect to nonlinear/instationary effects in the high angle of attack regime is given. Author (revised)

N94-34994*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
YAV-8B REACTION CONTROL SYSTEM BLEED AND CONTROL POWER USAGE IN HOVER AND TRANSITION
PAUL F. BORCHERS, ERNESTO MORALEZ, III, VERNON K. MERRICK, and MICHAEL W. STORTZ Apr. 1994 47 p
(Contract RTOP 533-02-37)
(NASA-TM-104021; A-93080; NAS 1.15:104021) Avail: CASI HC A03/MF A01

Using a calibrated Rolls-Royce Pegasus engine and existing aircraft instrumentation and pressure taps, total and individual nozzle reaction control system (RCS) bleed flow rates have been measured on a YAV-8B Harrier during typical short takeoff, transition, hover, and vertical landing maneuvers. RCS thrust forces were calculated from RCS nozzle total pressure measurements, and control power was determined from the moments produced by these thrusts and the aircraft's moments of inertia. These data document the characteristics of the YAV-8B RCS with its basic stability augmentation system (SAS) engaged. Advanced control system designs for the YAV-8B can be compared to the original SAS based on the total bleed use and the percentage of available bleed used. In addition, the peak and mean values of the bleed and control power data can be used for sizing the reaction controls for a future short takeoff and vertical landing (STOVL) aircraft. Author

N94-35258*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT TESTING A PROPULSION-CONTROLLED AIRCRAFT EMERGENCY FLIGHT CONTROL SYSTEM ON AN F-15 AIRPLANE
F. W. BURCHAM, JR., JOHN BURKEN, and TRINDEL A. MAINE NASA, Washington Jun. 1994 19 p Presented at the 7th Biennial Flight Test Conference, Colorado Springs, CO, 20-23 Jun. 1994
(Contract RTOP 533-02-34)
(NASA-TM-4590; H-1988; NAS 1.15:4590; AIAA PAPER 94-2123)
Copyright Avail: CASI HC A03/MF A01

Flight tests of a propulsion-controlled aircraft (PCA) system on an F-15 airplane have been conducted at the NASA Dryden Flight Research Center. The airplane was flown with all flight control surfaces locked both in the manual throttles-only mode and in an augmented system mode. In the latter mode, pilot thumbwheel commands and aircraft feedback parameters were used to position the throttles. Flight evaluation results showed that the PCA system can be used to land an airplane that has suffered a major flight control system failure safely. The PCA system was used to recover the F-15 airplane from a severe upset condition, descend, and land. Pilots from NASA, U.S. Air Force, U.S. Navy, and McDonnell Douglas Aerospace evaluated the PCA system and were favorably impressed with its capability. Manual throttles-only approaches were unsuccessful. This paper describes the PCA system operation and testing. It also presents flight test results and pilot comments. Author

N94-35796 Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
DIRECT REDUCED ORDER MIXED H2/H INFINITY CONTROL FOR THE SHORT TAKE-OFF AND LANDING/MANEUVER TECHNOLOGY DEMONSTRATOR (STOL/MTD) M.S. Thesis
WILLIAM C. REIGELSPERGER, JR. Mar. 1994 169 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A278675; AFIT/GAE/ENY/94M-3) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

One of the conclusions from the STOL/MTD program was the need for a multivariable method of designing controllers of low order. This research investigated that problem by studying reduced order mixed H-two/H-infinity control theory applied to the STOL Landing configuration which employs both thrust vectoring and the use of a canard. Model matching techniques were used to obtain responses that met handling qualities criteria and reduced pilot workload by decoupling pitch rate and velocity commands. The time responses were found through nonlinear simulation and showed that the full order designs did match the ideal models very well and had good noise and wind rejection. Singular value analysis showed that the commands were decoupled very well. The reduced order method was mixed H-two/H-infinity optimization. A fourth order controller that had good performance was found by using a performance constraint, and a fourth order controller that provided good margins was found using a robustness constraint. A third order controller was also found with a performance constraint. Recommendations for finding a low order controller, with good performance and robustness are given. DTIC

N94-35873*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLUTTER SUPPRESSION DIGITAL CONTROL LAW DESIGN AND TESTING FOR THE AFW WIND TUNNEL MODEL
VIVEK MUKHOPADHYAY *In its* NASA Workshop on Distributed Parameter Modeling and Control of Flexible Aerospace Systems p 135-149 Jun. 1994
Avail: CASI HC A03/MF A06

The design of a control law for simultaneously suppressing the symmetric and antisymmetric flutter modes of a sting mounted fixed-in-roll aeroelastic wind-tunnel model is described. The flutter suppression control law was designed using linear quadratic Gaussian theory, and it also involved control law order reduction, a gain root-locus study, and use of previous experimental results. A 23 percent increase in the open-loop flutter dynamic pressure was demonstrated during the wind-tunnel test. Rapid roll maneuvers at 11 percent above the symmetric flutter boundary were also performed when the model was in a free-to-roll configuration. Author (revised)

N94-35874*# California Univ., Los Angeles, CA. Dept. of Mechanical, Aerospace and Nuclear Engineering.
SELECTED TOPICS ON THE ACTIVE CONTROL OF HELICOPTER AEROMECHANICAL AND VIBRATION PROBLEMS
PERETZ P. FRIEDMANN *In* NASA. Langley Research Center, NASA Workshop on Distributed Parameter Modeling and Control of Flexible Aerospace Systems p 151-177 Jun. 1994
(Contract NAG2-477)
Avail: CASI HC A03/MF A06

This paper describes in a concise manner three selected topics on the active control of helicopter aeromechanical and vibration problems. The three topics are as follows: (1) the active control of helicopter air-resonance using an LQG/LTR approach; (2) simulation of higher harmonic control (HHC) applied to a four bladed hingeless helicopter rotor in forward flight; and (3) vibration suppression in forward flight on a hingeless helicopter rotor using an actively controlled, partial span, trailing edge flap, which is mounted on the blade. Only a few selected illustrative results are presented. The results obtained clearly indicate that the partial span, actively controlled flap has considerable potential for vibration reduction in helicopter rotors. Author (revised)

N94-35875*# Ohio State Univ., Columbus. Dept. of Electrical Engineering.
ROBUST CONTROL DESIGN TECHNIQUES FOR ACTIVE FLUTTER SUPPRESSION
HITAY OZBAY and GLEN R. BACHMANN *In* NASA. Langley Research Center, NASA Workshop on Distributed Parameter Modeling and Control of Flexible Aerospace Systems p 179-191 Jun. 1994
Avail: CASI HC A03/MF A06

In this paper, an active flutter suppression problem is studied for a thin airfoil in unsteady aerodynamics. The mathematical model of this system is infinite dimensional because of Theodorsen's function which is irrational. Several second order approximations of Theodorsen's function are compared. A finite dimensional model is obtained from such an approximation. We use H infinity control techniques to find a robustly stabilizing controller for active flutter suppression. Author (revised)

N94-35962*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PILOTED SIMULATION STUDY OF TWO TILT-WING CONTROL CONCEPTS
LOURDES G. BIRCKELBAW and LLOYD D. CORLISS *In its* 1993 Technical Paper Contest for Women. Gear Up 2000: Women in Motion p 1-12 Feb. 1994
Avail: CASI HC A03/MF A02

A two-phase piloted simulation study was conducted to investigate alternative wing and flap controls for tilt-wing aircraft. The initial phase of the study compared the flying qualities of both a conventional (programmed) flap and an innovative geared flap. The second phase of the study introduced an alternate method of pilot control for the geared flap and further studied the flying qualities of the programmed flap, and two geared flap configurations. In general, the pilot rating showed little variation between the programmed flap and the geared flap control concepts. Some differences between the two concepts were noticed and are discussed in this paper. The addition of pitch attitude stabilization in the second phase of the study greatly enhanced the aircraft flying qualities. This paper describes the simulated tilt-wing aircraft and the flap control concepts and presents the results of both phases of the simulation study. Author

N94-35972*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
GROUND VIBRATION TEST OF THE XV-15 TILTROTOR RESEARCH AIRCRAFT AND PRETEST PREDICTIONS
KAREN STUDEBAKER and ANITA ABREGO *In its* 1993 Technical Paper Contest for Women. Gear Up 2000: Women in Motion p 117-123 Feb. 1994
Avail: CASI HC A02/MF A02

The first comprehensive ground vibration survey was performed on the XV-15 Tiltrotor Research Aircraft to measure the vibration modes of the airframe and to provide data critical for determining whirl flutter stability margins. The aircraft was suspended by the wings with bungee cords and cables. A NASTRAN finite element model was used in the design of the suspension system to minimize its interference with the wing modes. The primary objective of the test was to measure the dynamic characteristics of the wings and pylons for aeroelastic stability analysis. In addition, over 130 accelerometers were placed on the airframe to characterize the fuselage, wing, and tail vibration. Pretest predictions were made with the NASTRAN model as well as correlations with the test data. The results showed that the suspension system provided the isolation necessary for modal measurements. Author (revised)

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.

N94-34630# Naval Air Warfare Center, Warminster, PA. Flight Dynamics and Controls Branch.
APPLICATION OF CENTRIFUGE BASED DYNAMIC FLIGHT SIMULATION TO ENHANCED MANEUVERABILITY RDT/E
J. F. CALVERT and D. A. KIEFER *In* AGARD, Technologies for Highly Manoeuvrable Aircraft 16 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

This paper addresses the strengths of centrifuge simulation to provide the unfamiliar and severe motion environment associated with high angle of attack and post-stall maneuvering. The approach to development and testing of centrifuge motion control algorithms is outlined, including inherent modeling constraints such as three degrees of freedom, estimated human perceptual models, and the machine-associated mechanical/structural considerations. Difficulties of algorithm development are illustrated using the results of a recent flying qualities experiment initiated to study the effects of motion on pilot ratings for proposed nose-down control power guideline criteria. Use of off-line computer models to tune algorithm performance is also presented. Finally, current capabilities of centrifuge simulation and a discussion of future applications is outlined. Author (revised)

N94-34632*# National Aeronautics and Space Administration, Washington, DC.
NATIONAL FACILITIES STUDY. VOLUME 1: FACILITIES INVENTORY
29 Apr. 1994 49 p
(NASA-TM-109854; NAS 1.15:109854) Avail: CASI HC A03/MF A01

The inventory activity was initiated to solve the critical need for a single source of site specific descriptive and parametric data on major public and privately held aeronautics and aerospace related facilities. This a challenging undertaking due to the scope of the effort and the short lead time in which to assemble the inventory and have it available to support the task group study needs. The inventory remains dynamic as sites are being added and the data is accessed and refined as the study progresses. The inventory activity also included the design and implementation of a computer database and analytical tools to simplify access to the data. This volume describes the steps which were taken to define the data requirements, select sites, and solicit and acquire data from them. A discussion of the inventory structure and analytical tools is also provided. Derived from text

N94-34633*# National Aeronautics and Space Administration, Washington, DC.
NATIONAL FACILITIES STUDY. VOLUME 2: TASK GROUP ON AERONAUTICAL RESEARCH AND DEVELOPMENT FACILITIES REPORT
29 Apr. 1994 413 p
(NASA-TM-109855; NAS 1.15:109855) Avail: CASI HC A18/MF A04

The Task Group on Aeronautics R&D Facilities examined the status and requirements for aeronautics facilities against the competitive need. Emphasis was placed on ground-based facilities for subsonic, supersonic and hypersonic aerodynamics, and propulsion. Subsonic and transonic wind tunnels were judged to be most critical and of highest priority. Results of the study are presented. Derived from text

N94-34634*# National Aeronautics and Space Administration, Washington, DC.
NATIONAL FACILITIES STUDY. VOLUME 2A: FACILITY STUDY OFFICE ON THE NATIONAL WIND TUNNEL COMPLEX Final Report
29 Apr. 1994 864 p
(NASA-TM-109856; NAS 1.15:109856) Avail: CASI HC A99/MF A10

The Facility Study Office (FSO) has completed its assigned activities. The results of the FSO efforts, studies, and assessments are documented. An overview of the FSO activities as well as a general comparison of all concepts considered are provided. Detailed information is also provided for the selected concept, Concept D-Option 5. Only findings are presented. The FSO developed recommendations only as a consequence of assumptions for cost and schedule assessments. Derived from text

N94-34635*# National Aeronautics and Space Administration, Washington, DC.
NATIONAL FACILITIES STUDY. VOLUME 3: MISSION AND REQUIREMENTS MODEL REPORT Final Report
29 Apr. 1994 102 p
(NASA-TM-109857; NAS 1.15:109857) Avail: CASI HC A06/MF A02

The National Facility Study (NFS) was initiated in 1992 by Daniel S. Goldin, Administrator of NASA as an initiative to develop a comprehensive and integrated long-term plan for future facilities. The resulting, multi-agency NFS consisted of three Task Groups: Aeronautics, Space Operations, and Space Research and Development (R&D) Task Groups. A fourth group, the Engineering and Cost Analysis Task Group, was subsequently added to provide cross-cutting functions, such as assuring consistency in developing an inventory of space facilities. Space facilities decisions require an assessment of current and future needs. Therefore, the two task groups dealing with space developed a consistent model of future space mission programs, operations and R&D. The model is a middle ground baseline constructed for NFS analytical purposes with excursions to cover potential space program strategies. The model includes three major sectors: DOD, civilian government, and commercial space. The model spans the next 30 years because of the long lead times associated with facilities development and usage. This document, Volume 3 of the final NFS report, is organized along the following lines: Executive Summary — provides a summary view of the 30-year mission forecast and requirements baseline, an overview of excursions from that baseline that were studied, and organization of the report; Introduction — provides discussions of the methodology used in this analysis; Baseline Model — provides the mission and requirements model baseline developed for Space Operations and Space R&D analyses; Excursions from the baseline — reviews the details of variations or 'excursions' that were developed to test the future program projections captured in the baseline; and a Glossary of Acronyms. Derived from text

N94-34636*# National Aeronautics and Space Administration, Washington, DC.
NATIONAL FACILITIES STUDY. VOLUME 4: SPACE OPERATIONS FACILITIES TASK GROUP Final Report
29 Apr. 1994 590 p
(NASA-TM-109858; NAS 1.15:109858) Avail: CASI HC A25/MF A06

The principal objectives of the National Facilities Study (NFS) were to: (1) determine where U.S. facilities do not meet national aerospace needs; (2) define new facilities required to make U.S. capabilities 'world class' where such improvements are in the national interest; (3) define where consolidation and phase-out of existing facilities is appropriate; and (4) develop a long-term national plan for world-class facility acquisition and shared usage. The Space Operations Facilities Task Group defined discrete tasks to accomplish the above objectives within the scope of the study. An assessment of national space operations facilities was conducted to determine the nation's capability to meet the requirements of space operations during the next 30 years. The mission model used in the study to define facility requirements is described in Volume 3. Based on this model, the major focus of the Task Group was to identify any substantive overlap or underutilization of space operations facilities and to identify any facility shortfalls that would necessitate facility upgrades or new facilities. The focus of this initial study was directed toward facility recommendations related to consolidations, closures, enhancements, and upgrades considered necessary to efficiently and effectively support the baseline requirements model. Activities related to identifying facility needs or recommendations for enhancing U.S. international competitiveness and achieving world-class capability, where appropriate, were deferred to a subsequent study phase. Derived from text

N94-34637*# National Aeronautics and Space Administration, Washington, DC.
NATIONAL FACILITIES STUDY. VOLUME 5: SPACE RESEARCH AND DEVELOPMENT FACILITIES TASK GROUP Final Report
29 Apr. 1994 211 p
(NASA-TM-109859; NAS 1.15:109859) Avail: CASI HC A10/MF A03

With the beginnings of the U.S. space program, there was a pressing need to develop facilities that could support the technology research and development, testing, and operations of evolving space systems. Redundancy in facilities that was once and advantage in providing flexibility and schedule accommodation is instead fast becoming a burden on scarce resources. As a result, there is a clear perception in many sectors that the U.S. has many space R&D facilities that are under-utilized and which are no longer cost-effective to maintain. At the same time, it is clear that the U.S. continues to possess many space R&D facilities which are the best — or among the best — in the world. In order to remain world class in key areas, careful assessment of current capabilities and planning for new facilities is needed. The National Facility Study (NFS) was initiated in 1992 to develop a comprehensive and integrated long-term plan for future aerospace facilities that meets current and projected government and commercial needs. In order to assess the nation's capability to support space research and development (R&D), a Space R&D Task Group was formed. The Task Group was co-chaired by NASA and DOD. The Task Group formed four major, technologically- and functionally-oriented working groups: Human and Machine Operations; Information and Communications; Propulsion and Power; and Materials, Structures, and Flight Dynamics. In addition to these groups, three supporting working groups were formed: Systems Engineering and Requirements; Strategy and Policy; and Costing Analysis. The Space R&D Task Group examined several hundred facilities against the template of a baseline mission and requirements model (developed in common with the Space Operations Task Group) and a set of excursions from the baseline. The model and excursions are described in Volume 3 of the NFS final report. In addition, as a part of the effort, the group examined key strategic issues associated with space R&D facilities planning for the U.S., and these are discussed in Section 4 of this volume. Derived from text

N94-34919*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FLOW QUALITY STUDIES OF THE NASA LEWIS RESEARCH CENTER ICING RESEARCH TUNNEL

E. ALLEN ARRINGTON (NYMA, Inc., Brook Park, OH.), MARK T. PICKETT, and DAVID W. SHELDON Jun. 1994 44 p Presented at the 18th Aerospace Ground Testing Conference, Colorado Springs, CO, 20-23 Jun. 1994; sponsored by AIAA

(Contract NAS3-25266; RTOP 505-62-84)

(NASA-TM-106545; E-8691; NAS 1.15:106545; AIAA PAPER 94-2590) Avail: CASI HC A03/MF A01

A series of studies have been conducted to determine the flow quality in the NASA Lewis Icing Research Tunnel. The primary purpose of these studies was to document airflow characteristics, including flow angularity, in the test section and tunnel loop. A vertically mounted rake was used to survey total and static pressure and two components of flow angle at three axial stations within the test section (test section inlet, test plane, and test section exit; 15 survey stations total). This information will be used to develop methods of improving the aerodynamic and icing characteristics within the test section. The data from surveys made in the tunnel loop were used to determine areas where overall tunnel flow quality and efficiency can be improved. A separate report documents similar flow quality surveys conducted in the diffuser section of the Icing Research Tunnel. The flow quality studies were conducted at several locations around the tunnel loop. Pressure, velocity, and flow angularity measurements were made by using both fixed and translating probes. Although surveys were made throughout the tunnel loop, emphasis was placed on the test section and tunnel areas directly upstream of the test section (settling chamber, bellmouth, and cooler). Flow visualization, by video recording smoke and tuft patterns, was also used during these studies. A great deal of flow visualization work was conducted in the area of the drive fan. Information gathered there will be used to improve the flow quality upstream and downstream of the fan. Author

N94-35267*# Sverdrup Technology, Inc., Brook Park, OH.

HOT CORROSION TEST FACILITY AT THE NASA LEWIS SPECIAL PROJECTS LABORATORY Final Report

RAYMOND C. ROBINSON and MICHAEL D. CUY May 1994 39 p

(Contract NAS3-25266; RTOP 537-04-20)

(NASA-CR-195323; E-8770; NAS 1.26:195323) Avail: CASI HC A03/MF A01

The Hot Corrosion Test Facility (HCTF) at the NASA Lewis Special Projects Laboratory (SPL) is a high-velocity, pressurized burner rig currently used to evaluate the environmental durability of advanced ceramic materials such as SiC and Si3N4. The HCTF uses laboratory service air which is preheated, mixed with jet fuel, and ignited to simulate the conditions of a gas turbine engine. Air, fuel, and water systems are computer-controlled to maintain test conditions which include maximum air flows of 250 kg/hr (550 lbm/hr), pressures of 100-600 kPa (1-6 atm), and gas temperatures exceeding 1500 C (2732 F). The HCTF provides a relatively inexpensive, yet sophisticated means for researchers to study the high-temperature oxidation of advanced materials, and the injection of a salt solution provides the added capability of conducting hot corrosion studies. Author

10
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.

A94-60106

CONTROL STRATEGIES FOR SPACE BOOSTERS USING AIR COLLECTION SYSTEMS

H. G. KAUFFMAN Wright State Univ., Dayton, OH, R. V. GRANDHI, W. L. HANKEY, and P. J. BELCHER *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 2 March-April 1994 p. 243-248 refs

(BTN-94-EIX94311330685) Copyright

A simple and efficient performance analysis method is developed for evaluating vehicle pitch and engine throttle controls to minimize booster fuel required to fill second-stage liquid oxygen (LOX) tanks and deliver the vehicle to the staging point. An optimization methodology finds a throttle schedule that controls both the air-breathing engine and the LOX collection rate. The altitude-velocity profile is derived from a variational calculus/energy management contouring method. Automatic adaptive-gain pitch-rate and throttle controls are developed. Results from a parametric study show that collecting on the run for an optimum schedule results in a 17% fuel savings over collection at a constant Mach number. Author (EI)

A94-60110

NAVIER-STOKES SOLVER FOR HYPERSONIC FLOW OVER A SLENDER CONE

CHANG-SHENG TAI Chung Cheng Inst of Technology, Taoyuan, Taiwan and AR-FU KAO *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 2 March-April 1994 p. 215-222 refs

(BTN-94-EIX94311330681) Copyright

A full Navier-Stokes code has been developed for predicting the aerodynamic properties of slender cones. This code can simulate an entire flowfield of slender cones, such as boundary layer and vortices. An explicit upwind flux-difference-split scheme combined with a multistage method has been implemented for solving the steady axisymmetric full Navier-Stokes equations. Experimental data are found to be in good agreement with the code predictions. This code can be extended to a multidimensional program for simulating the three-dimensional practical problem. Author (EI)

A94-60112

DETERMINATION OF SLENDER BODY AERODYNAMICS USING DISCRETE VORTEX METHODS

G. A. GEBERT Utah State Univ, Logan, UT *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 2 March-April 1994 p. 200-207 refs

(BTN-94-EIX94311330679) Copyright

Current aerodynamic interest has turned to the study of supermaneuverable fighters and weapon performance when launched in extreme flight conditions. The evaluation of design missile performance requires multiple runs of six degree-of-freedom (6-DOF) simulations, analyzing the missile behavior for a variety of launch and flight conditions. Before wind-tunnel tests, it is necessary to produce the aerodynamic loading of candidate missiles for 6-DOF analyses. Since semi-empirical formulas fail in regions of nonlinear aerodynamics, and solutions to the full Navier-Stokes equations are too costly and time consuming, an alternative method of discrete vortex analysis is reexamined. The present theory examines the three-dimensional nature of the shed vorticity and generalizes previous discrete vortex analyses. Consequently, the results demonstrate relative user independence in determining all slender-body loading at angles of attack from 0 to 70 deg. The rapid calculations of the discrete vortex method makes it a prime candidate for the determinations of high angle-of-attack aerodynamic databases. Author (EI)

A94-60191

SIMPLIFIED METHOD FOR EVALUATING THE FLIGHT STABILITY OF LIQUID-FILLED PROJECTILES

DANIEL J. WEBER Army Edgewood Arsenal, MD *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 1 January-February 1994 p. 130-134 refs

(BTN-94-EIX94311322905) Copyright

This paper describes a modification to the tricyclic theory to include the effect of a liquid payload on the motion and stability of the projectile. The influence on the projectile's motion by the liquid payload is similar to the Magnus effect. A computer program has been developed that determines the complex projectile motion using either theoretical estimates of liquid-fill characteristics or experimental results obtained from a test fixture for nonrigid payloads. Preliminary stability assessments for liquid-filled projectile can be made rapidly and provide a means of determining the relative importance between the aerodynamic and liquid-fill characteristics on the projectiles flight stability. EI

A94-60274

PRELIMINARY INVESTIGATIONS ON IMPROVING AIR-AUGMENTED ROCKET PERFORMANCE

K. N. ANIL Indian Inst. of Tech., Madras, India and K. A. DAMODARAN *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 432-434 refs

(BTN-94-EIX94321333323) Copyright

Use of the Petal nozzle instead of the conventional conical nozzle as the primary stream representing fuel-rich gases exiting from a rocket nozzle has demonstrated considerable improvement in the performance of an air-augmented rocket. This can be attributed to the improved mixing of the hot, exhaust gases containing unburnt fuel with the surrounding airstream, and subsequent heat release. EI

A94-60395* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AERODYNAMIC CHARACTERISTICS OF THE HL-20

GEORGE M. WARE NASA Langley Research Center, Hampton, VA and CHRISTOPHER I. CRUZ *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 30, no. 5 September-October 1993 p. 529-536 refs

(BTN-94-EIX94351137055) Copyright

Wind tunnel tests were made from subsonic to hypersonic speeds to define the aerodynamic characteristics of the HL-20 lifting-body configuration. The data have been assembled into an aerodynamic database for flight analysis of this proposed vehicle. The wind tunnel data indicates that the model is longitudinally and laterally stable (about a center-of-gravity location of 0.54 body length) over the test range from Mach 20 to 0.3. At hypersonic speeds, the HL-20 model trimmed at a lift/drag (L/D) ratio of 1.4. This value gives the vehicle a crossrange capability similar to that of the space shuttle. At subsonic speeds, the HL-20 has a trimmed L/D ratio of about 3.6. Replacing the flat-plate outboard fins with fins having an airfoil shape increased the maximum subsonic trimmed L/D to 4.2. Author (EI)

A94-60396* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SIX-DEGREE-OF-FREEDOM GUIDANCE AND CONTROL-ENTRY ANALYSIS OF THE HL-20

RICHARD W. POWELL NASA Langley Research Center, Hampton, VA *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 30, no. 5 September-October 1993 p. 537-542 refs

(BTN-94-EIX94351137056) Copyright

The ability of the HL-20 lifting body to fly has been evaluated for an automated (no pilot inputs) entry from atmospheric interface to landing. This evaluation was required to demonstrate that not only successful touchdown conditions would be possible for this low lift-to-drag-ratio vehicle (approximately equal to 4), but also the vehicle would not exceed its design dynamic pressure limit of 400 psf during entry. This dynamic pressure constraint limit, coupled with limited available pitch-control authority at low supersonic speeds, restricts the available maneuvering capability for the HL-20 to acquire the runway. One result of this analysis was that this restrictive maneuvering capability does not allow the use of a model-following atmospheric entry-guidance algorithm, such as that used by the Space Shuttle, but instead requires a more adaptable guidance algorithm. Therefore, for this analysis, a predictor-corrector guidance algorithm was developed that would provide successful touchdown conditions while not violating the dynamic pressure constraint. A flight-control system was designed and incorporated, along with the predictor-corrector guidance algorithm, into a six-degree-of-freedom simulation. This simulation was tested under many combinations of off-nominal atmospheric density profiles and winds and showed that the HL-20 remained controllable. This simulation also indicated that the HL-20 could reach the landing site and execute a successful landing under all off-nominal conditions simulated. Author (EI)

A94-60397* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EFFECT OF LIFT-TO-DRAG RATIO IN PILOT RATING OF THE HL-20 LANDING TASK

E. BRUCE JACKSON NASA Langley Research Center, Hampton, VA, ROBERT A. RIVERS, and MELVIN L. BAILEY *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 30, no. 5 September-October 1993 p. 543-548 refs

(BTN-94-EIX94351137057) Copyright

A man-in-the-loop simulation study of the handling qualities of the HL-20 lifting-body vehicle was made in a fixed-base simulation cockpit at NASA Langley Research Center. The purpose of the study was to identify and substantiate opportunities for improving the original design of the vehicle from a handling qualities and landing performance perspective. Using preliminary wind tunnel data, a subsonic aerodynamic model of the HL-20 was developed. This model was adequate to simulate the last 75-90 s of the approach and landing. A simple flight control system was designed and implemented. Using this aerodynamic model as a baseline, visual approaches and landings were made at several vehicle lift-to-drag ratios. Pilots rated the handling characteristics of each configuration using a conventional numerical pilot-rating scale. Results from the study showed a high degree of correlation between the lift-to-drag ratio and pilot rating. Level 1 pilot ratings were obtained when the L/D ratio was approximately 3.8 or higher. Author (EI)

A94-60398* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AERODYNAMIC HEATING ENVIRONMENT DEFINITION/ THERMAL PROTECTION SYSTEM SELECTION FOR THE HL-20

K. E. WURSTER NASA Langley Research Center, Hampton, VA and H. W. STONE *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 30, no. 5 September-October 1993 p. 549-557 refs

(BTN-94-EIX94351137058) Copyright

Definition of the aerothermal environment is critical to any vehicle such as the HL-20 Personnel Launch System that operates within the hypersonic flight regime. Selection of an appropriate thermal protection system design is highly dependent on the accuracy of the heating-environment prediction. It is demonstrated that the entry environment determines the thermal protection system design for this vehicle. The methods used to predict the thermal environment for the HL-20 Personnel Launch System vehicle are described. Comparisons of the engineering solutions with computational fluid dynamic predictions, as well as wind-tunnel test results, show good agreement. The aeroheating predictions over several critical regions of the vehicle, including the stagnation areas of the nose and leading edges, windward centerline and wing surfaces, and leeward surfaces, are discussed. Results of predictions based on the engineering methods found within the MINIVER aerodynamic heating code are used in conjunction with the results of the extensive wind-tunnel tests on this configuration to define a flight thermal environment. Finally, the selection of the thermal protection system based on these predictions and current technology is described. Author (EI)

A94-60399* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HL-20 COMPUTATIONAL FLUID DYNAMICS ANALYSIS
K. JAMES WEILMUENSTER NASA Langley Research Center, Hampton, VA and FRANCIS A. GREENE *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 30, no. 5 September-October 1993 p. 558-566 refs
(BTN-94-EIX94351137059) Copyright

The essential elements of a computational fluid dynamics analysis of the HL-20/personnel launch system aerothermal environment at hypersonic speeds including surface definition, grid generation, solution techniques, and visual representation of results are presented. Examples of solution technique validation through comparison with data from ground-based facilities are presented, along with results from computations at flight conditions. Computations at flight points indicate that real-gas effects have little or no effect on vehicle aerodynamics and, at these conditions, results from approximate techniques for determining surface heating are comparable with those obtained from Navier-Stokes solutions. Author (EI)

A94-60400* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRELIMINARY STRUCTURAL EVALUATION AND DESIGN OF THE HL-20
LANCE B. BUSH NASA Langley Research Center, Hampton, VA, JAMES C. ROBINSON, and DEBORAH M. WAHLS *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 30, no. 5 September-October 1993 p. 567-572 refs
(BTN-94-EIX94351137060) Copyright

A lifting body concept, the HL-20, was designed at NASA Langley Research Center, and a structural analysis of the configuration with a cylindrical pressurized crew cabin was presented. Loads for the vehicle were assembled from mission loading conditions such as abort, on-orbit pressurization, blast overpressure, aerodynamic maneuver, and touchdown. The critical loading conditions were identified, and resultant loads were mapped onto the structure in order to review the effects of the mission loading conditions. The HL-20 structural concept was sized for the mission loads, and the resulting structural weights were calculated. Author (EI)

A94-60405* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HUMAN FACTORS EVALUATION OF THE HL-20 FULL-SCALE MODEL
KELLI F. WILLSHIRE NASA Langley Research Center, Hampton, VA, LISA C. SIMONSEN, and WILLIAM L. WILLSHIRE, JR. *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 30, no. 5 September-October 1993 p. 606-614 refs
(BTN-94-EIX94351137065) Copyright

The human factors testing of the HL-20 personnel launch system full-scale model was conducted in both the vertical and horizontal positions at NASA Langley Research Center. Three main areas of testing were considered: an anthropometric fit evaluation, the ingress and egress of a 10-person crew, and pilot viewing. The subjects, ranging from the 5th to 95th percentile size, had sufficient clearance in the model, with the exception of the last two rows of seats and the cockpit area. Adjustable seat heights and/or placement of the seats farther forward would provide more headroom. In the horizontal position, the model's seat placement and aisle width allowed a quick and orderly 10-person egress for the no-keel (a structural support running the length on the aisle), 6-in.-high keel, and 12-in.-high keel conditions. Egress times were less than 20 s. For the vertical position, the model's long cylindrical shape with the ladder in the ceiling allowed a quick and orderly egress with average times less than 30 s. Ingress and egress procedures were demonstrated using shuttle partial-pressure suits. The reduced mobility experienced while wearing the suits did increase egress times, although they still remained acceptable. The window arrangement for pilot viewing was found to be reasonably acceptable, although slight modifications, such as an increased downward view, is desirable. Author (EI)

N94-35390*# National Aeronautics and Space Administration, Washington, DC.
AEROSPACE SAFETY ADVISORY PANEL Annual Report
Mar. 1993 82 p Original contains color illustrations
(NASA-TM-109840; NAS 1.15:109840) Avail: CASI HC A05/MF A01; 1 functional color page

The Aerospace Safety Advisory Panel (ASAP) provided oversight on the safety aspects of many NASA programs. In addition, ASAP undertook three special studies. At the request of the Administrator, the panel assessed the requirements for an assured crew return vehicle (ACRV) for the space station and reviewed the organization of the safety and mission quality function within NASA. At the behest of Congress, the panel formed an independent, ad hoc working group to examine the safety and reliability of the space shuttle main engine. Section 2 presents findings and recommendations. Section 3 consists of information in support of these findings and recommendations. Appendices A, B, C, and D, respectively, cover the panel membership, the NASA response to the findings and recommendations in the March 1992 report, a chronology of the panel's activities during the reporting period, and the entire ACRV study report. Derived from text

N94-35591*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CHALLENGING THE FUTURE - JOURNEY TO EXCELLENCE. AEROPROPULSION STRATEGIC PLAN FOR THE 1990'S
1990 27 p
(NASA-TM-109250; NAS 1.15:109250) Avail: CASI HC A03/MF A01

Over the past several months, the Lewis Aeropropulsion Management Council (AMC) has conducted a critical assessment of its strategic plan. This assessment clearly indicated a need for change, both in the aeropropulsion program emphasis and in the approach to carrying out that program. Customers sent a strong message that the program must improve the timeliness of research and technology products and services and must work more closely with them to develop and transfer new technology. The strategic plan defines AMC's vision for the future and underlying organizational values. It contains a set of broad strategies and actions that point the way toward achieving the goals of customer satisfaction, organizational effectiveness, and programmatic excellence. Those strategies are expected to form the basis for the development of specific tactical plans by Lewis aeropropulsion thrust teams, divisions, and branches. To guide tactical planning of the aeropropulsion program, this strategic plan outlines the agency's strategic directions and long-range aeronautics goals, the aeropropulsion goals and key objectives for achieving them, projections of Lewis aeropropulsion budgets, planned allocations of resources, and the processes that will be used to measure success in carrying out the strategic plan. CASI

N94-35605*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
FLIGHT MECHANICS/ESTIMATION THEORY SYMPOSIUM, 1994
KATHY R. HARTMAN, ed. Washington May 1994 533 p
Symposium held in Greenbelt, MD, 17-19 May 1994
(Contract RTOP 550-00-00)
(NASA-CP-3265; REPT-94B00060; NAS 1.55:3265) Avail: CASI HC A23/MF A04

This conference publication includes 41 papers and abstracts presented at the Flight Mechanics/Estimation Theory Symposium on May 17-19, 1994. Sponsored by the Flight Dynamics Division of Goddard Space Flight Center, this symposium featured technical papers on a wide range of issues related to orbit-attitude prediction, determination and control; attitude sensor calibration; attitude determination error analysis; attitude dynamics; and orbit decay and maneuver strategy. Government, industry, and the academic community participated in the preparation and presentation of these papers.

N94-35880*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AN OVERVIEW OF RECENT ADVANCES IN SYSTEM IDENTIFICATION

JER-NAN JUANG *In its* NASA Workshop on Distributed Parameter Modeling and Control of Flexible Aerospace Systems p 279-289 Jun. 1994

Avail: CASI HC A03/MF A06

This paper presents an overview of the recent advances in system identification for modal testing and control of large flexible structures. Several techniques are discussed including the Observer/Kalman Filter Identification, the Observer/Controller Identification, and the State-Space System Identification in the Frequency Domain. The System/Observer/Controller Toolbox developed at NASA Langley Research Center is used to show the applications of these techniques to real aerospace structures such as the Hubble spacecraft telescope and the active flexible aircraft wing. Author (revised)

N94-35902*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SECOND INTERNATIONAL SYMPOSIUM ON MAGNETIC SUSPENSION TECHNOLOGY, PART 2

NELSON J. GROOM, ed. and COLIN P. BRITCHER, ed., May 1994 258 p Symposium held in Seattle, WA, 11-13 Aug. 1993 Sponsored by NASA, Washington

(Contract RTOP 233-03-01-01)

(NASA-CP-3247-PT-2; L-17369-PT-2; NAS 1.55:3247-PT-2) Avail: CASI HC A12/MF A03

In order to examine the state of technology of all areas of magnetic suspension and to review related recent developments in sensors and controls approaches, superconducting magnet technology, and design/implementation practices, the 2nd International Symposium on Magnetic Suspension Technology was held at the Westin Hotel in Seattle, WA, on 11-13 Aug. 1993. The symposium included 18 technical sessions in which 44 papers were presented. The technical sessions covered the areas of bearings, bearing modelling, controls, vibration isolation, micromachines, superconductivity, wind tunnel magnetic suspension systems, magnetically levitated trains (MAGLEV), rotating machinery and energy storage, and applications. A list of attendees appears at the end of the document.

11

CHEMISTRY AND MATERIALS

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

A94-60275

TURBULENT COMBUSTION REGIMES FOR HYPERSONIC PROPULSION EMPLOYING HYDROGEN-AIR DIFFUSION FLAMES

G. BALAKRISHNAN California Univ., San Diego, La Jolla, CA and F. A. WILLIAMS *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 434-436 refs

(BTN-94-EIX94321333324) Copyright

Most designs of supersonic combustion engines involve turbulent hydrogen injection into the supersonic airstreams in the combustor which leads to nonpremixed combustion representative of turbulent diffusion flames. The present communication reports the results of calculations performed to determine the regimes in which this turbulent combustion is likely to occur. EI

A94-60348

RAMAN MEASUREMENTS AT THE EXIT OF A COMBUSTOR SECTOR

ANIL GULATI General Electric Co., Schenectady, NY *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 2 March-April 1994 p. 169-175 refs

(BTN-94-EIX94341338356) Copyright

Spontaneous Raman diagnostics are applied to the exit plane of an aircraft engine combustor sector fueled with both natural gas liquid fuel (kerosene). Profiles of temperature and major species are obtained at the sector exit. The Raman mean temperature data agrees well with thermocouple measurements at identical operating conditions. The rms profiles show up to 12 and 16% fluctuations in temperature at the centerline of the burner with natural gas and kerosene, respectively. The mean profiles of major species show the expected trends. Up to 6% unburnt oxygen is measured at the centerline with natural gas. The corresponding value with liquid fuel is 8%. Profiles of unburned hydrocarbons, carbons-monoxide, and hydrogen at the centerline indicate incomplete combustion at the measurement plane as also evidenced by the visible flame extending significantly beyond the sector exit. profiles of normalized rms mole fractions of major species are also presented. Finally, the Raman system is applied to a room temperature cell at elevated pressures to extend the system to this regime. The Raman signals increase linearly with pressure as expected. Author (EI)

A94-60853

EFFECT OF COARSE SECOND PHASE PARTICLES ON FATIGUE CRACK PROPAGATION OF AN AL-ZN-MG-CU ALLOY

R. GURBUZ Middle East Technical Univ., Ankara (Turkey) and S. P. ALPAY *Scripta Metallurgica et Materialia* (ISSN 0956-716X) vol. 30, no. 11 June 1, 1994 p. 1373-1376 refs

(BTN-94-EIX94301320144) Copyright

The aim of this work is to determine the role of the most commonly observed coarse second phase particles namely, Al7Cu2Fe, Mg2Si and CuAl2Mg on the stage 2 fatigue crack propagation of a 7050 aluminum alloy, which is widely used in airframe construction. Fe-containing Al7Cu2Fe particles do not contribute beneficially to fatigue life and strength of 7050 Al-alloy at the T73651 temper. EI

A94-60873

RETAINED MECHANICAL PROPERTIES OF A NEW AL-LI-CU-MG-AG ALLOY AS A FUNCTION OF THERMAL EXPOSURE TIME AND TEMPERATURE

A. P. REYNOLDS Analytical Services and Materials, Hampton, VA and D. M. ROYSTER *Scripta Metallurgica et Materialia* (ISSN 0956-716X) vol. 30, no. 11 June 1, 1994 p. 1485-1490 refs

(BTN-94-EIX94301320164) Copyright

Presented is a continuing study of the mechanical property stability of a new Al-Li-Cu-Mg-Ag alloy, RX818, after long term exposure to proposed high speed civil transport service temperatures. A 2.3 mm thick sheet in the T(sub 8) condition was used in this study. EI

A94-60892* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FIELD DEPLOYABLE NONDESTRUCTIVE IMPACT DAMAGE ASSESSMENT METHODOLOGY FOR COMPOSITE STRUCTURES

JOSEPH N. ZALAMEDA NASA. Langley Research Center, Hampton, VA, GARY L. FARLEY, and BARRY T. SMITH *Journal of Composites Technology and Research* (ISSN 0884-6804) vol. 16, no. 2 April 1994 p. 161-169 refs

(BTN-94-EIX94301321378) Copyright

A technique is being developed for rapid in-service detection and quantification of damage in composite airframe structures combining thermal and ultrasonic nondestructive evaluation (NDE). Thermal inspection techniques can be used to identify impact damage areas because it is fast, inspects large areas, and is noncontacting. Once an area of concern is identified, characterization of the depth and extent of the damage can be determined using ultrasonic volumetric imaging. Ultrasonic volumetric imaging quantifies the damage by giving a ply-by-ply view of the damage. Single-sided measurements were made on two types of samples, flat panels with through-the-thickness reinforcements and a 'Y'-stiffened skin. These samples were impacted with an aluminum ball at various velocities. The thermal results were compared with ultrasonic C-scans and the ultrasonic volumetric results were compared with destructive tests. The thermal images compared well with the C-scan images in both relative size and shape. It was found that the ultrasonic volumetric results gave a better indication of damage than achievable with the destructive specimen evaluation method. It has been shown that a multidisciplinary approach using thermal and ultrasonic NDE techniques is an efficient and informative inspection method for identifying and quantifying damage. Author (EI)

N94-35795 Galaxy Scientific Corp., Pleasantville, NJ.
UNLEADED AVGAS PROGRAM Interim Report
DAVID ATWOOD, AUGUSTO FERRARA, and PAULA RINGEBACH Mar. 1994 38 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A278650; DOT/FAA/CT-93/65) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The Federal Aviation Administration (FAA) Technical Center has performed extensive research toward finding an unleaded replacement for the current leaded aviation gasoline for general aviation aircraft. Described in the report are testing procedures, results to date, and future testing plans. The tests include vapor lock behavior, performance, endurance, detonation analysis, material compatibility, storage stability, volatility, emissions, water miscibility, and flight testing. The volatility tests include Reid Vapor Pressure, distillation, and vapor to liquid ratio tests. The endurance tests involved periodic checks of cylinder wear, particularly valve seat wear, leak downs to determine cylinder compression loss, and oil analysis. DTIC

12
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.

A94-60004
TRANSITION CORRELATIONS IN THREE-DIMENSIONAL BOUNDARY LAYERS
HELEN L. REED Arizona State Univ., Tempe, AZ and TIMOTHY S. HAYNES *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 923-929 refs
(BTN-94-EIX94301315968) Copyright

The stability and transition characteristics of three-dimensional boundary-layer flows are examined. First, the flow over a rotating cone is considered computationally. An increase of stagnation temperature is found to be only slightly stabilizing. Parameter studies on the simple rotating-cone geometry provide a large database of three-dimensional boundary-layer profiles and associated stability characteristics. To determine the possibility of correlating transition location with parameters based purely on basic-state three-dimensional boundary-layer profile characteristics, an empirical transition location of N = 9 is assumed. Transition location does not correlate with the traditional crossflow Reynolds number. A more appropriate definition for crossflow Reynolds number is found and termed R(sub cf). This new parameter appears to correlate for transition location when plotted against maximum crossflow velocity. Then, the flow over a yawed cone is considered experimentally. The correlation results obtained from the rotating-cone work are applied to the actual measured transition locations on two different yawed-cone models under various angle-of-attack conditions in two different experimental facilities and are verified. This correlation is only suggested as a tool for preliminary transition prediction and design in three-dimensional boundary layers; once a preliminary shape is selected, further linear stability theory or parabolized stability equation calculations are strongly urged. Author (EI)

A94-60017
SYMMETRY BREAKING IN VORTICAL FLOWS OVER CONES: THEORY AND NUMERICAL EXPERIMENTS
PETER M. HARTWICH Vigyan Research Associates, Inc., Hampton, VA *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1013-1020 refs
(BTN-94-EIX94301315981) Copyright

A stability analysis suggests that inviscid incompressible flow, independent from angle of attack and regardless whether attached or separated, over slender cones is only marginally stable in regions of decelerating circumferential flow. Reducing slenderness or surface curvature lowers the frequency spectrum of the harmonic perturbations and, thus, reduces their impact on the overall stability of flows over slender cones. Associating the notion of instabilities in such flows with the onset of vortex asymmetries provides a model for explaining a variety of flow phenomena in Navier-Stokes simulations of laminar (Re sub l = 0.6, 1.2, and 2.4 x 10(exp 6); l is body length) incompressible flows over three right circular cones (cone half-angle (delta) = 2.5, 5, and 10 deg) at moderate to high angles of attack (alpha/delta = 1, 2, and 3). Author (EI)

A94-60027
THREE-DIMENSIONAL CLOSURE OF THE PASSAGE-AVERAGED VORTICITY-POTENTIAL FORMULATION
XUDONG ZHANG Ecole Polytechnique, Montreal, ANDRE GARON, and RICARDO CAMARERO *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1080-1083 refs
(BTN-94-EIX94301315991) Copyright

Described in this paper is a modified three-dimensional model for simulating the rotor-stator interaction flow. Fully three-dimensional flows are individually computed in the rotor and stator blade rows of this model. EI

A94-60034
NUMERICAL INVESTIGATION OF CYLINDER WAKE FLOW WITH A REAR STAGNATION JET
J. D. MO Memphis State Univ., TN and M. R. DUKE, JR. *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1095-1098 refs
(BTN-94-EIX94301315998) Copyright

Wake flow characteristics, being a topic of interest for years now, create a considerable drag and an oscillating lateral force that causes mechanical vibrations in the cylinder. The mechanics of the increasing form drag is addressed. EI

A94-60039
LOCALIZATION OF AEROELASTIC MODES IN MISTUNED HIGH-ENERGY TURBINES
CHRISTOPHE PIERRE Univ of Michigan, Ann Arbor, MI, TODD E. SMITH, and DURBHA V. MURTHY *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 318-328 refs
(BTN-94-EIX94321333307) Copyright

The effects of blade mistuning on the aeroelastic vibration characteristics of high-energy turbines are investigated, using the first stage of the oxidizer turbopump in the Space Shuttle main rocket engine as an example. A modal aeroelastic analysis procedure is used in concert with a linearized unsteady aerodynamic theory that accounts for the effects of blade thickness, camber, and steady loading. High sensitivity of the dynamic characteristics of mistuned rotors is demonstrated. In particular, the aeroelastic free vibration modes become localized to a few blades, possibly leading to rogue blade failure, and the locus of the aeroelastic eigenvalues loses its regular structure when small mistuning (of the order usually present in actual rotors) is introduced. Perturbation analyses that yield physical insights into these phenomena are presented. A powerful but easily calculated stochastic sensitivity measure that allows the global prediction of mistuning effects is developed. Author (EI)

A94-60040

AXIAL COMPRESSOR PERFORMANCE DURING SURGE

I. J. DAY Univ of Cambridge, Cambridge, United Kingdom *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 329-336 refs

(BTN-94-EIX94321333308) Copyright

There is limited information available in the literature about flow conditions in axial compressors during surge. This article presents detailed measurements from a low-speed test rig instrumented to pick up details of axial and circumferential flow disturbances. The results show that surge is initiated by rotating stall, and that the ensuing surge cycle is a sequence of well ordered cause-and-effect events. The differences in cycle behavior between 'classic surge' and 'deep surge' are investigated, and it is shown that the shape of the compressor characteristic determines which of these will occur. From the results, it is also concluded that some important factors, such as overall pressure rise and size of hysteresis loop, have not received sufficient attention in existing techniques for predicting the rotating stall/surge boundary. In line with these findings, an Appendix by E. M. Greitzer presents a more general version of the 'B Parameter', which takes into account the influence of compressor design variables on the stalling behavior of the compressor. Author (EI)

A94-60043

DYNAMIC AEROELASTIC STABILITY OF VERTICAL-AXIS WIND TURBINES UNDER CONSTANT WIND VELOCITY

FRED NITZSCHE DLR-Inst of Aeroelasticity, Goettingen, Germany *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 348-355 refs

(BTN-94-EIX94321333311) Copyright

The flutter problem associated with the blades of a class of vertical-axis wind turbines called Darrieus is studied in detail. The spinning blade is supposed to be initially curved in a particular shape characterized by a state of pure tension at the blade cross section. From this equilibrium position a three-dimensional linear perturbation pattern is superimposed to determine the dynamic aeroelastic stability of the blade in the presence of free wind speed by means of the Floquet-Lyapunov theory for periodic systems. Author (EI)

A94-60044*

LOW-NOISE, HIGH-STRENGTH, SPIRAL-BEVEL GEARS FOR HELICOPTER TRANSMISSIONS

DAVID G. LEWICKI NASA Lewis Research Center, Cleveland, OH, ROBERT F. HANDSCHUH, ZACHARY S. HENRY, and FAYDOR L. LITVIN *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 356-361 refs

(BTN-94-EIX94321333312) Copyright

Advanced-design spiral-bevel gears were tested in an OH-58D helicopter transmission using the NASA 500-hp Helicopter Transmission Test Stand. Three different gear designs tested included: the current design of the OH-58D transmission; a higher-strength design the same as the current but with a full fillet radius to reduce gear tooth bending stress (and thus, weight); and a lower-noise design the same as the high-strength but with modified tooth geometry to reduce transmission error and noise. Noise, vibration, and tooth strain tests were performed and significant gear stress and noise reductions were achieved. Author (EI)

A94-60101

ANALYSIS OF MULTIFASTENER COMPOSITE JOINTS

O. H. GRIFFIN, JR. Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, M. W. HYER, D. COHEN, M. J. SHUART, S. R. YALAMANCHILI, and C. B. PRASAD *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 2 March-April 1994 p. 278-284 refs

(BTN-94-EIX94311330690) Copyright

A new numerical procedure for determining load proportioning in multifastener mechanical joints in composite plates is presented. The joints are loaded in double lap fashion in tension with pins through the holes. The commercial finite element program ABAQUS is used to predict the load proportioning among fasteners using two independent plane stress finite element models, one representing the composite inner lap and one representing the two steel outer laps, interacting through rigid circular surfaces. The circular surfaces effectively represent rigid pins. Load proportioning is predicted for a number of geometries. Excellent correlation with experimental data is obtained. Experimental and computed surface strains are also found to compare well. The assumption of a radial cosine distribution of contact stress between fastener and hole boundary, often used in these studies, is shown to be substantially in error for some holes. Author (EI)

A94-60131

MEASUREMENT OF DIFFUSION IN FLUID SYSTEMS: APPLICATIONS TO THE SUPERCRITICAL FLUID REGION

THOMAS J. BRUNO National Inst. of Standards and Technology, Boulder, CO *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 8, no. 2 April-June 1994 p. 329-333 refs

(BTN-94-EIX94311330660) Copyright

The experimental procedures that are applicable to the measurement of diffusion in supercritical fluid solutions are reviewed. This topic is of great importance to the proper design of advanced aircraft and turbine fuels, since the fuels on these aircraft may sometimes operate under supercritical fluid conditions. More specifically, we will consider measurements of the binary interaction diffusion coefficient D exp 12 of a solute (species 1) and the solvent (species 2). In this discussion, the supercritical fluid is species 2, and the solute, species 1, will be at a relatively low concentration, sometimes approaching infinite dilution. After a brief introduction to the concept of diffusion, we will discuss in detail the use of chromatographic methods, and then briefly treat light scattering, nuclear magnetic resonance spectra, and physical methods. Author (EI)

A94-60137

INVERSE DESIGN OF SUPER-ELLIPTIC COOLING PASSAGES IN COATED TURBINE BLADE AIRFOILS

GEORGE S. DULIKRAVICH Pennsylvania State Univ., University Park, PA and THOMAS J. MARTIN *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 8, no. 2 April-June 1994 p. 288-294 refs

(BTN-94-EIX94311330654) Copyright

A highly accurate and reliable algorithm capable of performing automatic inverse design of coolant flow passage numbers, shapes, sizes, and locations inside coated solid objects has been developed. The use has the freedom to specify arbitrary temperatures and heat fluxes at the points on the outer surface of the object, and either temperatures or heat fluxes on the surfaces of the yet unknown coolant flow passages. The number of passages required could be guessed and the algorithm will automatically eliminate the unnecessary passages. The method allows even inexperienced designers to achieve an optimal configuration of coolant passages in a single computer run while satisfying user-specified manufacturing constraints that were incorporated via a barrier function method. The optimization algorithms used in this inverse design code were based on gradient search and on a modified Newton search. A simple method for escaping from local minima has been implemented that involves switching between two different formulations of the objective function. The optimal value of the gradient search parameter was found using a simple method of fitting a highly accurate spline through a set of points in the cost function/search parameter plane, and seeking out the value that will generate minimal error. Author (EI)

A94-60139

CONJUGATE CONDUCTION-CONVECTION HEAT TRANSFER WITH A HIGH-SPEED BOUNDARY LAYER

FREDERICK L. SHOPE Arnold Engineering Development Center, Arnold AFS, TN *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 8, no. 2 April-June 1994 p. 275-281 refs (BTN-94-EIX94311330652) Copyright

A space-marching boundary-layer program has been extensively modified to model conjugate conduction-convection heat transfer for the case of co-flowing high-speed gas and liquid coolant. Solid body conduction is modeled as one-dimensional, constant property heat transfer. The coolant is modeled empirically as a bulk fluid with combined forced convection and subcooled nucleate boiling. The flow solver was modified to solve the group of conjugate boundary equations simultaneously and implicitly with the existing momentum and energy equations for the gas. The resulting conjugate conduction-convection program has been applied to analysis of failure of a backside water-cooled nozzle for a high enthalpy, supersonic wind tunnel. The computational results have been used to establish that the primary failure mode is nucleate-boiling burnout and to propose a numerical burnout limit applicable to the specific nozzle configuration. Author (EI)

A94-60161

IN-FLIGHT VELOCITY MEASUREMENTS USING LASER DOPPLER ANEMOMETRY

H. W. JENTINK National Aerospace Lab., Amsterdam, Netherlands Antilles, M. STIEGLMEIER, and C. TROPEA *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 444-446 refs (BTN-94-EIX94311329139) Copyright

In this study, the newly designed Laser Doppler anemometry (LDA) is used to measure boundary-layer profiles on a twin engine Fairchild Swearingen Metro II aircraft in flight. Demonstrated are the potentials of the technique for in-flight applications. Also described are the operational aspects of the equipment. EI

A94-60175

COMPUTATIONAL ANALYSIS OF OFF-DESIGN WAVERIDERS

X. HE Oklahoma Univ., Norman, OK and M. L. RASMUSSEN *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 345-353 refs

(BTN-94-EIX94311329125) Copyright

Comprehensive inviscid and viscous numerical simulations of hypersonic flow past nonconical rounded-nose waveriders are presented. The flowfields and aerodynamic forces at off-design conditions are determined inviscidly by a space marching CFD code with the initial data plane provided by a time marching Navier-Stokes CFD code. Off-design conditions include off-design Mach numbers, angles of attack, and rounded leading edges. A wide range of waverider configurations is investigated and compared. On-design viscous flows past a waverider with a sharp leading edge at M(sub infinity) = 4 and at different Reynolds numbers and temperature boundary conditions are obtained by a time marching Navier-Stokes solver. These calculations show the effects of viscous interactions, which are influential near the leading edges, and determine the viscous drag. The inviscid calculations show that L/D decreases as M(sub infinity) increases (with alpha = 0). At the on-design Mach numbers, the maximum L/D may occur at slight positive or negative alpha, depending on the shape of the waverider, and zero lift occurs at a negative alpha approximately equal to half of the body thickness. The effects of slight leading-edge blunting produce only local effects in the flowfield and small losses in L/D. The characters of the flowfields in the base plane are illustrated. Author (EI)

A94-60209

WIDE-EYE (TM)/HELMET MOUNTED DISPLAY SYSTEM FOR ROTORCRAFT APPLICATIONS

LOGAN R. ZINTSMASTER Kaiser Electronics, San Jose, CA *IEEE Aerospace and Electronic Systems Magazine* (ISSN 0885-8985) vol. 9, no. 3 March 1994 p. 6-11

(BTN-94-EIX94331335528) Copyright

This paper describes the Kaiser Electronics developed WIDE-EYE Helmet Mounted Display System that uses a Kaiser unique aircraft retained unit/pilot retained unit (ARU/PRU) helmet display unit design. The overall system block diagram is presented and each major subsystem is described in detail. Extensions to the basic design to add full color capability are also described. Author (EI)

A94-60210

FINDER, A SYSTEM PROVIDING COMPLEX DECISION SUPPORT FOR COMMERCIAL TRANSPORT REPLANNING OPERATIONS

VINCENT BITTERMANN Commercial Avionics Div., Velizy (France), GUY DEKER, PIERRE SASSUS, JEAN-CHRISTOPHE MIELNIK, and JEAN-MARIE JUD *IEEE Aerospace and Electronic Systems Magazine* (ISSN 0885-8985) vol. 9, no. 3 March 1994 p. 12-18 refs (BTN-94-EIX94331335529) Copyright

Decision-aid systems, likely to appear in future aircraft generations, could play a central role in the cockpit thanks to the broad spectrum of functionalities and decision support facilities they will offer to the crew. As part of such systems, the exploratory FINDER mock-up is a knowledge based system (KBS) designed to help crew members continually optimize their flight plan by suggesting solutions considering exhaustive information related to flight context, either on pilot request or upon external information occurrence. The successful evaluation by Air France pilots of that first mock-up dedicated to diversion procedure on pilot request has led to the current development of an enhanced system with nominal enroute operations and real-time capabilities. Nominal enroute operations concern the optimization with respect to an evolutive constraining of favoring environment (due to weather, traffic or regulated areas, and ETOPS constraints). This study paves the way for a future flight assistant system concept which is already under investigation and may take place in SEXTANT Avionique's future development steps. Author (EI)

A94-60256

SHEAR BUCKLING RESPONSE OF TAILORED COMPOSITE PLATES

SHERRILL B. BIGGERS Clemson Univ, Clemson, SC and STEPHANE S. PAGEAU *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 1100-1103 refs

(BTN-94-EIX94301316000) Copyright

The piecewise-uniform approach to tailoring as a means of improving the shear buckling loads of composite plates is evaluated. The primary objective is to determine the tailoring patterns and the degree of concentration of the material used. EI

A94-60268

STRUCTURE AND PENETRATION OF A SUPERCRITICAL FLUID JET IN SUPERSONIC FLOW

J. C. HERMANSON United Technologies Research Cent, East Hartford, CT, United States, P. PAPAS, and I. W. KAY *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 3 May-June 1994 p. 387-394 refs

(BTN-94-EIX94321333317) Copyright

The penetration characteristics and turbulent structure of transverse supercritical nitrogen (and reference subcooled liquid ethanol) jets were examined experimentally by the use of spark shadowgraph imaging. For given injection and freestream stagnation pressures, supercritical nitrogen jets penetrated significantly less into the supersonic stream than subcooled ethanol jets. The jet penetration further decreased with increases in the degree of superheat. The supercritical nitrogen jets were characterized by large-scale structure not generally observed for the case of subcooled ethanol injection. Practical difficulties inherent in the use of liquid fuel simulants in unheated supersonic flows for the simulation of supersonic combustion environments are discussed. Author (EI)

A94-60335
STRUCTURAL INTEGRITY AND CONTAINMENT ASPECTS OF SMALL GAS TURBINE ENGINES
S. S. GUPTA Pratt & Whitney Canada and R. GOMUC Canadian *Aeronautics and Space Journal* (ISSN 0008-2821) vol. 40, no. 1 March 1994 p. 19-26 refs
(BTN-94-EIX94331337500) Copyright
Structural integrity of rotating components in gas turbine engines is very crucial since their failure implies high impact energy, which, if uncontained, could mean damage to aircraft structures, controls, and so forth, and, in the worst scenario, even loss of lives. This final consequence has led to very stringent airworthiness regulations for engine/aircraft certifications. This paper discusses the historical statistics of noncontainment events in turbofans, turboprops, and turboshafts and shows how the damage severity varies between different applications and how changes to regulations are continuing in order to improve the reliability of aircraft/rotorcraft. The paper also presents design challenges resulting from the analysis complexity of containment/noncontainment event and the way Pratt & Whitney Canada design/analysis/test system caters to all the requirements. The weight and cost impact of possible changes to current regulations are also presented. Author (EI)

A94-60352* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPROXIMATE SIMILARITY PRINCIPLE FOR A FULL-SCALE STOVL EJECTOR
WENDY S. BARANKIEWICZ NASA Lewis Research Center, Cleveland, OH, GAIL P. PERUSEK, and MOUNIR B. IBRAHIM *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 2 March-April 1994 p. 198-203 refs
(BTN-94-EIX94341338360) Copyright
Full-scale ejector experiments are expensive and difficult to implement at engine exhaust temperatures. For this reason the utility of using similarity principles, in particular the Munk and prim principle for isentropic flow, was explored. Static performance test data for a full-scale thrust augmenting ejector were analyzed for primary flow temperature up to 1560 R. At different primary temperatures, exit pressure contours were compared for similarity. A nondimensional flow parameter is then used to eliminate primary nozzle temperature dependence and verify similarity between the hot and cold flow experiments. Under the assumption that an appropriate similarity principle can be established, properly chosen performance parameters were found to be similar for both flow and cold flow model tests. Author (EI)

A94-60412
NATURAL CONVECTION IN A CAVITY WITH FINS ATTACHED TO BOTH VERTICAL WALLS
GEORGE N. FACAS Trenton State College, Trenton, NJ *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 7, no. 4 October-December 1993 p. 555-560 refs
(BTN-94-EIX94351142119) Copyright
Numerical calculations are presented for two-dimensional natural convection flow inside an air-filled cavity with fins/baffles - of length 0.1, 0.3, and 0.5 of the cavity width - attached along both the heated and the cooled side of the cavity. The governing equations in the stream function-vorticity formulation are solved using finite differences. The Arakawa differencing scheme is used to represent the convection terms. Flow characteristics are investigated for three baffle lengths and Grashof numbers in the range of 9.0 x 10(exp 3) to 1.0 x 10(exp 5). A multicellular flow structure is found to exist for a baffle length of 0.1. However, when the baffle length is equal to 0.3 or greater, the fluid flow breaks down into secondary circulations—in addition to the primary circulation—and that, in turn, results in higher heat transfer rates across the two sides of the cavity. Author (EI)

A94-60421
MEASUREMENT AND PREDICTION OF DYNAMIC TEMPERATURES IN UNSYMMETRICALLY COOLED GLASS WINDOWS
ROBERT E. FIELD Northern Illinois University, DeKalb, IL and RAYMOND VISKANTA *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 7, no. 4 October-December 1993 p. 616-623 refs
(BTN-94-EIX94351142128) Copyright
Semitransparent materials, such as glass, have many applications in high-temperature environments such as supersonic aircraft canopies and spacecraft windows. At elevated temperatures the energy transfer within semitransparent materials is dominated by radiation, making both the prediction and measurement of internal temperatures substantially more difficult than for opaque substances. Experimental measurement of the dynamic internal temperature distribution in soda-lime glass plates cooling from an initial temperature of approximately = 550 C has been performed. The boundary conditions on the plates were established using the laboratory ambient for the front surface and employing a radiant heater at the rear surface. The surface and internal plate temperatures were measured using thermocouples fused in the glass. The temperature data are compared to predictions obtained from the solution of the transient energy equation where the internal radiative transfer has been accounted for using rigorous radiative transfer theory. The predicted and measured temperatures, experimental method, process used to fuse the thermocouples in the test plates, and the formulation of the energy equation for semitransparent materials are discussed. Author (EI)

A94-60951
PROCESSING YTTRIUM BARIUM COPPER OXIDE SUPERCONDUCTOR IN NEAR-ZERO GRAVITY
DONALD R. PETTIT Los Alamos Natl. Lab., Los Alamos, NM, DEAN E. PETERSON, KIMBERLY A. KUBAT-MARTIN, JOHN J. PETROVIC, HASKELL SHEINBERG, YATES COULTER, and DELBERT E. DAY *Journal of Crystal Growth* (ISSN 0022-0248) vol. 139, no. 3-4 May 2 1994 p. 302-308 refs
(BTN-94-EIX94311332378) Copyright
The effects of processing YBa2Cu3O(x) (Y123) superconductor in the near-zero gravity (0 g) environment provided by the NASA KC-135 airplane flying on parabolic trajectories were studied. A new sheet float zone furnace, designed for this study, enabled fast temperature ramps. Up to an 18 g sample was processed with each parabola. Samples of Y123 were processed as bulk sheets and composites containing Ag and Pd. The 0 g processed samples were multi-phase yet retained a localized Y123 stoichiometry where a single ground-based (1 g) oxygen anneal at temperatures of 800 C recovered nearly 100 vol% superconducting Y123. The 1 g processed control samples remained multi-phase after the same ground-based anneal with less than 45 vol% as superconducting Y123. The superconducting transition temperature was 91 K for both 0 g and 1 g processed samples. Melt texturing of bulk Y123 in 0 g produced aligned grains about a factor of three larger than in analogous 1 g samples. Transport-critical current densities were at or below 18 A/sq cm, due to the formation of cracks caused by the rapid heating rates required by the short time at 0 g. Author (EI)

N94-34581# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
AN ASSESSMENT OF FATIGUE DAMAGE AND CRACK GROWTH PREDICTION TECHNIQUES [L'EVALUATION DE L'ENDOMMAGEMENT EN FATIGUE ET LES TECHNIQUES DE PREDICTION DE LA PROPAGATION DES FISSURES]
Mar. 1994 278 p 77th Meeting held in Bordeaux, France, 29-30 Sep. 1993
(AGARD-R-797; ISBN-92-835-0734-7) Copyright Avail: CASI HC A13/MF A03
Fatigue is an important consideration in structural design and monitoring of continued airworthiness of military aircraft. This Workshop titled 'An Assessment of Fatigue Damage and Crack Growth Prediction Techniques' provided a forum for an in-depth discussion of the correlation between in-service experience and results from analytical predictive models, specimen level tests, component tests, and full-scale tests. Additionally, it made possible an examination of the

operating standards that different countries adopt with respect to various elements in the design process for assessment of fatigue damage.

N94-34586# Pisa Univ. (Italy). Dept. of Aerospace Engineering.
AN ASSESSMENT OF FATIGUE CRACK GROWTH PREDICTION MODELS FOR AEROSPACE STRUCTURES
A. SALVETTI, L. LAZZERI, and A. PIERACCI *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 17 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

The current state of crack growth prediction models for aerospace applications is reviewed with special reference to limitations and possible improvements. The present work aims at examining the different crack growth prediction models with reference to effective application for practical use (i.e. with the objective of identifying the experimental data necessary to apply the model) and at quantifying the reliability of the different models. Both crack growth prediction models currently used by aerospace industries and prediction methods under development within the scientific community are considered. An experimental program has been carried out to help achieve the objectives. Author (revised)

N94-34587# McDonnell-Douglas Corp., Saint Louis, MO.
A COMBINED APPROACH TO BUFFET RESPONSE ANALYSES AND FATIGUE LIFE PREDICTION
J. H. JACOBS and R. PEREZ *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 11 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

Experimental measurement and neural network based prediction of wind tunnel model empennage random pressures are discussed. Artificially generated neural network power spectral densities of surface pressures are used to augment existing data and then load an elastic finite element model to obtain response spectra. Details on the use of actual response spectra from flight test data are also discussed. A random spectra fatigue method is described which effectively combines buffet and maneuver loads into a time series based on aircraft usage data. A peak-valley damage analysis procedure is employed to compute the aggregate fatigue life of the structure based on five combined load time series information. Applications of the method as a continual learning tool for buffet response spectra is elaborated. Author (revised)

N94-34588# Deutsche Aerospace A.G., Munich (Germany). Military Aircraft Div.
NOTCH FATIGUE ASSESSMENT OF AIRCRAFT COMPONENTS USING A FRACTURE MECHANICS BASED PARAMETER
CHR. BOLLER, M. BUDERATH, P. HEULER, and M. VORMWALD *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 16 p Mar. 1994
Copyright Avail: CASI HC A03/MF A03

Fatigue life evaluation has been performed for flight-by-flight loaded coupons and real aircraft structural components made of 7075-T7351 using the local strain approach and a fracture mechanics based parameter. Results show that this approach can well compete with the traditionally used nominal stress approach. The advantages are a better understanding of material's fatigue behavior and a less experimental effort required for the determination of baseline data making the local strain approach interesting also for redesign within aircraft mid-life improvement updates. Author

N94-34590*# Army Vehicle Structures Lab., Hampton, VA.
ROTORCRAFT FATIGUE LIFE-PREDICTION: PAST, PRESENT, AND FUTURE
RICHARD A. EVERETT, JR. and W. ELBER *In* AGARD, An Assessment of Fatigue Damage and Crack Growth Prediction Techniques 31 p Mar. 1994 Sponsored by NASA. Langley
Copyright Avail: CASI HC A03/MF A03

In this paper the methods used for calculating the fatigue life of metallic dynamic components in rotorcraft is reviewed. In the past, rotorcraft fatigue design has combined constant amplitude tests of full-scale parts with flight loads and usage data in a conservative manner to provide 'safe life' component replacement times. This is in contrast to other industries, such as the automobile industry, where spectrum loading in fatigue testing is a part of the design procedure. Traditionally, the linear cumulative damage rule has been used in a deterministic manner using a conservative value for fatigue strength based on a one in a thousand probability of failure. Conservatism on load and usage are also often employed. This procedure will be discussed along with the current U.S. Army fatigue life specification for new rotorcraft which is the so-called 'six nines' reliability requirement. In order to achieve the six nines reliability requirement the exploration and adoption of new approaches in design and fleet management may also be necessary if this requirement is to be met with a minimum impact on structural weight. To this end a fracture mechanics approach to fatigue life design may be required in order to provide a more accurate estimate of damage progression. Also reviewed in this paper is a fracture mechanics approach for calculating total fatigue life which is based on a crack-closure small crack considerations. Author

N94-34721*# Washington Univ., Saint Louis, MO.
COMBINED LAURA-UPS SOLUTION PROCEDURE FOR CHEMICALLY-REACTING FLOWS M.S. Thesis
WILLIAM A. WOOD 6 Jun. 1994 78 p
(NASA-TM-107964; NAS 1.15:107964) Avail: CASI HC A05/MF A01

A new procedure seeks to combine the thin-layer Navier-Stokes solver LAURA with the parabolized Navier-Stokes solver UPS for the aerothermodynamic solution of chemically-reacting air flowfields. The interface protocol is presented and the method is applied to two slender, blunted shapes. Both axisymmetric and three dimensional solutions are included with surface pressure and heat transfer comparisons between the present method and previously published results. The case of Mach 25 flow over an axisymmetric six degree sphere-cone with a noncatalytic wall is considered to 100 nose radii. A stability bound on the marching step size was observed with this case and is attributed to chemistry effects resulting from the noncatalytic wall boundary condition. A second case with Mach 28 flow over a sphere-cone-cylinder-flare configuration is computed at both two and five degree angles of attack with a fully-catalytic wall. Surface pressures are seen to be within five percent with the present method compared to the baseline LAURA solution and heat transfers are within 10 percent. The effect of grid resolution is investigated and the nonequilibrium results are compared with a perfect gas solution, showing that while the surface pressure is relatively unchanged by the inclusion of reacting chemistry the nonequilibrium heating is 25 percent higher. The procedure demonstrates significant, order of magnitude reductions in solution time and required memory for the three dimensional case over an all thin-layer Navier-Stokes solution. Author

N94-34722*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN ORIENTED STRUCTURAL ANALYSIS
GARY L. GILES Jun. 1994 12 p Proposed for presentation at the Second International Conference on Computational Structures Technology, Athens, Greece, 30 Aug. - 1 Sep. 1994
(Contract RTOP 509-10-11-02)
(NASA-TM-109124; NAS 1.15:109124) Avail: CASI HC A03/MF A01

Desirable characteristics and benefits of design oriented analysis methods are described and illustrated by presenting a synoptic description of the development and uses of the Equivalent Laminated Plate Solution (ELAPS) computer code. ELAPS is a design oriented structural analysis method which is intended for use in the early design of aircraft wing structures. Model preparation is minimized by using a few large plate segments to model the wing box structure. Computational efficiency is achieved by using a limited number of global displacement functions that encompass all segments over the wing planform. Coupling with other codes is facilitated since the output quantities such as

deflections and stresses are calculated as continuous functions over the plate segments. Various aspects of the ELAPS development are discussed including the analytical formulation, verification of results by comparison with finite element analysis results, coupling with other codes, and calculation of sensitivity derivatives. The effectiveness of ELAPS for multidisciplinary design application is illustrated by describing its use in design studies of high speed civil transport wing structures.
Author

N94-34966*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PHYSICS OF FORCED UNSTEADY SEPARATION
LAWRENCE W. CARR, ed. Mar. 1992 328 p Workshop held in Moffett Field, CA; sponsored by AFOSR and ARO
(Contract RTOP 505-59-53)
(NASA-CP-3144; A-91055; NAS 1.55:3144) Avail: CASI HC A15/MF A03

This report contains the proceedings of a workshop held at NASA Ames Research Center in April 1990. This workshop was jointly organized by NASA, the Air Force Office of Scientific Research (AFOSR), and the Army Research Office (ARO), and was directed toward improved understanding of the physical processes that cause unsteady separation to occur. The proceedings contain the written contributions for the workshop, and include selected viewgraphs used in the various presentations.

N94-34976*# Lockheed Missiles and Space Co., Sunnyvale, CA.
WILL THE REAL DYNAMIC INSTABILITY MECHANISM PLEASE BE RECOGNIZED!
L. E. ERICSSON *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 163-175 Mar. 1992
Avail: CASI HC A03/MF A03

There is a richness of flow mechanisms that can cause dynamic instability. Only after asking the right questions and carefully considering the answers can the fluid dynamic source of the observed dynamic instability be recognized. This is illustrated by two carefully chosen examples.
Author

N94-34980*# United Technologies Research Center, East Hartford, CT.
DEPARTURE SOLUTIONS OF THE UNSTEADY THIN-LAYER AND FULL NAVIER-STOKES EQUATIONS SOLVED USING STREAMLINE CURVATURE BASED ITERATION TECHNIQUES
M. BARNETT, D. TURNER, and A. P. ROTHMAYER *In* NASA. Ames Research Center, Physics of Forced Unsteady Separation p 209-218 Mar. 1992 Sponsored in part by NSF
Avail: CASI HC A02/MF A03

The development of a thorough understanding of the mechanisms for vortex eruptions from viscous layers, which are believed to be associated with phenomena such as dynamic stall onset and transition, is crucial if accurate models of such phenomena are to be formulated. The development of such models may, in turn, allow for the possibility that such effects could be accounted for during the design of various aerodynamic devices such as wings, helicopter rotors, and turbomachinery blading and thus lead to designs which are stall free or stall resistant and which have better stall-recovery properties. The present investigation is being conducted as part of an effort to develop analytical and numerical tools which can be used to help improve our understanding of the vortex-eruption mechanism at high Reynolds numbers. The addition of the normal-momentum equation to the classical unsteady boundary-layer equations is crucial according to recent asymptotic analyses of the vortex-eruption problem and is a key feature of the analyses being developed by the present authors. The purpose of this paper is as follows: to describe departure solution behavior observed when using unsteady, streamline-curvature based solution procedures in which nontrivial transverse pressure gradient effects are included; and to show that special treatment of the time-derivative of the normal velocity is needed to eliminate the ill-posed solution behavior, which is observed when small spatial and temporal step sizes are used.
Author (revised)

N94-35074* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE THERMAL ISOLATION FOR TEMPERATURE RESPONSIVE SENSORS Patent
SCOTT D. MARTINSON, inventor (to NASA), DAVID L. GRAY, inventor (to NASA), DEBRA L. CARRAWAY, inventor (to NASA), and DANIEL C. REDA, inventor (to NASA) 17 May 1994 8 p Filed 2 Jan. 1992 Supersedes N92-29954 (30 - 20, p 3446)
(NASA-CASE-LAR-14612-1; US-PATENT-5,311,772; US-PATENT-APPL-SN-820431; US-PATENT-CLASS-73-147; US-PATENT-CLASS-73-204.18; INT-PATENT-CLASS-G01F-1/68; INT-PATENT-CLASS-G01M-9/11) Avail: US Patent and Trademark Office

The detection of flow transition between laminar and turbulent flow and of shear stress or skin friction of airfoils is important in basic research for validation of airfoil theory and design. These values are conventionally measured using hot film nickel sensors deposited on a polyimide substrate. The substrate electrically insulates the sensor and underlying airfoil but is prevented from thermally isolating the sensor by thickness constraints necessary to avoid flow contamination. Proposed heating of the model surface is difficult to control, requires significant energy expenditures, and may alter the basic flow state of the airfoil. A temperature responsive sensor is located in the airflow over the specified surface of a body and is maintained at a constant temperature. An active thermal isolator is located between this temperature responsive sensor and the specific surface of the body. The total thickness of the isolator and sensor avoid any contamination of the flow. The temperature of this isolator is controlled to reduce conductive heat flow from the temperature responsive sensor to the body. This temperature control includes (1) operating the isolator at the same temperature as the constant temperature of the sensor; and (2) establishing a fixed boundary temperature which is either less than or equal to, or slightly greater than the sensor constant temperature. The present invention accordingly thermally isolates a temperature responsive sensor in an energy efficient, controllable manner while avoiding any contamination of the flow.
Official Gazette of the U.S. Patent and Trademark Office

N94-35224*# NYMA, Inc., Brook Park, OH.
DATA REDUCTION PROCEDURES FOR LASER VELOCIMETER MEASUREMENTS IN TURBOMACHINERY ROTORS Final Report
JAN LEPICOVSKY Jul. 1994 11 p Presented at the 7th International Symposium on Applications of Laser Techniques to Fluid Mechanics, Lisbon, Portugal, 11-14 Jul. 1994; sponsored by ADIST, CML, CTAMFUTL, Direccao Geral de Turismo, European Research Office, United States Army, Navy and Air Force Depts., Fundacao Calouste Gulbenkian, FLAD, IST, ITEC, JNICT, and TAP - Air Portugal
(Contract NAS3-27186; RTOP 505-62-20)
(NASA-CR-195343; E-8920; NAS 1.26:195343) Avail: CASI HC A03/MF A01

Blade-to-blade velocity distributions based on laser velocimeter data acquired in compressor or fan rotors are increasingly used as benchmark data for the verification and calibration of turbomachinery computational fluid dynamics (CFD) codes. Using laser Doppler velocimeter (LDV) data for this purpose, however, must be done cautiously. Aside from the still not fully resolved issue of the seed particle response in complex flowfields, there is an important inherent difference between CFD predictions and LDV blade-to-blade velocity distributions. CFD codes calculate velocity fields for an idealized rotor passage. LDV data, on the other hand, stem from the actual geometry of all blade channels in a rotor. The geometry often varies from channel to channel as a result of manufacturing tolerances, assembly tolerances, and incurred operational damage or changes in the rotor individual blades.
Author

N94-35226# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA
9 Mar. 1994 46 p Transl. into ENGLISH from various Russian articles
(JPRS-UST-94-006) Avail: CASI HC A03/MF A01

Translated articles cover the following topics: electrophysical properties of heterogeneous composites in high-frequency region of electromagnetic field; Zont-M helicopter deck landing signal generating system; retrieval of geopotential and temperature fields by radio measurement method for model of general circulation of atmosphere: computation method; global climate observing system; reflection of internal wave packets from plane rigid boundary; vortical systems behind cylinder in continuously stratified fluid; three-dimensional problem of flow of multilayer fluid of finite and infinite depth around source; energy losses in radiation of gravity waves accompanying characteristics of submerged body; and anomalous frequency dispersion of internal waves in ocean. Author

N94-35342# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA
10 Feb. 1994 78 p Transl. into ENGLISH from various Russian articles
(JPRS-UST-94-005) Avail: CASI HC A05/MF A01

Translated articles cover the following topics: optimal rotation axis of satellite TV receiving antenna; measurement of structural parameters of signals, received from identified targets; diagnostics of gallium arsenide films grown by the atomic-layer epitaxy method; acoustic diagnostic methods in new-generation aerospace equipment development; analysis of cryogenic field heat exchangers-gasifiers in aircraft gas turbine engines; mass characteristics optimization of hydrogen hydride spacecraft refrigerator; lift-to-drag ratio at supersonic velocities; delta wing in hypersonic viscous gas flow with intermediate interaction allowing for wake flow; numerical simulation of chemically and thermodynamically nonequilibrium flows at low and intermediate Reynolds numbers; measurement of the total content and altitude distribution of ozone from the Meteor-3 satellites; comparison of model profiles of stratosphere trace species and observational data; and simulation of rising of gas-dust cloud forming during impact of asteroids and comets. CASI

N94-35385# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA
3 May 1994 62 p Transl. into ENGLISH from various Russian articles
(JPRS-UST-94-010) Avail: CASI HC A04/MF A01

Translated articles cover the following topics: optimal systems to detect and classify moving objects; multiple identification of optical readings in multisensor information and measurement system; method of first integrals in synthesis of optimal control; study of the development of turbulence in the region of a break above a triangular wing; electroerosion machining in aviation engine construction; and cumulation of a flat shock wave in a tube by a thin parietal gas layer of lower density. CASI

N94-35387# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA
8 Jun. 1994 98 p
(JPRS-UST-94-012) Avail: CASI HC A05/MF A02

Translated articles cover the following topics: electrical conductivity of CeO_2-Ta_2O_5 ceramics in air and combustion gases; optimization of hypersonic wings; aero-optical nozzles of gas dynamic lasers; effect of injector nozzle design parameters for the model combustion chamber of a liquid-propellant rocket engine on the generation of transverse gas vibrations; new materials and processes: prospects for development and creation of aviation engineering; spectral profile of wave numbers of longitudinal vortices and features of the flow in a supersonic stream; numerical calculation of the three dimensional laminar compressible boundary layer on contoured delta wings with supersonic leading edges; electro-erosion machining in aviation engine construction; study of the development of turbulence in the region of a break above a triangular wing; optical reconstruction of microwave holograms; constraints on parameters of theoretical model of motion of trial bodies in satellite experiment for refining value of gravitational constant; astrogeodetic network at beginning of third millennium; prospects and problems in remote sensing of earth; digital mapping and geoinformation systems; new generation of equipment for meteorological lab aircraft; and geological factors in global changes: importance of catastrophes and periodicity of processes. Author

N94-35500*# Auburn Univ., AL. Dept. of Mechanical Engineering.
INFLUENCE OF BACKUP BEARINGS AND SUPPORT STRUCTURE DYNAMICS ON THE BEHAVIOR OF ROTORS WITH ACTIVE SUPPORTS Annual Status Report
GEORGE T. FLOWERS Jun. 1994 25 p
(Contract NAG3-1507)
(NASA-CR-196119; NAS 1.26:196119) Avail: CASI HC A03/MF A01

Progress over the past year includes the following: A simplified rotor model with a flexible shaft and backup bearings has been developed. A simple rotor model which includes a flexible disk and bearings with clearance has been developed and the dynamics of the model investigated. A rotor model based upon the T-501 engine has been developed which includes backup bearing effects. Parallel simulation runs are being conducted using an ANSYS based finite element model of the T-501. The magnetic bearing test rig is currently floating and dynamics/control tests are being conducted. A paper has been written that documents the work using the T-501 engine model. Work has continued with the simplified model. The finite element model is currently being modified to include the effects of foundation dynamics. A literature search for material on foil bearings has been conducted. A finite element model is being developed for a magnetic bearing in series with a foil backup bearing. Derived from text

N94-35803 Pennsylvania State Univ., University Park, PA. Dept. of Aerospace Engineering.
THE AERODYNAMIC AND HEAT TRANSFER EFFECTS OF AN ENDWALL BOUNDARY LAYER FENCE IN A 90 DEGREE TURNING SQUARE DUCT M.S. Thesis
DEAN H. RIZZO May 1994 76 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A278903) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This experimental study investigates the utility of boundary layer fences in turbine passage flow. Boundary layer fences have recently been reintroduced as a possible method to achieve favorable effects in turbines. Previous studies have used linear cascades which necessarily introduce a horseshoe vortex resulting from the endwall boundary layer impinging on the blade leading edge. The present study uses a curved square duct that exhibits no horseshoe vortex, but does have the characteristic passage vortices of a turning flow. The turbine passage is simulated to study the interaction effects of the boundary layer fence and the passage flow dominated by the passage vortices. Specifically, a single boundary layer fence of varying dimensions is attached to a heated endwall of the duct. The flow is fully turbulent at the inlet of the duct. Five-hole probe and liquid crystal thermography experimental techniques are used to determine the changes in the aerodynamic flowfield and the heat transfer coefficient of the heated endwall as compared to the same duct with no fence. Hotwire measurements are also presented for the description of the inlet flow field turbulence. This study adds to the currently small volume of information on fences in passage flow in several important aspects. The effect of the fence on the passage vortex is studied in a known flow configuration. The increased pressure losses of thicker (wider) fences are investigated and results show a significant dependence on fence dimensions. Liquid crystal thermography is used to obtain a high-resolution map of the endwall heat transfer coefficient for two fence configurations. DTIC

N94-35837*# SatCon Technology Corp., Cambridge, MA.
AEROSPACE APPLICATIONS OF MAGNETIC BEARINGS
JAMES DOWNER, JAMES GOLDIE, VIJAY GONDHALEKAR, and RICHARD HOCKNEY *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 1 p 3-26 May 1994
Avail: CASI HC A03/MF A04

Magnetic bearings have traditionally been considered for use in aerospace applications only where performance advantages have been the primary, if not only, consideration. Conventional wisdom has been that magnetic bearings have certain performance advantages which must be traded off against increased weight, volume, electric power consumption, and system complexity. These perceptions have hampered the use of magnetic bearings in many aerospace applications because weight, volume, and power are almost always primary considerations. This paper will review progress on several active aerospace magnetic bearings programs at SatCon Technology Corporation. The magnetic bearing programs at SatCon cover a broad spectrum of applications including: a magnetically-suspended spacecraft integrated power and attitude control system (IPACS), a magnetically-suspended momentum wheel, magnetic bearings for the gas generator rotor of a turboshaft engine, a vibration-attenuating magnetic bearing system for an airborne telescope, and magnetic bearings for the compressor of a space-rated heat pump system. The emphasis of these programs is to develop magnetic bearing technologies to the point where magnetic bearings can be truly useful, reliable, and well tested components for the aerospace community. Author

N94-35842*# Draper (Charles Stark) Lab., Inc., Cambridge, MA.
CONTROL OF MAGLEV VEHICLES WITH AERODYNAMIC AND GUIDEWAY DISTURBANCES
KARL FLUECKIGER, STEVE MARK, RUTH CASWELL, and DUNCAN MCCALLUM *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 1 p 93-107 May 1994
Avail: CASI HC A03/MF A04

A modeling, analysis, and control design methodology is presented for maglev vehicle ride quality performance improvement as measured by the Pepler Index. Ride quality enhancement is considered through active control of secondary suspension elements and active aerodynamic surfaces mounted on the train. To analyze and quantify the benefits of active control, the authors have developed a five degree-of-freedom lumped parameter model suitable for describing a large class of maglev vehicles, including both channel and box-beam guideway configurations. Elements of this modeling capability have been recently employed in studies sponsored by the U.S. Department of Transportation (DOT). A perturbation analysis about an operating point, defined by vehicle and average crosswind velocities, yields a suitable linearized state space model for multivariable control system analysis and synthesis. Neglecting passenger compartment noise, the ride quality as quantified by the Pepler Index is readily computed from the system states. A statistical analysis is performed by modeling the crosswind disturbances and guideway variations as filtered white noise, whereby the Pepler Index is established in closed form through the solution to a matrix Lyapunov equation. Data is presented which indicates the anticipated ride quality achieved through various closed-loop control arrangements. Author

N94-35846*# Politecnico di Torino (Italy). Dipt. di Meccanica.
DESIGN, CONSTRUCTION, AND TESTING OF A FIVE ACTIVE AXES MAGNETIC BEARING SYSTEM
CRISTIANA DELPRETE, GIANCARLO GENTA, and STEFANO CARABELLI *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 1 p 147-161 May 1994 Sponsored by Italian Ministry of Univ. and Scientific Research
Avail: CASI HC A03/MF A04

A high speed electric spindle based on active electromagnetic suspension technology has been designed, built, and tested. The main goal of the research work was the construction of a highly modular unit which can be used for teaching and research purposes. The design of the electromechanical components and of the control unit is described in detail, together with the characterization tests performed on the various subsystems. A description of the preliminary tests on the unit, conducted at speeds not in excess of the first deformation critical speed of the rotor, concludes the work. Author

N94-35858*# General Electric Co., Schenectady, NY. Electronic Technologies Lab.
MODELLING AND CONTROL OF A ROTOR SUPPORTED BY MAGNETIC BEARINGS
R. GURUMOORTHY and A. K. PRADEEP *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 1 p 335-352 May 1994
Avail: CASI HC A03/MF A04

In this paper we develop a dynamical model of a rotor and the active magnetic bearings used to support the rotor. We use this model to develop a stable state feedback control of the magnetic bearing system. We present the development of a rigid body model of the rotor, utilizing both Rotation Matrices (Euler Angles) and Euler Parameters (Quaternions). In the latter half of the paper we develop a stable state feedback control of the actively controlled magnetic bearing to control the rotor position under inbalances. The control law developed takes into account the variation of the model with rotational speed. We show stability over the whole operating range of speeds for the magnetic bearing system. Simulation results are presented to demonstrate the closed loop system performance. We develop the model of the magnetic bearing, and present two schemes for the excitation of the poles of the actively controlled magnetic bearing. We also present a scheme for averaging multiple sensor measurements and splitting the actuation forces amongst redundant actuators. Author

N94-35863*# National Defence Academy, Tokyo (Japan).
THIRD ORDER LPF TYPE COMPENSATOR FOR FLEXIBLE ROTOR SUSPENSION
OSAMI MATSUSHITA, NAOHIKO TAKAHASHI, and MICHIYUKI TAKAGI *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 1 p 421-431 May 1994
Avail: CASI HC A03/MF A04

The tuning job of the compensator for levitating flexible rotors supported by active magnetic bearings (AMB) concerns providing a good damping effect to the critical speed modes while avoiding the spillover problem on the instability of higher bending modes. In this paper, an idea for design of the control law of the compensator based on utilizing a third order low pass filter (LPF) is proposed to essentially enable elimination of the spillover instability. According to the proposed design method, good damping effects for the critical speeds are obtained by the usual phase lead/lag function. Stabilization for all of higher bending modes is completed by the additional function of the 3rd order LPF due to its phase lag approaching about -270 degrees in the high frequency domain. This idea is made clear by experiments and simulations. Author

N94-35903*# General Electric Co., Lynn, MA. Aircraft Engines.
INTEGRATION OF MAGNETIC BEARINGS IN THE DESIGN OF ADVANCED GAS TURBINE ENGINES
ALBERT F. STORACE, DEVENDRA K. SOOD, JAMES P. LYONS, and MARK A. PRESTON *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 2 p 435-449 May 1994
(Contract DAAJ02-92-C-0055)
Avail: CASI HC A03/MF A03

Active magnetic bearings provide revolutionary advantages for gas turbine engine rotor support. These advantages include tremendously improved vibration and stability characteristics, reduced power loss, improved reliability, fault-tolerance, and greatly extended bearing service life. The marriage of these advantages with innovative structural network design and advanced materials utilization will permit major increases in thrust to weight performance and structural efficiency for future gas turbine engines. However, obtaining the maximum payoff requires two key ingredients. The first key ingredient is the use of modern magnetic bearing technologies such as innovative digital control techniques, high-density power electronics, high-density magnetic actuators, fault-tolerant system architecture, and electronic (sensorless) position estimation. This paper describes these technologies. The second key ingredient is to go beyond the simple replacement of rolling element bearings with magnetic bearings by incorporating magnetic bearings as an integral part of the overall engine design. This is analogous to the proper approach to designing with composites, whereby the designer tailors the geometry and load carrying function of the structural system or component for the composite instead of simply substituting composites in a design originally intended for metal material. This paper describes methodologies for the design integration of magnetic bearings in gas turbine engines. Author

N94-35905*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ELECTROMECHANICAL SIMULATION AND TEST OF ROTATING SYSTEMS WITH MAGNETIC BEARING OR PIEZOELECTRIC ACTUATOR ACTIVE VIBRATION CONTROL

ALAN B. PALAZZOLO (Texas A&M Univ., College Station, TX.), PUNAN TANG (Texas A&M Univ., College Station, TX.), CHAESIL KIM (Texas A&M Univ., College Station, TX.), DANIEL MANCHALA (Texas A&M Univ., College Station, TX.), TIM BARRETT (Texas A&M Univ., College Station, TX.), ALBERT F. KASCAK (Army Aviation Systems Command, Cleveland, OH.), GERALD BROWN, GERALD MONTAGUE, ELISEO DIRUSSO, STEVE KLUSMAN et al. *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 2 p 467-478 May 1994

Avail: CASI HC A03/MF A03

This paper contains a summary of the experience of the authors in the field of electromechanical modeling for rotating machinery - active vibration control. Piezoelectric and magnetic bearing actuator based control are discussed. Author

N94-35907*# Wisconsin Univ., Madison, WI. Center for Applied Microelectronics.

PLANAR ROTATIONAL MAGNETIC MICROMOTORS WITH INTEGRATED SHAFT ENCODER AND MAGNETIC ROTOR LEVITATION

HENRY GUCKEL, T. R. CHRISTENSON, K. J. SKROBIS, J. KLEIN, and M. KARNOWSKY *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 2 p 501-511 May 1994

(Contract N00014-91-J-1876; NSF ECS-91-16566; NSF DMR-88-21625; SRC-88-MC-507)

Avail: CASI HC A03/MF A03

Deep x-ray lithography and electroplating may be combined to form a fabrication tool for micromechanical devices with large structural heights, to 500 micron, and extreme edge acuities, less than 0.1 micron-run-out per 100 micron of height. This process concept which originated in Germany as LIGA may be further extended by adding surface micromachining. This extension permits the fabrication of precision metal and plastic parts which may be assembled into three-dimensional micromechanical components and systems. The processing tool may be used to fabricate devices from ferromagnetic material such as nickel and nickel-iron alloys. These materials when properly heat treated exhibit acceptable magnetic behavior for current to flux conversion and marginal behavior for permanent magnet applications. The tool and materials have been tested via planar, magnetic, rotational micromotor fabrication. Three phase reluctance machines of the 6:4 configuration with 280 micron diameter rotors have been tested and analyzed. Stable rotational speeds to 34,000 rpm with output torques above 10 x 10(exp -9) N-m have been obtained. The behavior is monitored with integrated shaft encoders which are photodiodes which measure the rotor response. Magnetic levitation of the rotor via reluctance forces has been achieved and has reduced frictional torque losses to less than 1 percent of the available torque. The results indicate that high speed limits of these actuators are related to torque ripple. Hysteresis motors with magnetic bearings are under consideration and will produce high speed rotational machines with excellent sensor application potential. Author

N94-35911*# Sulzer-Escher Wyss Ltd., Zurich (Switzerland).

ROTOR DYNAMIC BEHAVIOUR OF A HIGH-SPEED OIL-FREE MOTOR COMPRESSOR WITH A RIGID COUPLING SUPPORTED ON FOUR RADIAL MAGNETIC BEARINGS

J. SCHMIED and J. C. PRADETTO *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 2 p 557-572 May 1994

Avail: CASI HC A03/MF A03

The combination of a high-speed motor, dry gas seals, and magnetic bearings realized in this unit facilitates the elimination of oil. The motor is coupled with a quill shaft to the compressor. This yields higher natural frequencies of the rotor than with the use of a diaphragm coupling and helps to maintain a sufficient margin of the maximum speed to the frequency of the second compressor bending mode. However, the controller of each bearing then has to take the combined modes of both machines into account. The requirements for the controller to ensure stability and sufficient damping of all critical speeds are designed and compared with the implemented controller. The calculated closed loop behavior was confirmed experimentally, except the stability of some higher modes due to slight frequency deviations of the rotor model to the actual rotor. The influence of a mechanical damper as a device to provide additional damping to high models is demonstrated theoretically. After all, it was not necessary to install the damper, since all modes cold be stabilized by the controller. Author (revised)

N94-35915*# Kanagawa Academy of Science and Technology, Kawasaki (Japan).

MAGNETICALLY SUSPENDED STEPPING MOTORS FOR CLEAN ROOM AND VACUUM ENVIRONMENTS

TOSHIRO HIGUCHI *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 2 p 625-639 May 1994

Avail: CASI HC A03/MF A03

To answer the growing needs for super-clean or contact free actuators for uses in clean rooms, vacuum chambers, and space, innovative actuators which combine the functions of stepping motors and magnetic bearings in one body were developed. The rotor of the magnetically suspended stepping motor is suspended like a magnetic bearing and rotated and positioned like a stepping motor. The important trait of the motor is that it is not a simple mixture or combination of a stepping motor and conventional magnetic bearing, but an amalgam of a stepping motor and a magnetic bearing. Owing to optimal design and feed-back control, a toothed stator and rotor are all that are needed structurewise for stable suspension. More than ten types of motors such as linear type, high accuracy rotary type, two-dimensional type, and high vacuum type were built and tested. This paper describes the structure and design of these motors and their performance for such applications as precise positioning rotary table, linear conveyor system, and theta-zeta positioner for clean room and high vacuum use. Derived from text

N94-35918*# Xerad, Inc., Santa Monica, CA.

FUTURE ULTRA-SPEED TUBE-FLIGHT Abstract Only

ROBERT M. SALTER *In* NASA. Langley Research Center, Second International Symposium on Magnetic Suspension Technology, Part 2 p 669-670 May 1994

Avail: CASI HC A01/MF A03

Future long-link, ultra-speed, surface transport systems will require electromagnetically (EM) driven and restrained vehicles operating under reduced-atmosphere in very straight tubes. Such tube-flight

trains will be safe, energy conservative, pollution-free, and in a protected environment. Hypersonic (and even hyperballistic) speeds are theoretically achievable. Ultimate system choices will represent tradeoffs between amortized capital costs (ACC) and operating costs. For example, long coasting links might employ aerodynamic lift coupled with EM restraint and drag make-up. Optimized, combined EM lift, and thrust vectors could reduce energy costs but at increased ACC. (Repulsive levitation can produce lift-over-drag l/d ratios a decade greater than aerodynamic). Alternatively, vehicle-emanated, induced-mirror fields in a conducting (aluminum sheet) road bed could reduce ACC but at substantial energy costs. Ultra-speed tube flight will demand fast-acting, high-precision sensors and computerized magnetic shimming. This same control system can maintain a magnetic 'guide way' invariant in inertial space with inertial detectors imbedded in tube structures to sense and correct for earth tremors. Ultra-speed tube flight can complete with aircraft for transit time and can provide even greater passenger convenience by single-model connections with local subways and feeder lines. Although cargo transport generally will not need to be performed at ultra speeds, such speeds may well be desirable for high throughput to optimize channel costs. Thus, a large and expensive pipeline might be replaced with small EM-driven pallets at high speeds.
Author (revised)

N94-35945*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A SUPERSONIC TUNNEL FOR LASER AND FLOW-SEEDING TECHNIQUES
ROBERT J. BRUCKNER and JAN LEPICOVSKY Jun. 1994 15 p
Presented at the 12th Applied Aerodynamics Conference, Colorado Springs, CO, 20-24 Jun. 1994; sponsored by AIAA
(Contract NAS3-27186; RTOP 505-62-10)
(NASA-TM-106588; E-8852; NAS 1.15:106588; AIAA PAPER 94-1825) Avail: CASI HC A03/MF A01

A supersonic wind tunnel with flow conditions of 3 lbm/s (1.5 kg/s) at a free-stream Mach number of 2.5 was designed and tested to provide an arena for future development work on laser measurement and flow-seeding techniques. The hybrid supersonic nozzle design that was used incorporated the rapid expansion method of propulsive nozzles while it maintained the uniform, disturbance-free flow required in supersonic wind tunnels. A viscous analysis was performed on the tunnel to determine the boundary layer growth characteristics along the flowpath. Appropriate corrections were then made to the contour of the nozzle. Axial pressure distributions were measured and Mach number distributions were calculated based on three independent data reduction methods. A complete uncertainty analysis was performed on the precision error of each method. Complex shock-wave patterns were generated in the flow field by wedges mounted near the roof and floor of the tunnel. The most stable shock structure was determined experimentally by the use of a focusing schlieren system and a novel, laser based dynamic shock position sensor. Three potential measurement regions for future laser and flow-seeding studies were created in the shock structure: deceleration through an oblique shock wave of 50 degrees, strong deceleration through a normal shock wave, and acceleration through a supersonic expansion fan containing 25 degrees of flow turning.
Author

N94-35974*# Purdue Univ., West Lafayette, IN. School of Aeronautics and Astronautics.
FREQUENCY DOMAIN ANALYSIS OF THE RANDOM LOADING OF CRACKED PANELS Final Report, 1 Oct. 1990 - 30 Sep. 1993
JAMES F. DOYLE 16 Jun. 1994 89 p
(Contract NAG1-1173)
(NASA-CR-196021; NAS 1.26:196021) Avail: CASI HC A05/MF A01

The primary effort concerned the development of analytical methods for the accurate prediction of the effect of random loading on a panel with a crack. Of particular concern was the influence of frequency on the stress intensity factor behavior. Many modern structures, such as those found in advanced aircraft, are lightweight and susceptible to critical vibrations, and consequently dynamic response plays a very important role in their analysis. The presence of flaws and cracks can have catastrophic consequences. The stress intensity factor, K, emerges as a very significant parameter that characterizes the crack behavior. In analyzing the dynamic response of panels that contain cracks, the finite element method is used, but because this type of problem is inherently computationally intensive, a number of ways of calculating K more efficiently are explored.
CASI

13
GEOSCIENCES

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

N94-35596 Massachusetts Inst. of Tech., Lexington.
THE INFLUENCE OF DATA LINK-PROVIDED GRAPHICAL WEATHER ON PILOT DECISION-MAKING
ANN-MARIE T. LIND, ADAM DERSHOWITZ, and STEVEN R. BUSSOLARI 6 Apr. 1994 80 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract DTFA01-93-Z-02012)
(AD-A278871; MIT-ATC-215; DOT/FAA/RD-94/9) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This report documents the findings of a human factors study conducted to estimate the effects of the Graphical Weather Service (GWS) on general aviation (GA) aircraft utility, pilot situational awareness, and the weather dissemination workload imposed on ground personnel. GWS is a data link application, being developed at MIT Lincoln Laboratory through the sponsorship of the Federal Aviation Administration, that will provide near-real-time graphical weather information to the General Aviation pilot in the cockpit. Twenty instrument-rated pilots participated in the study. Subjects were presented with recorded actual weather information in the context of a series of hypothetical pre-flight briefings and accompanying 'flights'. GWS images were accessible on a Macintosh Computer. The study design enabled the analysis of the effects of GWS and the determination of whether those effects were influenced by the experience level of the pilot/user. Objective and subjective measures of effectiveness were collected. Results indicate that GWS had a substantial effect on weather-related decision-making. This was true for pilots with varying levels of instrument experience. Subject confidence in the ability to assess the weather situation was markedly increased when GWS was used. Subjects with GWS made fewer calls for weather information to weather dissemination ground personnel, thus indicating a potential decrease in ground personnel workload. Subjects found GWS to be very useful and were enthusiastic about receiving data link services in the GA cockpit in the future.
DTIC

N94-35720 Massachusetts Inst. of Tech., Lexington.
DATA REQUIREMENTS FOR CEILING AND VISIBILITY PRODUCTS DEVELOPMENT
J. L. KELLER 13 Apr. 1994 41 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract DTFA01-93-Z-02012; F19628-90-C-0002)
(AD-A278959; ATC-212; DOT/FAA/RD-94/5) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The Federal Aviation Administration (FAA) Integrated Terminal Weather System (ITWS) is supporting the development of weather products important for air traffic control in the terminal area. These products will take advantage of new terminal area sensors, including Terminal Doppler Weather Radar (TDWR), Next Generation Weather Radar (NEXRAD), and the Meteorological Data Collection and Reporting System (MDCRS). Some of these ITWS products will allow air traffic managers to anticipate significant short-term changes in ceiling and visibility. This report focuses on the scientific data requirements for supporting prototype model-system development and diagnostics. Model diagnostics can include case studies to determine the most important physical processes that were responsible for a particular ceiling and visibility event, providing the insight necessary for the development of effective ceiling and visibility product algorithms. In time such case study diagnostics could also include careful off-line failure analyses that may affect the design of the operational system. General ceiling and visibility test beds are discussed. Updated reports will be released periodically as the ITWS ceiling and visibility project proceeds. DTIC

N94-35807 Massachusetts Inst. of Tech., Lexington.
TERMINAL DOPPLER WEATHER RADAR (TDWR) LOW LEVEL WIND SHEAR ALERT SYSTEM 3 (LLWAS 3) INTEGRATION STUDIES AT ORLANDO INTERNATIONAL AIRPORT Project Report, 1991 - 1992
RODNEY E. COLE and RUSSELL F. TODD 20 Apr. 1994 55 p
Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract DTFA01-93-Z-02012; F19628-90-C-0002)
(AD-A278957; ATC-216; DOT/FAA/RD-94/12) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

In 1993 the Federal Aviation Administration (FAA) began deploying two new wind shear detection systems: the Terminal Doppler Weather Radar (TDWR) and the third-generation Low Level Windshear Alert System (LLWAS 3). Currently, nine airports are scheduled to receive both a TDWR and an LLWAS 3. This number may eventually increase to as high as 45. When co-located the systems will be integrated to provide a single set of wind shear alerts and improve system performance. The TDWR production schedule required one of three integration algorithms to be chosen for specification by fall 1991. The three algorithms are the prototype integration algorithm developed at the National Center for Atmospheric Research (NCAR) and the two algorithms developed at MIT Lincoln Laboratory (MIT LL). To assess the performance of the three algorithms, MIT LL performed a study of integration, TDWR, and LLWAS 3 algorithms at Orlando International Airport (MCO) in the summer of 1991. Based on the results of this study, MIT LL and NCAR issued a joint recommendation that the FAA procure one of the integration algorithms developed at MIT LL. This algorithm was demonstrated at the Orlando International Airport in the summer of 1992. Results of the 1991 comparative study and a follow-up study of the TDWR, LLWAS 3, and Message Level integration algorithms at Orlando in 1992 are discussed. All the algorithms met the requirement of detecting 90 percent of microburst level wind shear with loss events. LLWAS 3, Build 5 TDWR, and the MIT LL integration algorithms with Build 5 TDWR all met the requirement that less than 10 percent of wind shear alerts be false. DTIC

15
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.

A94-60176* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DESIGN AND ANALYSIS OF A KALMAN FILTER FOR TERRAIN-REFERENCED POSITIONING AND GUIDANCE
RICHARD E. ZELENKA NASA. Ames Research Center, Moffett Field, CA *Journal of Aircraft* (ISSN 0021-8669) vol. 31, no. 2 March-April 1994 p. 339-344 refs
(BTN-94-EIX94311329124) Copyright

Avionic systems that depend on digitized terrain elevation data for guidance generation or navigational reference require accurate absolute and relative distance measurements to the terrain, especially as they approach lower altitudes. This is particularly exacting in low-altitude helicopter missions, where aggressive terrain hugging maneuvering create minimal horizontal and vertical clearances and demand precise terrain positioning. Sole reliance on airborne precision navigation and stored terrain elevation data for above-ground-level (AGL) positioning severely limits the operational altitude of such systems. A Kalman filter is presented which blends radar altimeter returns, precision navigation, and stored terrain elevation data for AGL positioning. The filter is evaluated using low-altitude helicopter flight test data acquired over moderately rugged terrain. The proposed Kalman filter is found to remove large disparities in predicted AGL altitude (i.e., from airborne navigation and terrain elevation data) in the presence of measurement anomalies and dropouts. Previous work suggested a minimum clearance altitude of 220-ft AGL for a near-terrain guidance system; integration of a radar altimeter suggests operation of that system to 50 ft, subject to obstacle-avoidance limitations. Author (EI)

A94-60197
DRAG REDUCTION OF TURBULENT FLOW OVER A PROJECTILE, PART 1
JAN-KAUNG FU Chinese Air Force Academy, Kaohsiung (Taiwan) and SHEN-MIN LIANG *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 31, no. 1 January-February 1994 p. 85-92 refs
(BTN-94-EIX94311322899) Copyright

A numerical study is made to analyze the drag performance of a secant-ogive-cylinder-boattail projectile in the transonic Mach number regime between 0.91 and 1.20. To improve the projectile's performance, two drag reduction methods, boattailing and base bleed, are applied. The effectiveness of each method and the combination of both methods are studied by varying the values of parameters such as boattail angle, bleed quantity, and bleed area. The computed distributions of surface pressure coefficient of the projectile with different boattail angles are in close agreement with experimental data. EI

A94-60212
SYNTHETIC VISION FOR ENHANCING POOR VISIBILITY FLIGHT OPERATIONS
H. MOLLER Technische Univ, Munich (Germany) and G. SACHS *IEEE Aerospace and Electronic Systems Magazine* (ISSN 0885-8985) vol. 9, no. 3 March 1994 p. 27-33 refs
(BTN-94-EIX94331335531) Copyright

The present paper is concerned with computer generated vision as a further technique providing visual cues for the pilot. Computer generated vision may be used in combination with the aforementioned sensor based techniques. Thus, it is possible to compensate for limitations which sensor based visual systems have in providing sufficient visibility range or in generating a normal looking image. In addition, computer generated imagery has the potential for providing additional information to the pilot for controlling the flight path or for warning purposes. This potential can yield improved and/or more information as compared with the natural view when looking out of the cockpit window. EI

N94-34921*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
ADA DEVELOPERS' SUPPLEMENT TO THE RECOMMENDED APPROACH
RUSH KESTER (Computer Sciences Corp., Greenbelt, MD.) and LINDA LANDIS (Computer Sciences Corp., Greenbelt, MD.) Nov. 1993 36 p
(Contract RTOP 552-00-00)
(NASA-CR-189345; SEL-81-305SP1; NAS 1.26:189345) Avail: CASI HC A03/MF A01

This document is a collection of guidelines for programmers and managers who are responsible for the development of flight dynamics applications in Ada. It is intended to be used in conjunction with the Recommended Approach to Software Development (SEL-81-305), which describes the software development life cycle, its products, reviews, methods, tools, and measures. The Ada Developers' Supplement provides additional detail on such topics as reuse, object-oriented analysis, and object-oriented design. Author

N94-35063*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
VISTA GOES ONLINE: DECISION-ANALYTIC SYSTEMS FOR REAL-TIME DECISION-MAKING IN MISSION CONTROL
MATTHEW BARRY, ERIC HORVITZ, CORINNE RUOKANGAS, and SAMPATH SRINIVAS *In* NASA. Goddard Space Flight Center, The 1994 Goddard Conference on Space Applications of Artificial Intelligence p 241-252 May 1994
Avail: CASI HC A03/MF A03

The Vista project has centered on the use of decision-theoretic approaches for managing the display of critical information relevant to real-time operations decisions. The Vista-I project originally developed a prototype of these approaches for managing flight control displays in the Space Shuttle Mission Control Center (MCC). The follow-on Vista-II project integrated these approaches in a workstation program which currently is being certified for use in the MCC. To our knowledge, this will be the first application of automated decision-theoretic reasoning techniques for real-time spacecraft operations. We shall describe the development and capabilities of the Vista-II system, and provide an overview of the use of decision-theoretic reasoning techniques to the problems of managing the complexity of flight controller displays. We discuss the relevance of the Vista techniques within the MCC decision-making environment, focusing on the problems of detecting and diagnosing spacecraft electromechanical subsystems component failures with limited information, and the problem of determining what control actions should be taken in high-stakes, time-critical situations in response to a diagnosis performed under uncertainty. Finally, we shall outline our current research directions for follow-on projects. Author

N94-35064*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MISSION EVALUATION ROOM INTELLIGENT DIAGNOSTIC AND ANALYSIS SYSTEM (MIDAS)
GINGER L. PACK, JANE FALGOUT, JOSEPH BARCIO, STEVE SHNURER, DAVID WADSWORTH, and LOUIS FLORES *In* NASA. Goddard Space Flight Center, The 1994 Goddard Conference on Space Applications of Artificial Intelligence p 253-267 May 1994
Avail: CASI HC A03/MF A03

The role of Mission Evaluation Room (MER) engineers is to provide engineering support during Space Shuttle missions, for Space Shuttle systems. These engineers are concerned with ensuring that the systems for which they are responsible function reliably, and as intended. The MER is a central facility from which engineers may work, in fulfilling this obligation. Engineers participate in real-time monitoring of shuttle telemetry data and provide a variety of analyses associated with the operation of the shuttle. The Johnson Space Center's Automation and Robotics Division is working to transfer advances in intelligent systems technology to NASA's operational environment. Specifically, the MER Intelligent Diagnostic and Analysis System (MIDAS) project provides MER engineers with software to assist them with monitoring, filtering and analyzing Shuttle telemetry data, during and after Shuttle missions. MIDAS off-loads to computers and software, the tasks of data gathering, filtering, and analysis, and provides the engineers with information which is in a more concise and usable form needed to support decision making and engineering evaluation. Engineers are then able to concentrate on more difficult problems as they arise. This paper describes some, but not all of the applications that have been developed for MER engineers, under the MIDAS Project. The sampling described herewith was selected to show the range of tasks that engineers must perform for mission support, and to show the various levels of automation that have been applied to assist their efforts.
Author

N94-35071*# Durham Univ. (England). Artificial Intelligence Systems Research Group.
ENGINEERING LARGE-SCALE AGENT-BASED SYSTEMS WITH CONSENSUS
A. BOKMA, A. SLADE, S. KERRIDGE, and K. JOHNSON *In* NASA. Goddard Space Flight Center, The 1994 Goddard Conference on Space Applications of Artificial Intelligence p 343-356 May 1994
Avail: CASI HC A03/MF A03

The paper presents the consensus method for the development of large-scale agent-based systems. Systems can be developed as networks of knowledge based agents (KBA) which engage in a collaborative problem solving effort. The method provides a comprehensive and integrated approach to the development of this type of system. This includes a systematic analysis of user requirements as well as a structured approach to generating a system design which exhibits the desired functionality. There is a direct correspondence between system requirements and design components. The benefits of this approach are that requirements are traceable into design components and code thus facilitating verification. The use of the consensus method with two major test applications showed it to be successful and also provided valuable insight into problems typically associated with the development of large systems. Author (revised)

N94-35240*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
RUNTIME SUPPORT FOR DATA PARALLEL TASKS Final Report
MATTHEW HAINES, BRYAN HESS, PIYUSH MEHROTRA, JOHN VANROSENDALE, and HANS ZIMA Apr. 1994 23 p Submitted for publication
(Contract NAS1-19480; RTOP 505-90-52-01)
(NASA-CR-194904; NAS 1.26:194904; ICASE-94-26) Avail: CASI HC A03/MF A01

We have recently introduced a set of Fortran language extensions that allow for integrated support of task and data parallelism, and provide for shared data abstractions (SDA's) as a method for communications and synchronization among these tasks. In this paper we discuss the design and implementation issues of the runtime system necessary to support these extensions, and discuss the underlying requirements for such a system. To test the feasibility of this approach, we implement a prototype of the runtime system and use this to support an abstract multidisciplinary optimization (MDO) problem for aircraft design. We give initial results and discuss future plans. Author

N94-35256*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
COST AND SCHEDULE ESTIMATION STUDY REPORT
STEVE CONDON (Computer Sciences Corp., Greenbelt, MD.), MYRNA REGARDIE (Computer Sciences Corp., Greenbelt, MD.), MIKE STARK, and SHARON WALIGORA Nov. 1993 133 p
(Contract RTOP 552-00-00)
(NASA-CR-189344; SEL-93-002; NAS 1.26:189344) Avail: CASI HC A07/MF A02

This report describes the analysis performed and the findings of a study of the software development cost and schedule estimation models used by the Flight Dynamics Division (FDD), Goddard Space Flight Center. The study analyzes typical FDD projects, focusing primarily on those developed since 1982. The study reconfirms the standard SEL effort estimation model that is based on size adjusted for reuse; however, guidelines for the productivity and growth parameters in the baseline effort model have been updated. The study also produced a schedule prediction model based on empirical data that varies depending on application type. Models for the distribution of effort and schedule by life-cycle phase are also presented. Finally, this report explains how to use these models to plan SEL projects.
Author

N94-35958# Naval Surface Warfare Center, Dahlgren, VA. Weapons Systems Dept.

USER'S GUIDE FOR AN INTERACTIVE PERSONAL COMPUTER INTERFACE FOR THE AEROPREDICTION CODE

THOMAS C. HYMER, FRANK G. MOORE, and CORNELL DOWNS Jun. 1994 101 p

(NSWCDD/TR-94/107) Avail: CASI HC A06/MF A02

This report describes interactive, user-friendly, preprocessing and post-processing PC modules designed to operate with the latest version of the NSWC Aeroprediction Code (AP93). As part of the preprocessing input module, geometry inputs are now automated by giving the user many options. By using this new software, a set of aerodynamic coefficients can be obtained on most weapon configurations in less than 15 minutes from time of initial setup to computer outputs, compared to 2 to 4 hours for the AP93 computer mainframe version. While the computer cost savings are modest (the AP93 executes on a large computer in less than a second), the manpower savings and productivity enhancements can be significant. The user's guide attempts to aid users of the AP93 by correlating AP93 PC interface data inputs and the corresponding source code variable names. This cross-referencing information is given in italics in the discussion. Author (revised)

16
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.

A94-60009

NEW MULTIGRID APPROACH FOR THREE-DIMENSIONAL UNSTRUCTURED, ADAPTIVE GRIDS

VIJAYAN PARTHASARATHY Univ. of Texas, Austin and Y. KALLINDERIS *AIAA Journal* (ISSN 0001-1452) vol. 32, no. 5 May 1994 p. 956-963 refs

(BTN-94-EIX94301315973) Copyright

A new multigrid method with adaptive unstructured grids is presented. The three-dimensional Euler equations are solved on tetrahedral grids that are adaptively refined or coarsened locally. The multigrid method is employed to propagate the fine grid corrections more rapidly by redistributing the changes-in-time of the solution from the fine grid to the coarser grids to accelerate convergence. A new approach is employed that uses the parent cells of the fine grid cells in an adapted mesh to generate successively coarser levels of multigrid. This obviates the need for the generation of a sequence of independent, nonoverlapping grids as well as the relatively complicated operations that need to be performed to interpolate the solution and the residuals between the independent grids. The solver is an explicit, vertex-based, finite volume scheme that employs edge-based data structures and operations. Spatial discretization is of central-differencing type combined with special upwind-like smoothing operators. Application cases include adaptive solutions obtained with multigrid acceleration for supersonic and subsonic flow over a bump in a channel, as well as transonic flow around the ONERA M6 wing. Two levels of multigrid resulted in reduction in the number of iterations by a factor of 5. Author (EI)

A94-60143* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COUPLED RADIATION EFFECTS IN THERMOCHEMICAL NONEQUILIBRIUM SHOCK-CAPTURING FLOWFIELD CALCULATIONS

LIN C. HARTUNG NASA. Langley Research Center, Hampton, VA, ROBERT A. MITCHELTREE, and PETER A. GNOFFO *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 8, no. 2 April-June 1994 p. 244-250 refs

(BTN-94-EIX94311330648) Copyright

Lunar and Mars return conditions are examined using the Langley aerothermodynamic upwind relaxation algorithm flowfield code and the Langley optimized radiative nonequilibrium radiation code to assess the effect of radiative coupling on axisymmetric thermochemical nonequilibrium flows. Coupling of the two codes is achieved iteratively. Special treatment required to couple radiation in a shock-capturing method is discussed. Results indicate that while coupling effects are generally the same as occur in equilibrium flows, under certain conditions radiation can modify the chemical kinetics of a nonequilibrium flow, and thus alter relaxation processes. Coupling effects are found to be small for all cases considered, except for a 5 m diam aerobrake returning from Mars at 13.6 km/s. Author (EI)

A94-60349

COMPARISON OF OPTICAL MEASUREMENT TECHNIQUES FOR TURBOMACHINERY FLOWFIELDS

JOHN R. FAGAN Purdue Univ, West Lafayette, IN and SANFORD FLEETER *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 2 March-April 1994 p. 176-182 refs

(BTN-94-EIX94341338357) Copyright

A preliminary set of measurements were made of the flowfield in the Purdue Research Centrifugal Compressor using a laser two-focus (L2F) velocimeter and a laser Doppler velocimeter (LDV). After a review of the preliminary results, the LDV system was chosen to continue this research due to the advantages it demonstrated over the L2F system in making measurements in this flowfield. The L2F data are compared and contrasted to the LDV data. While this comparison is not to insinuate the local features of the LDV data are universally correct, an evaluation of the global features of the compressor flowfield based upon the LDV measurements demonstrate consistency, i.e. measurements at various planes in the flowfield demonstrate conservation of mass and a reasonable distribution of work in the compressor. In addition, methodologies to determine the effect of the measurement volume geometry for the two systems are presented. Finally, the advantages and disadvantages of using the L2F system for turbomachinery flowfields is discussed in terms of measurement accuracy, applicability to general turbomachinery flowfields, and the capability to make measurements in regions of high noise due to stray reflections. Specific examples based upon this experimental work are presented. Author (EI)

A94-60361

FEASIBILITY STUDY OF A CONTAINED PULSED NUCLEAR PROPULSION ENGINE

ALEXANDER G. PARLOS Texas A&M Univ., College Station, TX and JOHN D. METZGER *Journal of Propulsion and Power* (ISSN 0748-4658) vol. 10, no. 2 March-April 1994 p. 269-278 refs

(BTN-94-EIX94341338369) Copyright

The result of a feasibility analysis of a contained pulsed nuclear propulsion (CPNP) engine concept utilizing the enormously dense energy generated by small nuclear detonations is presented in this article. This concept was initially proposed and studied in the 1950s and 1960s under the program name HELIOS. The current feasibility of the concept is based upon materials technology that has advanced to a state that allows the design of pressure vessels required to contain the blast associated with small nuclear detonations. The impulsive nature of the energy source provides the means for circumventing the materials thermal barriers that are inherent in steady-state nuclear propulsion concepts. The rapid energy transfer to the propellant results in high thrust levels for times less than 1 s following the detonation. The preliminary feasibility analysis using off-the-shelf materials technology appears to indicate that the CPNP concept can have thrust-to-weight ratios on the order of 1 or greater. Though the specific impulse is not a good indicator for impulsive engines, an operating-cycle averaged specific impulse of approximately 1000 or greater seconds was calculated. Author (EI)

A94-60410
THREE-DIMENSIONAL THERMAL ANALYSIS FOR LASER-STRUCTURAL INTERACTIONS
HARTMUT H. LEGNER Physical Sciences, Inc., Andover, MA, ALBERT W. BAILEY, and MICHAEL F. HINDS *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 7, no. 4 October-December 1993 p. 545-546 refs
(BTN-94-EIX94351142117) Copyright

A three-dimensional thermal analysis method with direct application to laser-structural interactions has been developed. This robust, implicit finite-volume technique solves the enthalpic form of the heat condition equation for laser radiation interacting with three-dimensional aerospace structures. It utilizes finite elements derived from the structural analysis and accommodates arbitrary beam profiles to compute the ablative material response. Computed results for a composite hat-stiffened panel are illustrated. This method has also treated laser-structural problems involving oblique beam incidence, complex structures, multiple materials, and beam slewing. EI

A94-60430
NEW TWO-TEMPERATURE DISSOCIATION MODEL FOR REACTING FLOWS
DAVID P. OLYNICK North Carolina State Univ., Raleigh, NC and H. A. HASSAN *Journal of Thermophysics and Heat Transfer* (ISSN 0887-8722) vol. 7, no. 4 October-December 1993 p. 687-696 refs
(BTN-94-EIX94351142137) Copyright

A new two-temperature dissociation model for the coupled vibration-dissociation process is derived from kinetic theory. It is applied for flows undergoing compression. The model minimizes uncertainties associated with the two-temperature model of Park. The effects of the model on AOTV-type flowfields are examined and compared with the Park model. Calculations are carried out for flows with and without ionization. When considering flows with ionization, a four-temperature model is employed. For Fire II conditions, the assumption of equilibrium between the vibrational and electron-electronic temperatures is somewhat poor. A similar statement holds for the translational and rotational temperatures. These trends are consistent with results obtained using the direct simulation Monte Carlo (DSMC) method. Author (EI)

N94-35963*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
ENGINE EXHAUST CHARACTERISTICS EVALUATION IN SUPPORT OF AIRCRAFT ACOUSTIC TESTING
KIMBERLY A. ENNIX *In* NASA. Ames Research Center, 1993 Technical Paper Contest for Women. Gear Up 2000: Women in Motion p 13-20 Feb. 1994
Avail: CASI HC A02/MF A02

NASA Dryden Flight Research Facility and NASA Langley Research Center completed a joint acoustic flight test program. Test objectives were (1) to quantify and evaluate subsonic climb-to-cruise noise and (2) to obtain a quality noise database for use in validating the Aircraft Noise Prediction Program. These tests were conducted using aircraft with engines that represent the high nozzle pressure ratio of future transport designs. Test flights were completed at subsonic speeds that exceeded Mach 0.3 using F-18 and F-16XL aircraft. This paper describes the efforts of NASA Dryden Flight Research Facility in this flight test program. Topics discussed include the test aircraft, setup, and matrix. In addition, the engine modeling codes and nozzle exhaust characteristics are described. Author

N94-36031*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
COMPUTATION OF HELICOPTER ROTOR ACOUSTICS IN FORWARD FLIGHT
ROGER STRAWN (Army Aviation Systems Command, Moffett Field, CA.) and RUPAK BISWAS Mar. 1994 11 p Presented at the 19th Army Science Conference, Orlando, FL, 20-24 Jun. 1994 Submitted for publication
(Contract NAS2-13721)
(NASA-CR-196132; NAS 1.26:196132; RIACS-TR-94-06) Avail: CASI HC A03/MF A01

This paper presents a new method for computing acoustic signals from helicopter rotors in forward flight. The aerodynamic and acoustic solutions in the near field are computed with a finite-difference solver for the Euler equations. A nonrotating cylindrical Kirchhoff surface is then placed around the entire rotor system. This Kirchhoff surface moves subsonically with the rotor in forward flight. The finite-difference solution is interpolated onto this cylindrical surface at each time step and a Kirchhoff integration is used to carry the acoustic signal to the far field. Computed values for high-speed impulsive noise show excellent agreement with model-rotor and flight-test experimental data. Results from the new method offer high accuracy with reasonable computer resource requirements. Author

17
SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

N94-34730*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA/DOD AEROSPACE KNOWLEDGE DIFFUSION RESEARCH PROJECT. PAPER 42: AN ANALYSIS OF THE TRANSFER OF SCIENTIFIC AND TECHNICAL INFORMATION (STI) IN THE US AEROSPACE INDUSTRY
JOHN M. KENNEDY (Indiana Univ., Bloomington, IN.), THOMAS E. PINELLI, LAURA F. HECHT, and REBECCA O. BARCLAY 1994 17 p Presented at the Annual Meeting of the American Sociological Association, Los Angeles, CA, 5-9 Aug. 1994
(Contract NAGW-1682)
(NASA-TM-109863; NAS 1.15:109863) Avail: CASI HC A03/MF A01

The U.S. aerospace industry has a long history of federal support for research related to its needs. Since the establishment of the National Advisory Committee for Aeronautics (NACA) in 1915, the federal government has provided continuous research support related to flight and aircraft design. This research has contributed to the international preeminence of the U.S. aerospace industry. In this paper, we present a sociological analysis of aerospace engineers and scientists and how their attitudes and behaviors impact the flow of scientific and technical information (STI). We use a constructivist framework to explain the spotty dissemination of federally funded aerospace research. Our research is aimed towards providing federal policymakers with a clearer understanding of how and when federally funded aerospace research is used. This understanding will help policymakers design improved information transfer systems that will aid the competitiveness of the U.S. aerospace industry. Author (revised)

N94-35899*# National Aeronautics and Space Administration, Washington, DC.
BUDGET ESTIMATES, FISCAL YEAR 1995. VOLUME 1: AGENCY SUMMARY, HUMAN SPACE FLIGHT, AND SCIENCE, AERONAUTICS AND TECHNOLOGY
1994 340 p
(NASA-TM-109791; NAS 1.15:109791) Avail: CASI HC A15/MF A03; SOD HC

The NASA budget request has been restructured in FY 1995 into four appropriations: human space flight; science, aeronautics, and technology; mission support; and inspector general. The human space flight appropriations provides funding for NASA's human space flight activities. This includes the on-orbit infrastructure (space station and Spacelab), transportation capability (space shuttle program, including operations, program support, and performance and safety upgrades), and the Russian cooperation program, which includes the flight activities associated with the cooperative research flights to the Russian Mir space station. These activities are funded in the following budget line items: space station, Russian cooperation, space shuttle, and payload utilization and operations. The science, aeronautics, and technology appropriations provides funding for the research and development activities of NASA. This includes funds to extend our knowledge of the earth, its space environment, and the universe and to invest in new technologies, particularly in aeronautics, to ensure the future competitiveness of the nation. These objectives are achieved through the following elements: space science, life and microgravity sciences and applications, mission to planet earth, aeronautical research and technology, advanced concepts and technology, launch services, mission communication services, and academic programs. CASI

N94-35262# Federal Aviation Administration, Washington, DC.
THE FEDERAL AVIATION ADMINISTRATION PLAN FOR RESEARCH, ENGINEERING AND DEVELOPMENT
May 1994 190 p Original contains color illustrations
Avail: CASI HC A09/MF A02; 1 functional color page

The Federal Aviation Administration (FAA) manages and operates the National Airspace System (NAS), a significant national resource. However, the demands on this system are continuously growing, and changing technologies provide the opportunity to improve system effectiveness and efficiency. To this end, the FAA's research, engineering, and development program is an investment in the future that will sustain the United States preeminence in aviation throughout the world. Without this investment, the United States leadership would erode. Thus, the importance of aviation to the nation mandates a comprehensive research, engineering, and development program to ensure both the safety of public air transportation and the fulfillment of national priorities and policy goals. Derived from text

N94-35370*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DIRECTOR'S DISCRETIONARY FUND Report, FY 1992
May 1993 133 p
(Contract RTOP 307-51-50)
(NASA-TM-103997; A-93031; NAS 1.15:103997) Avail: CASI HC A07/MF A02

This technical memorandum contains brief technical papers describing research and technology development programs sponsored by the ARC Director's Discretionary Fund during fiscal year 1992 (Oct. 1991 through Sep. 1992). An appendix provides administrative information for each of the 45 sponsored research programs. Author

N94-35444# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AGARD HIGHLIGHTS 93/2
Sep. 1993 47 p Original contains color illustrations
(AGARD-HIGHLIGHTS-93/2) Copyright Avail: CASI HC A03/MF A01

Highlights of the activities and accomplishments of the Advisory Group for Aerospace Research and Development (AGARD) during the second quarter of 1993 are discussed. Topics covered include technology cooperation with Russia, including aircraft flight safety; the von Karman Medal and the Scientific Achievement Award for 1993; two articles on a visit to Zhukovsky, including discussion on fluid dynamics related to helicopters; international air traffic handling cooperation; and the European Transonic Wind Tunnel (ETW). CASI

N94-35961*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
1993 TECHNICAL PAPER CONTEST FOR WOMEN. GEAR UP 2000: WOMEN IN MOTION
ROBIN ORANS, ed., SOPHIE DUCKETT, ed., and SUSAN WHITE, ed. Feb. 1994 131 p Contest held in Moffett Field, CA, 1993
(NASA-CP-10134; A-93034; NAS 1.55:10134) Avail: CASI HC A07/MF A02

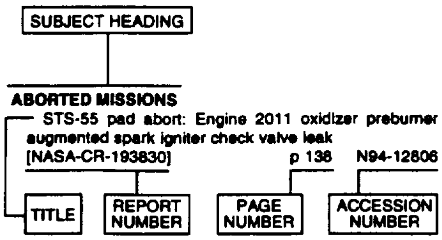
The NASA Ames Research Center Advisory Committee for Women (ACW) sponsored the second ACW Technical paper Contest for Ames women in order to increase the visibility of, and to encourage writing for publication by Ames women scientists, engineers, and technicians. The topics of the contest paper mirrored in the topics of the 1993 Society for Women Engineers (SWE) National Convention, which included technological, workplace, global, and family issues.

N94-36117*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
RESEARCH AND TECHNOLOGY, 1993
May 1994 306 p Original contains color illustrations
(NASA-TM-108816; A-94041; NAS 1.15:108816) Avail: CASI HC A14/MF A03; 12 functional color pages

Selected research and technology activities at Ames Research Center, including the Moffett Field site and the Dryden Flight Research Facility, are summarized. These activities exemplify the center's varied and productive research efforts for 1993. This year's report presents some of the challenging work recently accomplished in the areas of aerospace systems, flight operations and research, aerophysics, and space research. Author (revised)

SUBJECT

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence.

A

D

O

P

Q

R

S

Typical Personal Author Index Listing

PERSONAL AUTHOR

ANDRISANI, DOMINICK, II
A feasibility study regarding the addition of a fifth control to a rotorcraft in-flight simulator
[NASA-CR-193240] p 112 N94-10895

TITLE | REPORT NUMBER | PAGE NUMBER | ACCESSION NUMBER

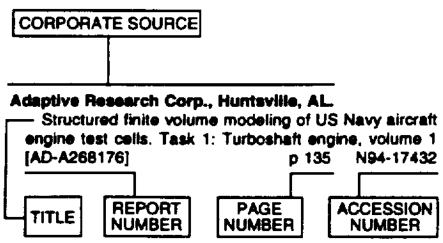
Listings in this index are arranged alphabetically by personal author. The title of the document is used to provide a brief description of the subject matter. The report number helps to indicate the type of document (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence.

A

B

AUTHOR

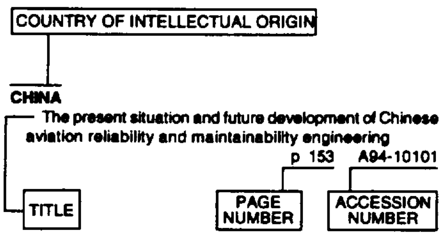
Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

SOURCE

Typical Foreign Technology Index Listing



Listings in this index are arranged alphabetically by country of intellectual origin. The title of the document is used to provide a brief description of the subject matter. The page number and accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

F O R E I G N

Typical Contract Number Index Listing

AF PROJ. 2404 .... p 44 N94-17461

CONTRACT NUMBER | PAGE NUMBER | ACCESSION NUMBER

Listings in this index are arranged alphanumerically by contract number. Under each contract number the accession numbers denoting documents that have been produced as a result of research done under the contract are shown. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

Typical Report Number Index Listing

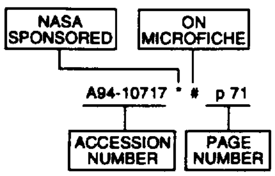
NASA SPONSORED — ON MICROFICHE

NASA-CR-167690 .... p 139 N94-12810 * #

REPORT NUMBER — PAGE NUMBER — ACCESSION NUMBER

Listings in this index are arranged alphanumerically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

Typical Accession Number Index Listing



Listings in this index are arranged alphanumerically by accession number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

ACCESSION

AVAILABILITY OF CITED PUBLICATIONS

OPEN LITERATURE ENTRIES (A94-60000 Series)

Inquiries and requests should be addressed to: CASI, 800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934. Orders are also taken by telephone, (301) 621-0390, e-mail, help@sti.nasa.gov, and fax, (301) 621-0134. Please refer to the accession number when requesting publications.

STAR ENTRIES (N94-10000 Series)

One or more sources from which a document announced in *STAR* is available to the public is ordinarily given on the last line of the citation. The most commonly indicated sources and their acronyms or abbreviations are listed below, and their addresses are listed on page APP-3. If the publication is available from a source other than those listed, the publisher and his address will be displayed on the availability line or in combination with the corporate source line.

Avail: CASI. Sold by the NASA Center for AeroSpace Information. Prices for hard copy (HC) and microfiche (MF) are indicated by a price code following the letters HC or MF in the *STAR* citation. Current values for the price codes are given in the tables on page APP-5.

NOTE ON ORDERING DOCUMENTS: When ordering publications from CASI, use the N accession number or other report number. It is also advisable to cite the title and other bibliographic identification.

Avail: SOD (or GPO). Sold by the Superintendent of Documents, U.S. Government Printing Office, in hard copy.

Avail: BLL (formerly NLL): British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England. Photocopies available from this organization at the price shown. (If none is given, inquiry should be addressed to the BLL.)

Avail: DOE Depository Libraries. Organizations in U.S. cities and abroad that maintain collections of Department of Energy reports, usually in microfiche form, are listed in *Energy Research Abstracts*. Services available from the DOE and its depositories are described in a booklet, *DOE Technical Information Center - Its Functions and Services* (TID-4660), which may be obtained without charge from the DOE Technical Information Center.

Avail: ESDU. Pricing information on specific data, computer programs, and details on Engineering Sciences Data Unit (ESDU) topic categories can be obtained from ESDU International Ltd. Requesters in North America should use the Virginia address while all other requesters should use the London address, both of which are on page APP-3.

Avail: Fachinformationszentrum Karlsruhe. Gesellschaft für wissenschaftlich-technische Information mbH 76344 Eggenstein-Leopoldshafen, Germany.

Avail: HMSO. Publications of Her Majesty's Stationery Office are sold in the U.S. by Pendragon House, Inc. (PHI), Redwood City, CA. The U.S. price (including a service and mailing charge) is given, or a conversion table may be obtained from PHI.

Avail: Issuing Activity, or Corporate Author, or no indication of availability. Inquiries as to the availability of these documents should be addressed to the organization shown in the citation as the corporate author of the document.

Avail: NASA Public Document Rooms. Documents so indicated may be examined at or purchased from the National Aeronautics and Space Administration (JBD-4), Public Documents Room (Room 1H23), Washington, DC 20546-0001, or public document rooms located at NASA installations, and the NASA Pasadena Office at the Jet Propulsion Laboratory.

Avail: NTIS. Sold by the National Technical Information Service. Initially distributed microfiche under the NTIS SRIM (Selected Research in Microfiche) are available. For information concerning this service, consult the NTIS Subscription Section, Springfield, VA 22161.

Avail: Univ. Microfilms. Documents so indicated are dissertations selected from *Dissertation Abstracts* and are sold by University Microfilms as xerographic copy (HC) and microfilm. All requests should cite the author and the Order Number as they appear in the citation.

Avail: US Patent and Trademark Office. Sold by Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, at the standard price of $1.50 each, postage free.

Avail: (US Sales Only). These foreign documents are available to users within the United States from the National Technical Information Service (NTIS). They are available to users outside the United States through the International Nuclear Information Service (INIS) representative in their country, or by applying directly to the issuing organization.

Avail: USGS. Originals of many reports from the U.S. Geological Survey, which may contain color illustrations, or otherwise may not have the quality of illustrations preserved in the microfiche or facsimile reproduction, may be examined by the public at the libraries of the USGS field offices whose addresses are listed on page APP-3. The libraries may be queried concerning the availability of specific documents and the possible utilization of local copying services, such as color reproduction.

FEDERAL DEPOSITORY LIBRARY PROGRAM

In order to provide the general public with greater access to U.S. Government publications, Congress established the Federal Depository Library Program under the Government Printing Office (GPO), with 53 regional depositories responsible for permanent retention of material, inter-library loan, and reference services. At least one copy of nearly every NASA and NASA-sponsored publication, either in printed or microfiche format, is received and retained by the 53 regional depositories. A list of the regional GPO libraries, arranged alphabetically by state, appears on the inside back cover of this issue. These libraries are *not* sales outlets. A local library can contact a regional depository to help locate specific reports, or direct contact may be made by an individual.

PUBLIC COLLECTION OF NASA DOCUMENTS

An extensive collection of NASA and NASA-sponsored publications is maintained by the British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England for public access. The British Library Lending Division also has available many of the non-NASA publications cited in *STAR*. European requesters may purchase facsimile copy or microfiche of NASA and NASA-sponsored documents, those identified by both the symbols # and * from ESA — Information Retrieval Service European Space Agency, 8-10 rue Mario-Nikis, 75738 CEDEX 15, France.

STANDING ORDER SUBSCRIPTIONS

NASA SP-7037 supplements and annual index are available from the NASA Center for AeroSpace Information (CASI) on standing order subscription. Standing order subscriptions do not terminate at the end of a year, as do regular subscriptions, but continue indefinitely unless specifically terminated by the subscriber.

ADDRESSES OF ORGANIZATIONS

British Library Lending Division
Boston Spa, Wetherby, Yorkshire
England

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Washington, DC 20231

Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830

European Space Agency-
Information Retrieval Service ESRIN
Via Galileo Galilei
00044 Frascati (Rome) Italy

Engineering Sciences Data Unit International
P.O. Box 1633
Manassas, VA 22110

Engineering Sciences Data Unit
International, Ltd.
251-259 Regent Street
London, W1R 7AD, England

Fachinformationszentrum Karlsruhe
Gesellschaft für wissenschaftlich-technische
Information mbH
76344 Eggenstein-Leopoldshafen, Germany

Her Majesty's Stationery Office
P.O. Box 569, S.E. 1
London, England

NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934

National Aeronautics and Space Administration
Scientific and Technical Information Program
(JTT)
Washington, DC 20546-0001

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Pendragon House, Inc.
899 Broadway Avenue
Redwood City, CA 94063

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

University Microfilms
A Xerox Company
300 North Zeeb Road
Ann Arbor, MI 48106

University Microfilms, Ltd.
Tylers Green
London, England

U.S. Geological Survey Library National Center
MS 950
12201 Sunrise Valley Drive
Reston, VA 22092

U.S. Geological Survey Library
2255 North Gemini Drive
Flagstaff, AZ 86001

U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

U.S. Geological Survey Library
Box 25046
Denver Federal Center, MS914
Denver, CO 80225

CASI PRICE TABLES

STANDARD PRICE DOCUMENTS

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
A01	$ 9.00	$ 18.00
A02	12.50	25.00
A03	17.50	35.00
A04-A05	19.50	39.00
A06-A09	27.00	54.00
A10-A13	36.50	73.00
A14-A17	44.50	89.00
A18-A21	52.00	104.00
A22-A25	61.00	122.00
A99	Call For Price	Call For Price

MICROFICHE

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
A01	$ 9.00	$ 18.00
A02	12.50	25.00
A03	17.50	35.00
A04	19.50	39.00
A06	27.00	54.00
A10	36.50	73.00

IMPORTANT NOTICE

CASI Shipping and Handling Charges
U.S.—ADD $3.00 per TOTAL ORDER
Canada and Mexico—ADD $3.50 per TOTAL ORDER
All Other Countries—ADD $7.50 per TOTAL ORDER
Does NOT apply to orders
requesting CASI RUSH HANDLING.
CASI accepts most credit/charge cards.

NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934
Telephone: (301) 621-0390
E-mail: help@sti.nasa.gov
Fax: (301) 621-0134

REPORT DOCUMENT PAGE

1. Report No. NASA SP-7037 (308)	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Aeronautical Engineering A Continuing Bibliography (Supplement 308)		5. Report Date September 1994
		6. Performing Organization Code JTT
7. Author(s)		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address NASA Scientific and Technical Information Program		11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546-0001		13. Type of Report and Period Covered Special Publication
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report lists 269 reports, articles and other documents recently announced in the NASA STI Database.

17. Key Words (Suggested by Author(s)) Aeronautical Engineering Aeronautics Bibliographies		18. Distribution Statement Unclassified - Unlimited Subject Category - 01	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 104	22. Price A06/HC

For sale by the NASA Center for AeroSpace Information, 800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934

FEDERAL REGIONAL DEPOSITORY LIBRARIES

ALABAMA
AUBURN UNIV. AT MONTGOMERY LIBRARY
Documents Dept.
7300 University Dr.
Montgomery, AL 36117-3596
(205) 244-3650 Fax: (205) 244-0678

UNIV. OF ALABAMA
Amelia Gayle Gorgas Library
Govt. Documents
Box 870266
Tuscaloosa, AL 35487-0266
(205) 348-6046 Fax: (205) 348-8833

ARIZONA
DEPT. OF LIBRARY, ARCHIVES, AND PUBLIC RECORDS
Federal Documents
Third Floor State Capitol
1700 West Washington
Phoenix, AZ 85007
(602) 542-4121 Fax: (602) 542-4400, 542-4500

ARKANSAS
ARKANSAS STATE LIBRARY
State Library Services
One Capitol Mall
Little Rock, AR 72201
(501) 682-2869

CALIFORNIA
CALIFORNIA STATE LIBRARY
Govt. Publications Section
914 Capitol Mall - P.O. Box 942837
Sacramento, CA 94237-0001
(916) 322-4572 Fax: (916) 324-8120

COLORADO
UNIV. OF COLORADO - BOULDER
Norlin Library
Govt. Publications
Campus Box 184
Boulder, CO 83309-0184
(303) 492-8834 Fax: (303) 492-2185

DENVER PUBLIC LIBRARY
Govt. Publications Dept. BS/GPD
1357 Broadway
Denver, CO 80203
(303) 571-2135

CONNECTICUT
CONNECTICUT STATE LIBRARY
231 Capitol Avenue
Hartford, CT 06106
(203) 566-4971 Fax: (203) 566-3322

FLORIDA
UNIV. OF FLORIDA LIBRARIES
Documents Dept.
Library West
Gainesville, FL 32611-2048
(904) 392-0366 Fax: (904) 392-7251

GEORGIA
UNIV. OF GEORGIA LIBRARIES
Govt. Documents Dept.
Jackson Street
Athens, GA 30602
(404) 542-8949 Fax: (404) 542-6522

HAWAII
UNIV. OF HAWAII
Hamilton Library
Govt. Documents Collection
2550 The Mall
Honolulu, HI 96822
(808) 948-8230 Fax: (808) 956-5968

IDAHO
UNIV. OF IDAHO LIBRARY
Documents Section
Moscow, ID 83843
(208) 885-6344 Fax: (208) 885-6817

ILLINOIS
ILLINOIS STATE LIBRARY
Reference Dept.
300 South Second
Springfield, IL 62701-1796
(217) 782-7596 Fax: (217) 524-0041

INDIANA
INDIANA STATE LIBRARY
Serials/Documents Section
140 North Senate Avenue
Indianapolis, IN 46204
(317) 232-3678 Fax: (317) 232-3728

IOWA
UNIV. OF IOWA LIBRARIES
Govt. Publications Dept.
Washington & Madison Streets
Iowa City, IA 52242
(319) 335-5926 Fax: (319) 335-5830

KANSAS
UNIV. OF KANSAS
Govt. Documents & Map Library
6001 Malatt Hall
Lawrence, KS 66045-2800
(913) 864-4660 Fax: (913) 864-5380

KENTUCKY
UNIV. OF KENTUCKY LIBRARIES
Govt. Publications/Maps Dept.
Lexington, KY 40506-0039
(606) 257-3139 Fax: (606) 257-1563, 257-8379

LOUISIANA
LOUISIANA STATE UNIV.
Middleton Library
Govt. Documents Dept.
Baton Rouge, LA 70803
(504) 388-2570 Fax: (504) 388-6992

LOUISIANA TECHNICAL UNIV.
Prescott Memorial Library
Govt. Documents Dept.
305 Wisteria Street
Ruston, LA 71270-9985
(318) 257-4962 Fax: (318) 257-2447

MAINE
TRI-STATE DOCUMENTS DEPOS.
Raymond H. Fogler Library
Govt. Documents & Microforms Dept.
Univ. of Maine
Orono, ME 04469
(207) 581-1680

MARYLAND
UNIV. OF MARYLAND
Hornbake Library
Govt. Documents/Maps Unit
College Park, MD 20742
(301) 454-3034 Fax: (301) 454-4985

MASSACHUSETTS
BOSTON PUBLIC LIBRARY
Govt. Documents Dept.
666 Boylston Street
Boston, MA 02117
(617) 536-5400 ext. 226
Fax: (617) 267-8273, 267-8248

MICHIGAN
DETROIT PUBLIC LIBRARY
5201 Woodward Avenue
Detroit, MI 48202-4093
(313) 833-1440, 833-1409
Fax: (313) 833-5039

LIBRARY OF MICHIGAN
Govt. Documents Unit
P.O. Box 30007
Lansing, MI 48909
(517) 373-0640 Fax: (517) 373-3381

MINNESOTA
UNIV. OF MINNESOTA
Wilson Library
Govt. Publications Library
309 19th Avenue South
Minneapolis, MN 55455
(612) 624-5073 Fax: (612) 626-9353

MISSISSIPPI
UNIV. OF MISSISSIPPI
J.D. Williams Library
Federal Documents Dept.
106 Old Gym Bldg.
University, MS 38677
(601) 232-5857 Fax: (601) 232-5453

MISSOURI
UNIV. OF MISSOURI - COLUMBIA
Ellis Library
Govt. Documents
Columbia, MO 65201
(314) 882-6733 Fax: (314) 882-8044

MONTANA
UNIV. OF MONTANA
Maureen & Mike Mansfield Library
Documents Div.
Missoula, MT 59812-1195
(406)243-6700 Fax: (406) 243-2060

NEBRASKA
UNIV. OF NEBRASKA - LINCOLN
D.L. Love Memorial Library
Documents Dept.
Lincoln, NE 68588
(402) 472-2562

NEVADA
UNIV. OF NEVADA
Reno Library
Govt. Publications Dept.
Reno, NV 89557
(702) 784-6579 Fax: (702) 784-1751

NEW JERSEY
NEWARK PUBLIC LIBRARY
U.S. Documents Div.
5 Washington Street - P.O. Box 630
Newark, NJ 07101-0630
(201) 733-7812 Fax: (201) 733-5648

NEW MEXICO
UNIV. OF NEW MEXICO
General Library
Govt. Publications Dept.
Albuquerque, NM 87131-1466
(505) 277-5441 Fax: (505) 277-6019

NEW MEXICO STATE LIBRARY
325 Don Gaspar Avenue
Santa Fe, NM 87503
(505) 827-3826 Fax: (505) 827-3820

NEW YORK
NEW YORK STATE LIBRARY
Documents/Gift & Exchange Section
Federal Depository Program
Cultural Education Center
Albany, NY 12230
(518) 474-5563 Fax: (518) 474-5786

NORTH CAROLINA
UNIV. OF NORTH CAROLINA - CHAPEL HILL
CB#3912, Davis Library
BA/SS Dept. - Documents
Chapel Hill, NC 27599
(919) 962-1151 Fax: (919) 962-0484

NORTH DAKOTA
NORTH DAKOTA STATE UNIV. LIB.
Documents Office
Fargo, ND 58105
(701) 237-8886 Fax: (701) 237-7138
In cooperation with Univ. of North Dakota, Chester Fritz Library Grand Forks

OHIO
STATE LIBRARY OF OHIO
Documents Dept.
65 South Front Street
Columbus, OH 43266
(614) 644-7051 Fax: (614) 752-9178

OKLAHOMA
OKLAHOMA DEPT. OF LIBRARIES
U.S. Govt. Information Div.
200 NE 18th Street
Oklahoma City, OK 73105-3298
(405) 521-2502, ext. 252, 253
Fax: (405) 525-7804

OKLAHOMA STATE UNIV.
Edmon Low Library
Documents Dept.
Stillwater, OK 74078
(405) 744-6546 Fax: (405) 744-5183

OREGON
PORTLAND STATE UNIV.
Millar Library
934 SW Harrison - P.O. Box 1151
Portland, OR 97207
(503) 725-3673 Fax: (503) 725-4527

PENNSYLVANIA
STATE LIBRARY OF PENN.
Govt. Publications Section
Walnut St. & Commonwealth Ave. - P.O. Box 1601
Harrisburg, PA 17105
(717) 787-3752

SOUTH CAROLINA
CLEMSON UNIV.
Cooper Library
Public Documents Unit
Clemson, SC 29634-3001
(803) 656-5174 Fax: (803) 656-3025
In cooperation with Univ. of South Carolina, Thomas Cooper Library, Columbia

TENNESSEE
MEMPHIS STATE UNIV. LIBRARIES
Govt. Documents
Memphis, TN 38152
(901) 678-2586 Fax: (901) 678-2511

TEXAS
TEXAS STATE LIBRARY
United States Documents
P.O. Box 12927 - 1201 Brazos
Austin, TX 78711
(512) 463-5455 Fax: (512) 463-5436

TEXAS TECH. UNIV. LIBRARY
Documents Dept.
Lubbock, TX 79409
(806) 742-2268 Fax: (806) 742-1920

UTAH
UTAH STATE UNIV.
Merrill Library & Learning Resources Center, UMC-3000
Documents Dept.
Logan, UT 84322-3000
(801) 750-2684 Fax: (801) 750-2677

VIRGINIA
UNIV. OF VIRGINIA
Aldermman Library
Govt. Documents
Charlottesville, VA 22903-2498
(804) 824-3133 Fax: (804) 924-4337

WASHINGTON
WASHINGTON STATE LIBRARY
Document Section
MS AJ-11
Olympia, WA 98504-0111
(206) 753-4027 Fax: (206) 753-3546

WEST VIRGINIA
WEST VIRGINIA UNIV. LIBRARY
Govt. Documents Section
P.O. Box 6069
Morgantown, WV 26506
(304) 293-3640

WISCONSIN
ST. HIST. SOC. OF WISCONSIN LIBRARY
Govt. Publications Section
816 State Street
Madison, WI 53706
(608) 262-2781 Fax: (608) 262-4711
In cooperation with Univ. of Wisconsin - Madison, Memorial Library

MILWAUKEE PUBLIC LIBRARY
Documents Div.
814 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 278-2167 Fax: (414) 278-2137

POSTMASTER
Address Correction Requested
(Sections 137 and 159 Post Manual)

National Aeronautics and
Space Administration
Code JTT
Washington, DC 20546-0001

Official Business
Penalty for Private Use, $300

BULK RATE
POSTAGE & FEES PAID
NASA
Permit No. G-27