NASA SP-7037 (332)
July 1996

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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Typical Report Citation and Abstract

ON MICROFICHE ↓

ACCESSION NUMBER → **N96-10751#** Sandia National Labs., Albuquerque, NM. ← CORPORATE SOURCE

TITLE → **Minimizing phylogenetic number to find good evolutionary trees**

AUTHORS → Goldberg, Leslie Ann; Goldberg, Paul W.; Phillips, Cynthia A.; Sweedyk, Elizabeth (California Univ., Berkeley, CA.); and Warnow, Tandy (Pennsylvania Univ., Philadelphia, PA.) ← AUTHORS' AFFILIATION

PUBLICATION DATE → 1995 26 p Presented at the 1995 Symposium on Combinatorial Pattern Matching, Helsinki, Finland, 4-7 Jul. 1995 Sponsored by California Legislative Grant

CONTRACTS/GRANTS → Contract(s)/Grant(s): (DE-AC04-94AL-85000; NSF CCR-94-57800)

REPORT NO.(S) → Report No.(s): (DE95-011893; SAND-95-0831C; CONF-9507123-1) Avail: CASI HC A03/MF A01 ← AVAILABILITY AND PRICE CODE

ABSTRACT → Inferring phylogenetic trees is a fundamental problem in computational-biology. We present a new objective criterion, the phylogenetic number, for evaluating evolutionary trees for species defined by biomolecular sequences or other qualitative characters. The phylogenetic number of a tree T is the maximum number of times that any given character state arises in T. By contrast, the classical parsimony criterion measures the total number of times that different character states arise in T. We consider the following related problems: finding the tree with minimum phylogenetic number, and computing the phylogenetic number of a given topology in which only the leaves are labeled by species. When the number of states is bounded (as is the case for biomolecular sequence characters), we can solve the second problem in polynomial time. We can also compute a fixed-topology 2-phylogeny (when one exists) for an arbitrary number of states. This algorithm can be used to further distinguish trees that are equal under parsimony. We also consider a number of other related problems. DOE

SUBJECT TERMS → *Algorithms; Biological Evolution; Chemical Evolution; Genetics; Molecular Biology*

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 332)

JULY 1996

01 AERONAUTICS (GENERAL)

N96–22683* Johns Hopkins Univ., Baltimore, MD.
Electromagnetic stressing/optical detection technique for detection of disbonds in aging aircraft Ph.D. Thesis
Mayton, Donna Jean; et al1 Jan. 1994 84 p
Report No.(s): (NIPS–96–08280) Avail: Univ. Microfilms Order No. DA9429546

A novel electromagnetic stressing/optical detection method has been developed in response to the need for better nondestructive evaluation techniques for the detection of disbonds in aging aircraft lap joints. This technique uses magnetic pressure to pull the top surface of a thin conductive bonded sheet and senses the out–of–plane displacement of the surface with an optical lever fiber bundle detector. This method of inspection has the advantages of being noncontacting, relatively cheap, and because it pulls on the top surface, is a promising candidate for the detection of 'kissing' disbonds — a condition in which there is no material missing from the joint, but the adhesive has failed. A series of three models were developed and implemented to fully simulate the technique from the driving circuitry to the measured response of the sample. The driving circuit was computer modeled and the current through the electromagnetic coil as a function of time was predicted. An analytical pressure model was developed to predict pressure on the sample as a function of time for a given current input. The predicted pressure was used as the driving function in a finite element structural model which predicted displacement of the sample surface. Laboratory experiments were conducted on simple bonded and unbonded samples, and the two cases exhibited large differences in amplitude, resonant frequency, and damping. Tests were also performed on a simulated aircraft lap joint and the mechanical response of bonded and unbonded regions were distinguishable in the frequency domain. The series of models was used successfully to predict the displacement of the bonded and unbonded samples and compared to experimental results using a prototype system. The close correspondence between predicted and measured results indicates that the models are a useful tool in the design and implementation of this technique. Although the development of this technique was prompted by the failure of aging aircraft lap joints, it may be applied to any thin, conductive bonded structure.
Dissert. Abstr.
Adhesive Bonding; Bonded Joints; Debonding (materials); Lap Joints; Magnetic Effects; Nondestructive Tests; Optical Measurement;

N96–22869*# Aircraft Research Association Ltd., Bedford (England).
Collaboration in Aerospace: One European's Perspective
Green, J. E.; et al1 May 1995 26 p Presented at PICAST2–AAC6, Melbourne, Australia, 20–23 Mar. 1995
Report No.(s): (ARA–TM–414; NIPS–96–39308) Avail: CASI HC A03/MF A01

This lecture reviews European experience of collaboration in aerospace over the past forty years with particular reference to collaboration in aircraft development and production. It ranges from national and international collaboration in the provision of major wind tunnels, through inter–governmental collaboration on military aircraft and inter–company collaboration on civil aircraft to collaboration between aeronautical research organizations and also between learned societies. Finally, the general lessons to be drawn from this experience are outlined and their relevance to the developing aerospace industries of the Pacific Region is discussed.
Author
Aerospace Industry; Aircraft Design; Europe; International Cooperation; Research;

N96–22898*# Defence Science and Technology Organisation, Canberra (Australia).
F–111 Aircraft Fatigue Data Analysis System (AFDAS) in Service Development Progress Report, No. 1
Walker, K.; et al1 Jul. 1995 84 p
Report No.(s): (AD–A301201; DSTO–TR–05; DODA–AR–008–992; NIPS–96–30698) Avail: CASI HC A05/MF A01

The Aircraft Fatigue Data Analysis System (AFDAS) is a twelve channel, strain based fatigue data collection and analysis system. The RAAF have recognized that AFDAS

offers significant potential improvements over fatigue meters and parametric based systems for the purpose of fatigue monitoring and structural integrity management. AFDAS has therefore been implemented on a number of aircraft types, including the F–111. The system does, however, require further development and refinement. AMRL was requested by the RAAF to provide assistance and advice on the F–111 AFDAS installation. This report details the progress made so far on the current AMRL F–111 AFDAS support activity. The activity has included aspects which are unique to the F–111 and also some aspects which have a general applicability to the AFDAS installation on other aircraft types. Significant progress has been made in the following areas: (1) establishing why the strain sensor locations were chosen and how they relate to other locations of importance for fatigue or structural life monitoring reasons; (2) eliminating operational errors and difficulties which decrease the integrity of the data; and (3) developing new data screening procedures which check the data for inconsistencies and invalid results.
DTIC
Computer Programs; Data Reduction; F–111 Aircraft; Fatigue (materials); Strain Distribution; Strain Measurement; Structural Failure;

N96–23263*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Research and Technology, 1992
1 Jan. 1992 170 p
Report No.(s): (NASA–TM–105924; E–7425; NAS 1. 15:105924; NIPS–96–39490) Avail: CASI HC A08/MF A02

This report selectively summarizes the NASA Lewis Research Center's research and technology accomplishments for the fiscal year 1992. It comprises approximately 200 short articles submitted by the staff members of the technical directorates. The report is organized into six major sections: Aeronautics, Aerospace Technology, Space Flight Systems, Space Station Freedom, Engineering and Computational Support, and Lewis Research Academy. A table of contents by subject has been developed to assist the reader in finding articles of special interest. This report is not intended to be a comprehensive summary of all the research and technology work done over the past fiscal year. Most of the work is reported in Lewis–published technical reports, journal articles, and presentations prepared by Lewis staff or by contractors. In addition, university grants have enabled faculty members and graduate students to engage in sponsored research that is reported at technical meetings or in journal articles. For each article in this report a Lewis contact person has been identified, and where possible, a reference document is listed so that additional information can be easily obtained. The diversity of topics attests to the breadth of research and technology being pursued and to the skill mix of the staff that makes it possible.
Author
Aeronautical Engineering; Aerospace Engineering; Flight Instruments; NASA Programs; Research and Development; Space Station Freedom; Spacecraft Instruments;

02 AERODYNAMICS

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

N96–21512* Pennsylvania State Univ., University Park, PA.
Numerical Study of Steady and Oscillatory Flow Structures in an Axisymmetric Supersonic Inlet Ph.D. Thesis
Oh, Jong Yun; et al 1 Jan. 1994 183 p
Report No.(s): (NIPS–96–34394) Avail: Univ. Microfilms Order No. DA9504264

Steady and oscillatory flowfields of an axisymmetric mixed–compression supersonic inlet have been numerically studied by solving the compressible Euler and Navier–Stokes equations. Turbulence in the boundary layers is modeled using the algebraic model of Baldwin and Lomax for steady–state flow calculations and the two–layer model of Rodi for unsteady flow calculations. The governing equations are discretized with the finite–volume method, and the discretized equations are solved by the LU implicit scheme for the steady–state flows and by the four–stage Runge–Kutta explicit scheme for the unsteady flows. The upwind TVD scheme of Harten and Yee is adopted to capture shocks without numerical oscillations. Steady–state axisymmetric flowfields are investigated under various engine–operating conditions. The inviscid–flow results indicate that a vortex sheet, extending downstream from the shock intersection point, creates nonuniform flowfields in the radial direction at downstream of the terminal shock because of different compression histories of the flow just upstream of the shock. The viscous–flow results show that the boundary layers are thickened and separation bubbles are formed across the terminal shock due to shock/boundary–layer interactions. Unsteady axisymmetric flowfields are also analyzed to study the shock/acoustic–wave interactions. As the normal shock oscillates because of the fluctuating pressure imposed at the exit, the shock intersection point also fluctuates which can add one more mode of oscillation to the flowfields, especially to the velocity field. Finally, steady–state three–dimensional flowfields with finite angles of attack are investigated. When the angle of attack is not zero, the terminal shock is skewed due to different compression histories and the degree of skewness becomes greater with the increased angle of attack.
Dissert. Abstr.

Axisymmetric Bodies; Compressible Flow; Euler Equations of Motion; Inlet Flow; Inviscid Flow; Mathematical Models; Navier–stokes Equation; Oscillating Flow; Sound Waves; Steady Flow; Supersonic Inlets; Unsteady Flow; Viscous Flow;

N96–21524* Pennsylvania State Univ., University Park, PA.

The Interaction Between Crossing–Shock Waves and a Turbulent Boundary Layer Ph.D. Thesis

Garrison, Timothy Jon; et al1 Jan. 1994 297 p

Report No.(s): (NIPS–96–34137) Avail: Univ. Microfilms Order No. DA9504213

An experimental study has been performed to investigate the flowfield structure created by two crossing oblique shock waves interacting with a turbulent boundary layer. Such an interaction is of practical importance in the design of high–speed inlets. The interaction is created by a test model, consisting of two sharp fins mounted at symmetric angles–of–attack to a flat plate, placed in a supersonic free-stream flow. The interaction structure is examined for a range of symmetric fin angles from 7 to 15 degrees at free-stream Mach numbers of 3 and 3.85. This parametric study produces a broad range of interaction strengths, resulting in barely separated to strongly separated flows. A variety of experimental techniques are used to study the crossing–shock interaction. Planar laser scattering visualization and kerosene lampblack surface flow visualization are used to reveal the flowfield structure of these interactions. The visualizations show that the flowfield is comprised of a complex, irregular crossing of the two individual shock/boundary layer interactions created by each fin. Quantitative surface data are obtained through wall static pressure and skin friction coefficient measurements. The skin friction measurements, made using a laser interferometer skin friction meter, reveal regions with zero shear as well as regions of extremely high shear. Quantitative flowfield data, obtained through five–hole probe surveys, show the presence of a large, low–Mach–number, low–total–pressure region comprised of the separated incoming boundary layer fluid. The combined experimental dataset is used to formulate a detailed flowfield model of the crossing–shock interaction. The structure of these interactions is found to be similar over a broad range of interaction strengths and is dominated by a large, separated, viscous flow region which forms on the interaction plane of symmetry. Additionally, the experimental results are compared with two available computational solutions to assess the capabilities of current CFD programs to model such complex interactions.

Dissert. Abstr.

Angle of Attack; Fins; Flow Distribution; Flow Visualization; Free Flow; Oblique Shock Waves; Separated Flow; Shock Wave Interaction; Supersonic Flow; Turbulent Boundary Layer; Viscous Flow;

N96–21525* Pennsylvania State Univ., University Park, PA.

An Experimental Study of Fluctuating Pressure Loads Beneath Swept Shock Wave/Boundary Layer Interactions Ph.D. Thesis

Garg, Sanjay; et al1 Jan. 1994 156 p

Report No.(s): (NIPS–96–34136) Avail: Univ. Microfilms Order No. DA9504210

An experimental research program providing basic knowledge and establishing a database on the fluctuating pressure loads produced on aerodynamic surfaces beneath three–dimensional shock wave/boundary layer interactions is described. Such loads constitute a fundamental problem of critical concern to future supersonic and hypersonic flight vehicles. A turbulent boundary layer on flat plate is subjected to interactions with swept planar shock waves generated by sharp fins. Fin angles from 10 deg to 20 deg at free-stream Mach numbers of 3 and 4 produce a variety of interaction strengths from weak to very strong. Miniature pressure transducers flush–mounted in the flat plate have been used to measure interaction–induced wall pressure fluctuations. The distributions of properties of the pressure fluctuations, such as their rms level, amplitude distribution and power spectra, are also determined. Measurements have been made for the first time in the aft regions of these interactions, revealing fluctuating pressure levels as high as 155 dB, which places them in the category of significant aeroacoustic load generators. The fluctuations near the foot of the fin are dominated by low frequency (0–5 kHz) components, and are caused by a previously unrecognized random motion of the primary attachment line. This phenomenon is probably intimately linked to the unsteadiness of the separation shock at the start of the interaction. The characteristics of the pressure fluctuations are explained in light of the features of the interaction flowfield. In particular, physical mechanisms responsible for the generation of high levels of surface pressure fluctuations are proposed based on the results of the study. The unsteadiness of the flowfield of the surface is also examined via a novel, non–intrusive optical technique. Results show that the entire shock structure generated by the interaction undergoes relatively low–frequency oscillations.

Dissert. Abstr.

Control Surfaces; Interactional Aerodynamics; Pressure; Pressure Distribution; Shock Wave Interaction; Three Dimensional Boundary Layer; Turbulent Boundary Layer;

N96–21558* California Univ., Los Angeles, CA.

The control of 2–D wakes/mixing layers via suction at the trailing edge of a splitter plate Ph.D. Thesis

Leu, Tzong–Shyng; et al1 Jan. 1994 166 p

Report No.(s): (NIPS–96–34453) Avail: Univ. Microfilms Order No. DA9502028

Wake and mixing layer flows controlled by suction at the trailing edge of a splitter are investigated both experi-

mentally and theoretically. The experiments are performed in a shear layer water channel. In the wake flow controlled by a suction, a threshold suction speed is found to be equal to one half of freestream velocity. When the suction speed is below the threshold, the wake flow is unstable. When the suction speed is above the threshold, the wake becomes stable and no vortex shedding exists. The stability analysis is performed in order to understand the physical mechanism in this wake control problem. The results show the vortex shedding frequency can be well predicted by the velocity profile immediately behind the solid boundary. Furthermore, the threshold suction speed can be reasonably predicted by the global linear stability analysis in a weakly non–parallel flow. The observed changes of the global flow field are related to an absolute instability region near the trailing edge. The non–parallel flow effects are responsible for this global instability breakdown.
Dissert. Abstr.
Flow Distribution; Mixing Layers (fluids); Shear Layers; Suction; Trailing Edges; Velocity Distribution; Vortex Shedding; Wakes;

N96–21568* Rensselaer Polytechnic Inst., Troy, NY.
Lifting surface design using trailing edge devices, marginal aeroelastic stability and feedback control Ph.D. Thesis
Tseng, Stephen Pai–Yu; et al1 Jan. 1994 167 p
Report No.(s): (NIPS–96–34462) Avail: Univ. Microfilms Order No. DA9434604

Considerable promise is seen in the application of strain actuator technology as ?Smart Materials' for fulfilling control functions of various kinds in aircraft. However, the strain and force capability of these actuators are known to impose limitations. To overcome these limitations, the aeromechanical design of fixed and rotary wings from a control viewpoint have been investigated in this study. Three design analyses have been conducted using a simple model with a trailing–edge hinged flap or tab representing the strain actuators, including a fixed wing–flap–tab with constant forward speed, a wing–flap with pulsating velocity superimposed on constant forward speed, and a helicopter rotor blade in hovering flight. A generalized two–dimensional, time–domain, finite–state, Theodorsen–Greenberg unsteady aerodynamic model of the wing–flap in a pulsating velocity field has been extended and applied in these analyses to calculate the aerodynamic loads on the airfoils with a trailing–edge hinged control surface. State space representations of those lifting surface aerodynamics have been derived in time–varying format. Single– and multi–objective design optimizations have then been conducted to assess the capabilities of possible designs which maximize the amplification of the rotations and minimize force required of the control surfaces. As these optimal designs optimizations have ten been conducted to assess the capabilities of possible designs which maximize the amplification of the rotations and minimize the force required of the control surfaces. As these optimal designs tend to approach aeroelastic instability, Linear Quadratic Gaussian (LQG) feedback controller design has been applied to assure the stability of resulting motions and improve the output performance. A discrete periodic time–varying LQG controller has also been developed to stabilize the systems in the presence of pulsating velocity effects. A dynamic inflow model has been linearized and included in the design analyses of the helicopter rotor blade to represent the three–dimensional transient behavior of the complete rotor. The results of this research have shown the feasibility of applying properly designed trailing–edge control surfaces which make use of strain actuation concepts to both fixed and rotary wings. Further analyses and experiments are expected to be required to develop this concept of ?Smart Structure' control surfaces to the point where they are ready for practical aircraft applications.
Dissert. Abstr.
Aerodynamic Stability; Aeroelasticity; Aircraft Design; Controllers; Design Analysis; Feedback Control; Lifting Bodies; Linear Quadratic Gaussian Control; Tabs (control Surfaces); Trailing Edge Flaps;

N96–21659*# Instituto Nacional de Pesaciais Espaciais, Sao Jose dos Campos (Brazil).
Determination of Coefficeint of Drag of the Sphere–Cone Configurations by Method of Belotserkovskii M.S. Thesis [Determinacao do Coefficiente de Arrasto de Configuracoes Esfera–Cone Pelo Metodo de Belotserkovskii]
Dasilva, Fernando Cachucho ca; et al1 Feb. 1995 123 p In PORTUGUESE
Report No.(s): (INPE–5679–TDI/566; NIPS–96–35416) Avail: CASI HC A06/MF A02

A computational code based on the first aproximation of the method of Belotserkovskii has been developed to calculate the coefficient of drag of the sphere–cone configurations. In this method, the region of integration is subdivided in several strips using curves which shapes are determined by the profile of the region. The basic objective is to integrate, over this strips, the governing partial differential equations with respect to one of the independent variables. Following the integrands are approximated to m order polynomials in this variable. After integrating these polynomials an approximated system of ordinary differential equations is obtained as a function of the remaining independent variable. The results obtained for the pressure and drag coefficients are compared with the experimental data obtained in wind tunnels.
Author
Aerodynamic Drag; Cones; Drag Coefficients; Partial Differential Equations;

N96–21660*# High Technology Corp., Hampton, VA.
Large–Eddy Simulation of Turbulent Wall–Pressure

Fluctuations

Singer, Bart A.; et al 1 Feb. 1996 38 p

Contract(s)/Grant(s): (NAS1–20059; RTOP 505–59–50–02)

Report No.(s): (NASA–CR–198276; NAS 1.26:198276; NIPS–96–35609) Avail: CASI HC A03/MF A01

Large–eddy simulations of a turbulent boundary layer with Reynolds number based on displacement thickness equal to 3500 were performed with two grid resolutions. The computations were continued for sufficient time to obtain frequency spectra with resolved frequencies that correspond to the most important structural frequencies on an aircraft fuselage. The turbulent stresses were adequately resolved with both resolutions. Detailed quantitative analysis of a variety of statistical quantities associated with the wall–pressure fluctuations revealed similar behavior for both simulations. The primary differences were associated with the lack of resolution of the high–frequency data in the coarse–grid calculation and the increased jitter (due to the lack of multiple realizations for averaging purposes) in the fine–grid calculation. A new curve fit was introduced to represent the spanwise coherence of the cross–spectral density.

Author

Aircraft Noise; Computational Grids; Crank–nicholson Method; Noise Reduction; Pressure Oscillations; Quantitative Analysis; Runge–kutta Method; Structural Vibration; Turbulent Boundary Layer; Wall Pressure;

N96–21664*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A Computational and Experimental Study of Nonlinear Aspects of Induced Drag

Smith, Stephen C.; et al1 Feb. 1996 140 p

Report No.(s): (NASA–TP–3598; A–960804; NAS 1.60: 3598; NIPS–96–34550) Avail: CASI HC A07/MF A02

Despite the 80–year history of classical wing theory, considerable research has recently been directed toward planform and wake effects on induced drag. Nonlinear interactions between the trailing wake and the wing offer the possibility of reducing drag. The nonlinear effect of compressibility on induced drag characteristics may also influence wing design. This thesis deals with the prediction of these nonlinear aspects of induced drag and ways to exploit them. A potential benefit of only a few percent of the drag represents a large fuel savings for the world's commercial transport fleet. Computational methods must be applied carefully to obtain accurate induced drag predictions. Trefftz–plane drag integration is far more reliable than surface pressure integration, but is very sensitive to the accuracy of the force–free wake model. The practical use of Trefftz plane drag integration was extended to transonic flow with the Tranair full–potential code. The induced drag characteristics of a typical transport wing were studied with Tranair, a full–potential method, and A502, a high–order linear panel method to investigate changes in lift distribution and span efficiency due to compressibility. Modeling the force–free wake is a nonlinear problem, even when the flow governing equation is linear. A novel method was developed for computing the force–free wake shape. This hybrid wake–relaxation scheme couples the well–behaved nature of the discrete vortex wake with viscous–core modeling and the high–accuracy velocity prediction of the high–order panel method. The hybrid scheme produced converged wake shapes that allowed accurate Trefftz–plane integration. An unusual split–tip wing concept was studied for exploiting nonlinear wake interaction to reduced induced drag. This design exhibits significant nonlinear interactions between the wing and wake that produced a 12% reduction in induced drag compared to an equivalent elliptical wing at a lift coefficient of 0.7. The performance of the split–tip wing was also investigated by wing tunnel experiments. Induced drag was determined from force measurements by subtracting the estimated viscous drag, and from an analytical drag–decomposition method using a wake survey. The experimental results confirm the computational prediction.

Author

Induced Drag; Interactional Aerodynamics; Nonlinearity; Wakes; Wing Tips;

N96–21666*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

Effects of Winglets on the Drag of a Low–Aspect–Ratio Configuration

Smith, Leigh Ann; and Campbell, Richard L.; et al1 Feb. 1996 66 p

Report No.(s): (NASA–TP–3563; L–17456L; NAS 1.60: 3563; NIPS–96–34548) Avail: CASI HC A04/MF A01

A wind–tunnel investigation has been performed to determine the effect of winglets on the induced drag of a low–aspect–ratio wing configuration at Mach numbers between 0.30 and 0.85 and a nominal angle–of–attack range from –2 deg to 20 deg. Results of the tests at the cruise lift coefficient showed significant increases in lift–drag ratio for the winglet configuration relative to a wing–alone configuration designed for the same lift coefficient and Mach number. Further, even larger increases in lift–drag ratio were observed at lift coefficients above the design value at all Mach numbers tested. The addition of these winglets had a negligible effect on the static lateral–directional stability characteristics of the configuration. No tests were made to determine the effect of these winglets at supersonic Mach numbers, where increases in drag caused by winglets might be more significant. Computational analyses were also performed for the two configurations studied. Linear and small–disturbance formulations were used. The codes were found to give reasonable performance estimates sufficient for predicting changes of this magnitude.

Author

Aerodynamic Coefficients; Aerodynamic Configurations;

Aircraft Design; Angle of Attack; Drag Reduction; Induced Drag; Lift; Low Aspect Ratio Wings; Mach Number; Prediction Analysis Techniques; Wind Tunnel Tests; Winglets;

N96–21692* Minnesota Univ., Duluth, MN.

On the Dispersion of Particles in the Near Wake of a Blunt Obstruction Ph.D. Thesis

Gomes, Marcos Sebastiao dep; et al1 Jan. 1994 216 p

Report No.(s): (NIPS–96–34138) Avail: Univ. Microfilms Order No. DA9501098

This work examines the dispersion of particles in the flow around a blunt obstruction, more specifically the residence time for particles in the near wake region after a source for the aerosols has been removed. It involved the development of a numerical model and several experiments for the validation of the model and for extending our knowledge on the subject. The numerical procedure was based on the kappa–epsilon model of turbulence, using the SIMPLER algorithm (Patankar, 1980), developed for inertialess particles. Preliminary experiments in which the concentration was measured through a sampling line proved inadequate. The dynamic response was slow due to the convective and diffusive dispersion of particles inside the tubing. We investigated the problem and developed a procedure that may be applied to other aerosol measurements. After building novel instrumentation, new experiments were started. The dimensionless residence time for particles in the near wake region H = tau U/D (suggested by Humphries and Vincent, 1976; r is the time constant for the concentration decay, U is the free–stream velocity and D is the plate width) was measured in the range of Reynolds numbers 1,000 less than or equal to Re less than or equal to 10,000. H was found to be approximately constant at about 9 +/– 1.5 for Re greater than or equal to 4,000. These results were in agreement with the numerical procedure. We then investigated the effect of free–stream turbulence for a range of dimensionless turbulence parameters A(sub f) = k(sub f)(exp l/2) l(sub f)UD (k(sub f) is the turbulence kinetic energy and l(sub f) is the integral length scale of the freestream turbulence) from 0.0015 to 0.071, for 1,500 less than or equal to Re less than or equal to 11,000. For Re above 4,000 H was 7.2 +/– 1.5 for 0.0015 less than or equal to A(sub f) less than or equal to 0.013, progressively increasing up to 10 for A(sub f) = 0.071. This was explained by the interaction of the free–stream turbulence with the vortex shedding mechanism. Finally, we performed experiments to investigate inertial effects. The aerosol was in the aerodynamic diameter range from 14 to 47 micro m, corresponding to Stokes numbers (the ratio of particle response time to a time scale for changes in the Row) from 0.02 to 1.8. Visualization of the particles' trajectories identified organized structures as a consequence of centrifugal inertial effects, referred to as 'de–mixing' by Crowe (1992).

Dissert. Abstr.

Dynamic Response; K–epsilon Turbulence Model; Near Wakes; Reynolds Number; Turbulence; Vortex Shedding;

N96–21696* Iowa State Univ. of Science and Technology, Ames, IA.

Numerical Evaluation of Corona Discharge as a Means of Boundary Layer Control and Drag Reduction Ph.D. Thesis

El–Khabiry, Samir Hamza; et al1 Jan. 1994 192 p

Report No.(s): (NIPS–96–34133) Avail: Univ. Microfilms Order No. DA9503549

Problems of viscous drag reduction and boundary layer control have been and continue to be objectives of research for their economic impact and the enhancement of the flight characteristics of flying vehicles. Corona discharge is a new technique in this regard. The study of this technique requires consideration of the electrostatics and fluid mechanics. In order to effectively evaluate the technique with minimum complications, the geometry chosen was a dc positive corona discharge on a flat plate of zero thickness at zero angle of attack with the fluid flow as steady state, two–dimensional, incompressible viscous one. Five coupled partial differential equations govern this model requiring the simultaneous solution of these equations. A finite difference method has been employed to approximate these equations through an appropriate scheme for each equation. A clustered grid is used in the vertical direction to handle the high velocity gradient inside the boundary layer. The insufficient boundary conditions necessary for the numerical solution of Poisson's equation is compensated by making the numerical model find the appropriate computational domain which leads to a unique solution. Stability conditions of the five–point scheme approximating Poisson's equation has been determined computationally. Results obtained using the numerical model are presented. As a result of this research the corona discharge near a surface of finite conductivity is now better understood as an electrostatic phenomena. The corona discharge between wire–to–wire electrodes occurs if the electric potential difference between the electrodes is raised to a value higher than the corona onset voltage. The corona current is proportional to the potential difference between the electrodes and inversely proportional to the corona wire diameter. At the same time it does not significantly respond to the gap length between the electrodes until the corona wire diameter becomes large, then it varies inversely as the gap length. The corona discharge can be applied to reduce drag on bodies when the Reynolds number is relatively small. The drag reduction achieved by corona discharge inside a boundary layer is a function of many parameters. The drag reduction is proportional to both the electric potential difference and the gap length between the two electrodes and inversely proportional to the free stream velocity. It is also proportional to the location of the corona electrodes as measured from the plate leading edge and inversely proportional to the coro-

na wire diameter. The increased effect of corona discharge at low flow speeds confirms its ability to significantly enhance the cooling rate of a hot body by boosting the convection of the flow around that body. The quantitative analysis of electrostatic cooling is the natural extension of this study. Dissert. Abstr.

Boundary Conditions; Boundary Layer Control; Drag Reduction; Electric Corona; Electrostatics; Finite Difference Theory; Partial Differential Equations; Viscous Drag;

N96–22123*# Old Dominion Univ., Norfolk, VA.

An Experimental Investigation of Wall–Cooling Effects on Hypersonic Boundary–Layer Stability in a Quiet Wind Tunnel Final Report

Blanchard, Alan E.; and Selby, Gregory V.; et al1 Feb. 1996 120 p

Contract(s)/Grant(s): (NCC1–180; RTOP 505–59–50–02)

Report No.(s): (NASA–CR–198287; NAS 1.26:198287; NIPS–96–36713) Avail: CASI HC A06/MF A02

One of the primary reasons for developing quiet tunnels is for the investigation of high–speed boundary–layer stability and transition phenomena without the transition–promoting effects of acoustic radiation from tunnel walls. In this experiment, a flared–cone model under adiabatic– and cooled–wall conditions was placed in a calibrated, 'quiet' Mach 6 flow and the stability of the boundary layer was investigated using a prototype constant–voltage anemometer. The results were compared with linear–stability theory predictions and good agreement was found in the prediction of second–mode frequencies and growth. In addition, the same 'N=10' criterion used to predict boundary–layer transition in subsonic, transonic, and supersonic flows was found to be applicable for the hypersonic flow regime as well. Under cooled–wall conditions, a unique set of continuous spectra data was acquired that documents the linear, nonlinear, and breakdown regions associated with the transition of hypersonic flow under low–noise conditions.

Author

Boundary Layer Stability; Boundary Layer Transition; Hypersonic Boundary Layer; Hypersonic Wind Tunnels; Surface Cooling; Wind Tunnel Tests; Wind Tunnel Walls;

N96–22148*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A parametric study of supersonic laminar flow for swept wings using linear stability analysis

Cummings, Russell M.; Garcia, Joseph A.; and Tu, Eugene L.; et al22 Jun. 1995 13 p Presented at 26th AIAA Fluid Dynamics Conference, San Diego, CA, United States, 19–22 Jun. 1995

Report No.(s): (NASA–TM–111258; NAS 1.15:111258; AIAA PAPER 95–2277; NIPS–96–07973) Avail: CASI HC A03/MF A01

A parametric study to predict the extent of laminar flow on the upper surface of a generic swept–back wing (NACA 64A010 airfoil section) at supersonic speeds was conducted. The results were obtained by using surface pressure predictions from an Euler/Navier–Stokes computational fluid dynamics code coupled with a boundary layer code, which predicts detailed boundary layer profiles, and finally with a linear stability code to determine the extent of laminar flow. The parameters addressed are Reynolds number, angle of attack, and leading–edge wing sweep. The results of this study show that an increase in angle of attack, for specific Reynolds numbers, can actually delay transition. Therefore, higher lift capability, caused by the increased angle of attack, as well as a reduction in viscous drag due to the delay in transition is possible for certain flight conditions.

Author

Applications Programs (computers); Flow Stability; Laminar Flow; Linear Equations; Prediction Analysis Techniques; Pressure; Supersonic Flow; Supersonic Speed; Swept Wings; Upper Surface Blowing; Viscous Drag;

N96–22157*# California Univ., Davis, CA.

Analysis of in–flight boundary–layer state measurements on a subsonic transport wing in high–lift configuration

Vandam, C. P.; Los, S. M.; Miley, S. J.; (Old Dominion Univ., Norfolk, VA.)Yip, L. P.; (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.)Banks, D. W.; (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.)Roback, V. E.; (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.)and Bertelrud, A.; (Analytical Services and Materials, Inc., Hampton, VA.) et al21 Sep. 1995 18 p Presented at 1st AIAA Aircraft Engineering, Technology, and Operations Congress, Los Angeles, CA, United States, 19–21 Sep. 1995

Contract(s)/Grant(s): (NCC1–163; NCC1–207; NAS1–19000; NAS1–19864)

Report No.(s): (NASA–CR–200146; NAS 1.26:200146; AIAA PAPER 95–3911; NIPS–96–07976) Avail: CASI HC A03/MF A01

Flight experiments on NASA Langley's B737–100 (TSRV) airplane have been conducted to document flow characteristics in order to further the understanding of high–lift flow physics, and to correlate and validate computational predictions and wind–tunnel measurements. The project is a cooperative effort involving NASA, industry, and universities. In addition to focusing on in–flight measurements, the project includes extensive application of various computational techniques, and correlation of flight data with computational results and wind–tunnel measurements. Results obtained in the most recent phase of flight experiments are analyzed and presented in this paper. In–flight measurements include surface pressure distributions, measured using flush pressure taps and pressure belts on the slats, main ele-

ment, and flap elements; surface shear stresses, measured using Preston tubes; off–surface velocity distributions, measured using shear–layer rakes; aeroelastic deformations of the flap elements, measured using an optical positioning system; and boundary–layer transition phenomena, measured using hot–film anemometers and an infrared imaging system. The analysis in this paper primarily focuses on changes in the boundary–layer state that occurred on the slats, main element, and fore flap as a result of changes in flap setting and/or flight condition. Following a detailed description of the experiment, the boundary–layer state phenomenon will be discussed based on data measured during these recent flight experiments.
Author
Aerodynamic Configurations; Boundary Layer Transition; Flapping; Flow Characteristics; In–flight Monitoring; Lift; Pressure; Shear Stress; Subsonic Speed; Transport Aircraft; Wind Tunnel Tests;

N96–22176*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Effect of a delta tab on fine scale mixing in a turbulent two–stream shear layer
Foss, J. K.; and Zaman, K. B. m. Q.; et al1 Jan. 1996 13 p
Presented at 34th Aerospace Sciences Meeting and Exhibit, Reno, NV, United States, 15–18 Jan. 1996; Sponsored by American Inst. of Aeronautics and Astronautics,
Report No.(s): (NASA–TM–107131; E–10057; AIAA PAPER 96–0546; NAS 1.15:107131; NIPS–96–08123) Avail: CASI HC A03/MF A01

The fine scale mixing produced by a delta tab in a shear layer has been studied experimentally. The tab was placed at the trailing edge of a splitter plate which produced a turbulent two–stream mixing layer. The tab apex tilted downstream and into the high speed stream. Hot–wire measurements in the 3–D space behind the tab detailed the three velocity components as well as the small scale population distributions. These small scale eddies, which represent the peak in the dissipation spectrum, were identified and counted using the Peak–Valley–Counting technique. It was found that the small scale populations were greater in the shear region behind the tab, with the greatest increase occurring where the shear layer underwent a sharp turn. This location was near, but not coincident, with the core of the streamwise vortex, and away from the region exhibiting maximum turbulence intensity. Moreover, the tab increased the most probably frequency and strain rate of the small scales. It made the small scales smaller and more energetic.
Author
Mixing Layers (fluids); Shear Layers; Tabs (control Surfaces); Turbulent Mixing;

N96–22239*# Army Aviation Research and Development Command, Moffett Field, CA. Aeroflightdynamics Directorate.
Suppression of Dynamic Stall by Steady and Pulsed Upper–Surface Blowing
Weaver, D.; (California Polytechnic State Univ., San Luis Obispo, CA.)McAlister, K. W.; and Tso, J.; (California Polytechnic State Univ., San Luis Obispo, CA.) et al1 Feb. 1996 106 p
Report No.(s): (NASA–TP–3600; NAS 1.60:3600; USAATCOM–95–A–005; A–95103; NIPS–96–37017) Avail: CASI HC A06/MF A02

The Boeing–Vertol VR–7 airfoil was experimentally studied with steady and pulsed upper–surface blowing for sinusoidal pitching oscillations described by alpha = alpha(sub m) + 10 deg sin(omega t). The tests were conducted in the U.S. Army Aeroflightdynamics Directorate's Water Tunnel at NASA Ames Research Center. The experiment was performed at a Reynolds number of 100,000. Pitch oscillations with alpha(sub m) = 10 deg and 15 deg and with reduced frequencies ranging from k = 0.005 to 0.15 were examined. Blowing conditions ranged from C(sub mu) = 0.03 to 0.66 and F(+) = 0 to 3. Unsteady lift, drag, and pitching–moment loads were measured, and fluorescent–dye flow visualizations were obtained. Steady, upper–surface blowing was found to be capable of trapping a separation bubble near the leading edge during a portion of the airfoil's upward rotation. When this occurred, the lift was increased significantly and stall was averted. In all cases, steady blowing reduced the hysteresis amplitudes present in the loads and produced a large thrust force. The benefits of steady blowing diminished as the reduced frequency and mean angle of oscillation increased. Pulsed blowing showed only marginal benefits for the conditions tested. The greatest gains from pulsed blowing were achieved at F(+) = 0.9.
Author
Aerodynamic Stalling; Airfoils; Pitching Moments; Upper Surface Blowing;

N96–22264*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
Computational considerations for the simulation of shock–induced sound
Casper, Jay; and Carpenter, Mark H.; et al1 Dec. 1996 26p
Report No.(s): (NASA–TM–110222; NAS 1.15:110222; NIPS–96–08488) Avail: CASI HC A03/MF A01

The numerical study of aeroacoustic problems places stringent demands on the choice of a computational algorithm, because it requires the ability to propagate disturbances of small amplitude and short wavelength. The demands are particularly high when shock waves are involved, because the chosen algorithm must also resolve discontinuities in the solution. The extent to which a high–order–accurate shock–capturing method can be relied upon for aero-

acoustics applications that involve the interaction of shocks with other waves has not been previously quantified. Such a study is initiated in this work. A fourth–order–accurate essentially nonoscillatory (ENO) method is used to investigate the solutions of inviscid, compressible flows with shocks in a quasi–one–dimensional nozzle flow. The design order of accuracy is achieved in the smooth regions of a steady–state test case. However, in an unsteady test case, only first–order results are obtained downstream of a sound–shock interaction. The difficulty in obtaining a globally high–order–accurate solution in such a case with a shock–capturing method is demonstrated through the study of a simplified, linear model problem. Some of the difficult issues and ramifications for aeroacoustics simulations of flows with shocks that are raised by these results are discussed.
Author
Acoustic Simulation; Aeroacoustics; Shock Wave Interaction; Shock Waves;

N96–22270*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Calculation of Turbulent Subsonic Diffuser Flows Using the NPARC Navier–Stokes Code
Dudek, J. C.; Georgiadis, N. J.; and Yoder, D. A.; et al1 Feb. 1996 16 p Presented at 34th Aerospace Sciences Meeting and Exhibit, Reno, NV, United States, 15–18 Jan. 1996; Sponsored by American Inst. of Aeronautics and Astronautics,
Report No.(s): (NASA–TM–107177; E–10139; NAS 1.15:107177; AIAA PAPER 96–0497; NIPS–96–35614) Avail: CASI HC A03/MF A01

Axisymmetric subsonic diffuser flows were calculated with the NPARC Navier–Stokes code in order to determine the effects various code features have on the flow solutions. The code features examined in this work were turbulence models and boundary conditions. Four turbulence models available in NPARC were used: the Baldwin–Lomax algebraic model, the Baldwin–Barth one–equation model, and the Chien kappa–epsilon and Wilcox kappa–omega two–equation models. The three boundary conditions examined were the free boundary, the mass flux boundary and the subsonic outflow with variable static pressure. In addition to boundary condition type, the geometry downstream of the diffuser was varied to see if upstream influences were present. The NPARC results are compared with experimental data and recommendations are given for using NPARC to compute similar flows.
Author
Axisymmetric Flow; Computational Fluid Dynamics; Diffusers; Incompressible Flow; Navier–stokes Equation; Subsonic Flow; Turbulence Models; Turbulent Flow;

N96–22293*# Purdue Univ., Indianapolis, IN. School of Aeronautics and Astronautics.
High lift wake investigation Progress Report
Sullivan, J. P.; Schneider, S. P.; and Hoffenberg, R.; et al2 Feb. 1996 15 p Presented at 13th AIAA Applied Aerodynamics Conference, United States, Jun. 1995
Contract(s)/Grant(s): (NAG2–854)
Report No.(s): (NASA–CR–200256; AIAA PAPER 95–1912; NAS 1.26:200256; NIPS–96–08794) Avail: CASI HC A03/MF A01

The behavior of wakes in adverse pressure gradients is critical to the performance of high–lift systems for transport aircraft. Wake deceleration is known to lead to sudden thickening and the onset of reversed flow; this 'wake bursting' phenomenon can occur while surface flows remain attached. Although known to be important for high–lift systems, few studies of such decelerated wakes exist. In this study, the wake of a flat plate has been subjected to an adverse pressure gradient in a two–dimensional diffuser, whose panels were forced to remain attached by use of slot blowing. Pitot probe surveys, L.D.V. measurements, and flow visualization have been used to investigate the physics of this decelerated wake, through the onset of reversed flow.
Author
Flow Distribution; Flow Measurement; Lift Devices; Pressure Effects; Pressure Gradients; Pressure Measurement; Reversed Flow; Turbulent Flow; Wakes; Wind Tunnel Tests;

N96–22308*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
Efficient Helicopter Aerodynamic and Aeroacoustic Predictions on Parallel Computers
Wissink, Andrew M.; (Minnesota Univ., Minneapolis, MN.)Lyrintzis, Anastasios S.; (Purdue Univ., West Lafayette, IN.)Strawn, Roger C.; (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.)Oliker, Leonid; (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.)and Biswas, Rupak; (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.) et al1 Jan. 1996 14 p Presented at AIAA 34th Aerospace Sciences Meeting and Exhibit, Reno, NV, United States, 15–18 Jan. 1996
Contract(s)/Grant(s): (NAS2–13721)
Report No.(s): (NASA–CR–199469; NAS 1.26:199469; RIACS–TR–96–04; AIAA PAPER 96–0153; NIPS– 96–35634) Avail: CASI HC A03/MF A01

This paper presents parallel implementations of two codes used in a combined CFD/Kirchhoff methodology to predict the aerodynamics and aeroacoustics properties of helicopters. The rotorcraft Navier–Stokes code, TURNS, computes the aerodynamic flowfield near the helicopter blades and the Kirchhoff acoustics code computes the noise in the far field, using the TURNS solution as input. The overall par-

allel strategy adds MPI message passing calls to the existing serial codes to allow for communication between processors. As a result, the total code modifications required for parallel execution are relatively small. The biggest bottleneck in running the TURNS code in parallel comes from the LU–SGS algorithm that solves the implicit system of equations. We use a new hybrid domain decomposition implementation of LU–SGS to obtain good parallel performance on the SP–2. TURNS demonstrates excellent parallel speedups for quasi–steady and unsteady three–dimensional calculations of a helicopter blade in forward flight. The execution rate attained by the code on 114 processors is six times faster than the same cases run on one processor of the Cray C–90. The parallel Kirchhoff code also shows excellent parallel speedups and fast execution rates. As a performance demonstration, unsteady acoustic pressures are computed at 1886 far–field observer locations for a sample acoustics problem. The calculation requires over two hundred hours of CPU time on one C–90 processor but takes only a few hours on 80 processors of the SP2. The resultant far–field acoustic field is analyzed with state of–the–art audio and video rendering of the propagating acoustic signals.
Author
Aeroacoustics; Computational Fluid Dynamics; Helicopters; Navier–stokes Equation; Parallel Computers; Rotary Wing Aircraft; Sound Fields;

N96–22391* Old Dominion Univ., Norfolk, VA.
Simulation of active control of asymmetric flows around slender pointed forebodies Ph.D. Thesis
Sharafel–Din, Hazem Hafez; et al1 Jan. 1994 236 p
Report No.(s): (NIPS–96–33250) Avail: Univ. Microfilms Order No. DA9514746

At high angles of attack, the flowfield over slender forebodies becomes asymmetric with substantial side force, which may exceed the available control capability. The unsteady compressible Navier–Stokes equations are used to investigate the effectiveness of different active control methods to alleviate and possibly eliminate the flow asymmetry and the subsequent side force. Although the research work focuses on active control methods, a passive control method has been investigated. The implicit, Roe flux–difference splitting, finite volume scheme is used for the numerical computations. Both locally–conical and three–dimensional solutions of the Navier–Stokes equations are obtained. The asymmetric flow over five–degree semi–apex angle cone is used as a reference case to which the different control methods are applied and compared. For the passive control method, the side–strakes control is investigated. The parametric study includes the control effectiveness of the strake span length. For the active control methods, flow injection in the normal and tangential directions to the body surface has been investigated. Both uniform and pressure–sensitive mass flow injection are applied, and the effects of mass flow rate, injection angle and injection length have also been studied. Injection, with a parabolic profile, is applied from the cone sides tangent to its surface. Surface–heating, where temperature of the cone surface is increased, is also investigated. The effectiveness of a hybrid method of flow control, which combines injection with surface heating, has been studied. The cone spinning and rotary oscillation around its axis are applied as an active control method. The computational applications include the effects of uniform spinning rates and periodic rotary oscillations at different amplitudes and frequencies on the flow asymmetry.
Dissert. Abstr.
Active Control; Compressible Flow; Computational Fluid Dynamics; Finite Volume Method; Flow Distribution; Flux Difference Splitting; Forebodies; Navier–stokes Equation; Unsteady Flow;

N96–22406* Toronto Univ. (Ontario).
A study of the fortified Navier–Stokes approach for viscous airfoil computations Ph.D. Thesis
Bergeron, Maurice Denis; et al1 Jan. 1994 153 p
Report No.(s): (ISBN 0–315–92601–5; NIPS–96–33378)
Avail: Univ. Microfilms Order No. DANN92601

In general, the application of current computational methods to attached viscous airfoil flow results in lift predictions to within 3 percent and drag predictions to within 5 percent of experimental values. For separated flows, the errors can be considerably larger. These errors are a combination of physical–model errors and numerical errors. Very fine grids are required to reduce numerical errors in drag to acceptable levels which drastically increases the computer resources required, especially in three–dimensional computations. Therefore, there is considerable motivation to examine numerical methods which might reduce the number of grid points required to achieve a given level of accuracy in drag. One such method is the fortified Navier–Stokes (FNS) approach. A global Navier–Stokes solution computed on a coarse grid is 'fortified' with a boundary layer solution which is obtained efficiently on a fine grid superimposed near the body surface. Other authors have demonstrated that FNS increases the efficiency and accuracy of a Navier–Stokes solver when it is applied to flat plate flows. In this work, FNS is extended to viscous airfoil computations. Factors affecting the fortification process are investigated, suitable blending functions are developed and an overall fortification strategy is implemented with the diagonal form of an implicit approximate–factorization algorithm. Computational results are presented for five subsonic and transonic viscous airfoil cases which display a variety of attached and separated flow conditions. In all cases, the FNS approach is successful in reducing numerical errors in drag, particularly for cases dominated by friction drag. However, due to constraints on the amount of forcing which can be applied, the FNS approach is only partially effective at improving the

accuracy of the pressure field relative to the coarse–mesh Navier–Stokes solution. Therefore, the approach is most appropriate for attached and mildly separated flows.
Dissert. Abstr.
Airfoils; Computational Grids; Friction Drag; Navier–stokes Equation; Viscous Flow;

N96–22461* Notre Dame Univ., IN.
Numerical simulations of steady and unsteady oblique detonation phenomena with application to propulsion Ph.D. Thesis
Matthew, John; et al 1 Jan. 1994 249 p
Report No.(s): (NIPS–96–33236) Avail: Univ. Microfilms Order No. DA9516632

Oblique detonations and their propulsive applications were studied by numerically integrating the two–dimensional, reactive Euler equations in a generalized, curvilinear coordinate system. The integration was accomplished using the Roe scheme combined with fractional stepping: nonlinear flux limiting was used to prevent unphysical solution oscillations near discontinuities. The method was verified on one– and two–dimensional flows with exact solutions, and its ability to correctly predict one–dimensional detonation instability was demonstrated. Unsteady phenomena were considered in a study of straight oblique detonations attached to curved walls. Using the exact, steady oblique detonation solution as an initial condition, the numerical simulation predicted both steady and unsteady oblique detonation solutions when a detonation parameter known as the normal overdrive was varied. The normal overdrive value at which the oblique detonation transitioned from steady to unsteady behavior was slightly higher than the corresponding value for a one–dimensional detonation. An oblique detonation application was considered to determine the steady propagation speed of an idealized ram accelerator. Propagation speeds were found which gave rise to shocks of such strength as to induce a reaction zone to be in a region which allowed the combustion induced thrust to balance the wave drag. For fixed heat release greater than a critical value, two steady propagation speeds were predicted. The solution at the higher Mach number was stable to static perturbations while the solution at the lower Mach number was unstable. The Chapman–Jouguet velocity in the direction of projectile propagation was found to be relevant only as an overly conservative lower bound for possible flight speeds. In the far–field the detonation wave angle was found to be that of a Chapman–Jouguet oblique detonation.
Dissert. Abstr.
Detonation Waves; Differential Equations; Far Fields; Heat Transfer; Perturbation; Stability; Thrust Control;

N96–22495* Michigan Univ., Ann Arbor, MI.
The structure of sphere wakes at intermediate Reynolds numbers in still and turbulent environments Ph.D. Thesis
Wu, Jong–Shinn; et al 1 Jan. 1994 158 p
Report No.(s): (NIPS–96–34463) Avail: Univ. Microfilms Order No. DA9501066

The structure of sphere wakes was studied for sphere Reynolds numbers in the range of 30–4000 in still environments and for sphere Reynolds numbers in the range of 130–1600 in turbulent environments. Measurements included dye traces illuminated by a laser light sheet for flow visualization and laser velocimetry for streamwise and cross–stream velocities. Classical similarity results for turbulent and laminar wakes were used to interpret and correlate the measurements. There are three wake regions identified in still environments: a fast–decay wake region that was observed only when vortex shedding was present (Re280), followed in succession by turbulent and laminar wake regions. Mean velocities within the turbulent and laminar wake regions scaled according to classical similarity theories, with transition between these regions at conditions where their estimates of mean streamwise velocities along the axis were the same: this occurred at local wake Reynolds numbers, Re(sub w)10, which is defined in terms of centerline velocity and wake width. Within the turbulent wake region, turbulence intensities along the axis were roughly 85% for Re(sub w)70; however, as the onset of the laminar wake region was approached, turbulence intensities along the axis became proportional to Re(sub w)(exp 7/4), which is consistent with scaling proposed some years ago by Batchelor and Townsend, and Philips, for the final decay period of axisymmetric turbulent wakes. The structure of sphere wakes were measured in the turbulent environments with streamwise integral scales much larger than the sphere diameter and Kolmogorov length scales less than the sphere diameter. At these conditions, some phenomena observed for sphere wakes at comparable Reynolds numbers in nonturbulent environments were suppressed; instead, while the wakes were turbulent, their mean streamwise velocities scaled like self–preserving laminar wakes but with enhanced viscosities due to turbulence. Effective turbulent viscosities were relatively independent of position and the ratios of integral length scales and Kolmogorov length scales to sphere diameters; however, they progressively increased with sphere Reynolds numbers. Low and high Reynolds number regimes were observed, separated by a transition regime involving sphere Reynolds numbers in the range of 300–600 which was associated with the onset of vortex shedding in the near wake region. Wake mixing properties within the laminar–like turbulent wake region were affected by both the sphere Reynolds number and the ambient turbulence intensity in the low Reynolds number regime; in contrast, wake mixing properties mainly varied with the sphere Reynolds number in the high Reynolds number regime where wake turbulence was dominated by wake generated turbulence. Observed Strouhal numbers associated with eddy shedding were generally low-

er than the values observed earlier in turbulence–free environments.
Dissert. Abstr.
Flow Distribution; Laminar Wakes; Reynolds Number; Spheres; Turbulence; Turbulent Wakes;

N96–22753*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Skin friction reduction by micro–blowing technique Patent Application
Hwang, Danny P.; inventor. et al1 Dec. 1995 29 p
Report No.(s): (US–PATENT–APPL–SN–566211; NASA–CASE–LEW–15920–1; NIPS–96–08931) Avail: CASI HC A03/MF A01

A system and method for reducing skin friction of object in relative motion to a fluid is discussed. The prior art includes air and water craft where fluids were pumped out of the craft to lower friction or provide other desirable qualities. The invention includes a skin forming a boundary between the object and the fluid, the skin having holes through which air is blowable and a transmitting apparatus for transmitting air through the skin. The skin has an inner layer and an outer layer the inner layer being a low permeable porous sheet, the outer layer being a plate having high porosity holes. The system may further include a suction apparatus for suctioning air from the outer layer into the inner layer. The method includes the steps of transmitting air through the inner layer and passing the air transmitted through the inner layer through the outer layer. The method may further include the step of bleeding air off of the outer layer using the suction apparatus.
NASA
Blowing; Boundary Layer Control; Fluid Flow; Friction Reduction; Skin Friction; Suction;

N96–22849*# MCAT Inst., San Jose, CA.
Numerical Simulation of the Flow About the F–18 HARV at High Angle of Attack Final Report
Murman, Scott M.; et al1 Feb. 1995 38 p
Contract(s)/Grant(s): (NCC2–729)
Report No.(s): (NASA–CR–200742; NAS 1.26:200742; MCAT–95–13; NIPS–96–39299) Avail: CASI HC A03/MF A01

The flowfield about aircraft maneuvering at high angles of attack is characterized by large regions of separated flow, the formation of strong vortical structures on the leeward side of the aircraft, and a close coupling between the flows about the separate components of the aircraft. As part of NASA's High Alpha Technology Program, research has been aimed at developing and extending numerical methods to accurately predict the high Reynolds number flow about the NASA High Alpha Research Vehicle (HAR17) at large angles of attack. The HARV is a highly–instrumented F–18 aircraft which has been used for flight testing because of its exceptional high–angle–of–attack capability. The resulting codes have been validated by comparison of the numerical results with in–flight aerodynamic measurements and flow visualization obtained on the HARV. These flight–validated numerical methods have been used to perform numerical analyses and optimization of new control concepts for high–alpha maneuverability. This can lead to safer and more efficient aircraft operating at high angles of attack. This report summarizes research done over the pist two years as part of NASA Grant NCC 2–729. This research has been aimed at validating numerical methods for computing the flow about the complete F–18 HARV at alpha = 30 deg and alpha = 45 deg. At 30 deg angle of attack, the flow about the F–18 is dominated by the formation, and subsequent breakdown, of strong vortices over the wing leading–edge extensions (LEX). As the angle of attack is increased to alpha = 45 deg, the fuselage forebody of the F–18 contains significant laminar and transitional regions which are not present at alpha = 30 deg. Further, the flow over the LEX at alpha = 45 deg is dominated by an unsteady shedding in time, rather than strong coherent vortices. This complex physics, combined with the complex geometry of a full–aircraft configuration, provides a challenge for current computational fluid dynamics (CFD) techniques. The following sections present a numerical method and grid generation scheme that was used, a review of prior research done to numerically model the F–18 HARV, and a discussion of the current research. The current research is broken into three main topics; the effect of engine–inlet mass–flow rate on the F–18 vortex breakdown position, the results using a refined F–18 computational model to compute the flow at alpha = 30 deg and alpha = 45 deg, and research done using the simplified geometry of an ogive–cylinder configuration to investigate the physics of unsteady shear–layer shedding. The last section briefly summarizes the discussion.
Author
Angle of Attack; Computational Fluid Dynamics; Engine Inlets; F–18 Aircraft; Flow Distribution; Grid Generation (mathematics); High Reynolds Number; Inlet Flow; Vortices;

N96–23052* Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.
Crossflow stability and transition experiments in a swept–wing flow Ph.D. Thesis
Dagenhart, John Ray; et al1 Jan. 1993 291 p
Report No.(s): (NIPS–96–07364) Avail: Univ. Microfilms Order No. DA9318183

An experimental examination of crossflow instability and transition on a 45 swept wing is conducted in the Arizona State University Unsteady Wind Tunnel. The stationary–vortex pattern and transition location are visualized using both sublimating–chemical and liquid–crystal coatings. Extensive hot–wire measurements are conducted at several

measurement stations across a single vortex track. The mean and travelling–wave disturbances are measured simultaneously. Stationary crossflow disturbance profiles are determined by subtracting either a reference or a span–averaged velocity profile from the mean–velocity data. Mean, stationary–crossflow, and travelling–wave velocity data are presented as local boundary–layer profiles and as contour plots across a single stationary–crossflow vortex track. Disturbance–mode profiles and growth rates are determined. The experimental data are compared to predictions from linear stability theory. The mean–velocity profiles vary slightly across the stationary crossflow vortex at the first measurement station. The variation across the vortex increases with downstream distance until nearly all of the profiles become highly–distorted S–shaped curves. Local stationary crossflow disturbance profiles having either purely excess or deficit values develop at the upstream measurement stations. Further downstream the profiles take on crossover shapes not anticipated by the linear theory. The maximum streamwise stationary–crossflow velocity disturbances reach +/–20% of the edge velocity just before transition. The travelling–wave disturbances have single lobes at the upstream measurement stations as expected, but further downstream double lobed travelling–wave profiles develop. The travelling–wave intensity is always more than an order of magnitude lower than the stationary crossflow–vortex strength. The mean streamwise–velocity contours are nearly flat and parallel to the model surface at the first measurement station. Further downstream, the contours rise up and begin to roll over like a wave breaking on the beach. The stationary–crossflow contours show that a plume of low–velocity fluid rises near the center of the wavelength while high velocity regions develop near the surface at each end of the wavelength. There is no distinct pattern to the low–intensity travelling–wave contours until a short distance upstream of the transition location where the travelling–wave intensity suddenly peaks near the center of the vortex and then falls abruptly.
Dissert. Abstr.
Boundary Layer Stability; Boundary Layer Transition; Cross Flow; Swept Wings; Traveling Waves; Velocity Distribution; Vortices; Wind Tunnel Tests;

N96–23080* Georgia Inst. of Tech., Atlanta, GA.
An experimental study of the interaction between a rotor wake and an airframe with and without flow separation Ph.D. Thesis
Kim, Jaimoo; et al1 Jan. 1993 212 p
Report No.(s): (NIPS–96–07485) Avail: Univ. Microfilms Order No. DA9400426

The present study investigated the viscous interaction between a rotor wake and an airframe. Two different classes of viscous interaction were considered, interaction without and with pre–existing separated flow on the airframe surface. Two different simple configurations were used to simulate these situations: a rotor wake interaction with the boundary layer on a hemispheric cylinder airframe and a rotor wake interaction with a free shear layer downstream of a backward–facing step on the surface of the airframe. A tip vortex and a counter–rotating vortex were observed from a study of the isolated rotor wake, and their effects on the airframe pressure were identified. The tip vortex suction peak was observed all around the airframe and the flow visualization confirmed survival of the vortex filament under the airframe. A secondary vortex was visualized just upstream of the tip vortex when the tip vortex interacted with the airframe surface. Its effect was noted as a secondary suction peak on the airframe surface next to the tip vortex suction peak. Axial motion in the tip vortex was visualized and its effect on the airframe pressure was seen as a positive pressure peak. When the tip vortex interacted with the shear layer generated by an axisymmetric backward–facing step on the surface of the circular airframe, increased unsteadiness of the vortex location was observed with flow visualization and velocity histograms. Periodic destruction and reconstruction of the shear layer were observed both in the flow visualization and vorticity contours calculated from velocity measurement data. A velocity profile of the shear layer, measured with a fine vertical spacing, indicated that the flow reversal under the shear layer occurred only under the influence of the tip vortex. Periodic flapping of the shear layer due to the tip vortex effect was also observed in the velocity profile. Measurements of the periodic surface pressure distribution showed the tip vortex effect to be present all around the airframe. Surface pressure spectra measured just downstream of the backward–facing step indicated multiple harmonics of blade passage frequency and the undisturbed backstep flow frequency.
Dissert. Abstr.
Aircraft Wakes; Airframes; Boundary Layer Separation; Configuration Interaction; Flapping; Flow Visualization; Fluid–solid Interactions; Separated Flow; Vortices;

N96–23110* Georgia Inst. of Tech., Atlanta, GA.
A hybrid inverse optimization method for aerodynamic design of lifting surfaces Ph.D. Thesis
Santos, Luis Carlos de castr; et al1 Jan. 1993 141 p
Report No.(s): (NIPS–96–07623) Avail: Univ. Microfilms Order No. DA9400437

The present state of the world economy, challenges the aerospace industry to dramatically reduce the development cost of new designs. Adding that to the increasing demands in the performance of aerospace vehicles, more efficient ways of analysis and design of the aerodynamic configurations are necessary. Computational fluid dynamics presents itself as an alternative to costly wind tunnel studies, and can reduce development costs, during the preliminary design phase. A hybrid inverse optimization design method was developed to reduce the computational cost of the design pro-

cedure and also incorporate the enforcement of constraints. An existing solver independent inverse design technique was modified to include an optimization routine. The kernel of the inverse design routine, which is the solution of the linear system, resulting from finite difference approximation of an auxiliary equation, was replaced by an optimization technique. Using the conjugate direction method, the linear system is solved, in the least squares sense. The constraints are simultaneously enforced, keeping the computational cost very close to the original inverse design method, and adding the versatility of an optimization method. The method is general. Several applications of this approach to airfoil and wing design, using full–potential and Navier–Stokes flow solvers, in the transonic flight regime are presented. The low computational effort and generality of the technique represent an improvement to the state–of–the–art in aerodynamic design and allow its application in a Multidisciplinary Design optimization structure.
Dissert. Abstr.
Computational Fluid Dynamics; Cost Reduction; Finite Difference Theory; Multidisciplinary Design Optimization;

N96–23114* Iowa State Univ. of Science and Technology, Ames, IA.
A numerical investigation of laminar airfoil stall Ph.D. Thesis
Black, Daniel Wayne; et al1 Jan. 1993 183 p
Report No.(s): (NIPS–96–07613) Avail: Univ. Microfilms Order No. DA9334962

The details of an interacting boundary layer algorithm capable of calculating large scale laminar separation past airfoils at low speeds is given. Rationale behind various convergence acceleration methods is given. It is shown that linear based acceleration methods are limited to 50 percent savings in convergence rate. A nonlinear extrapolation method is proposed and tested on two simple model problems. Savings exceed the 50 percent limitation of the previous methods. Boundary layer results for laminar flow past symmetric airfoils at zero incidence are presented as a test of the methods. Leading edge marginal separation results at finite Reynolds numbers are presented. Richardson extrapolation of successive calculations is used to improve accuracy. Results for a zero thickness uncambered plate at angle of attack are presented.
Dissert. Abstr.
Aerodynamic Stalling; Angle of Attack; Boundary Layer Separation; Boundary Layers; Computational Fluid Dynamics; Grid Generation (mathematics); Laminar Flow; Leading Edges; Reynolds Number; Uncambered Wings;

N96–23115* Old Dominion Univ., Hampton, VA.
Boundary layer influences on the subsonic near–wake of a family of three–dimensional bluff bodies Ph.D. Thesis
Alcorn, Charles William; et al1 Jan. 1993 192 p
Report No.(s): (NIPS–96–07612) Avail: Univ. Microfilms Order No. DA9333593

A study is reported on subsonic bluff body near–wake flows. It has been determined that one family of bluff bodies, namely slanted–base ogive cylinders, can experience either a closed recirculating near–wake or a longitudinal vortex near–wake depending on the base slant–angle and the Reynolds number. This suggests a dependence of near–wake parameters on the state of the boundary layer ahead of separation. This report addresses the influence of the boundary layer on the near wake of slanted–base bluff bodies. Experiments were conducted in two facilities, the 6–inch Magnetic Suspension and Balance System (MSBS) at NASA Langley Research Center and the Old Dominion University low–speed wind tunnel. Interference–free drag measurements in the 6–inch MSBS validated previous drag results. Measurements in the ODU facility were made to determine base pressures, wake stagnation point locations, and boundary layer velocity profiles. Furthermore, spectral and cross–spectral analyses of the fluctuating streamwise velocity in the near–wake were performed to determine frequencies and coherence of large–scale structures. It was determined that despite variations in the boundary layer state, base pressures and wake stagnation point locations correlate with the Reynolds number based on the boundary layer momentum thickness as the independent variable. Variations in the frequency and coherence of large–scale structures were shown to exist with fixed boundary layer transition. A two–dimensional representation of a slanted–base configuration was studied analytically using classical theories and computationally using an existing finite element package. This study confirmed that the sudden changeover in wake structure is a result of flow reattachment onto the slanted–base.
Dissert. Abstr.
Bluff Bodies; Boundary Layers; Near Wakes; Recirculative Fluid Flow; Reynolds Number; Subsonic Flow; Three Dimensional Bodies; Vortices; Wind Tunnel Tests;

N96–23132*# National Aerospace Lab., Tokyo (Japan).
Effect of Blade Tip Planform on Shock Wave of Advancing Helicopter Blade
Aoyama, Takashi; and Saito, Shigeru; et al1 Jul. 1995 24p In JAPANESE (ISSN 0389–4010)
Report No.(s): (NAL–TR–1275; NIPS–96–39537) Avail: CASI HC A03/MF A01

Shock waves are generated on the advancing side of the blade tip of a helicopter rotor in the high–speed forward flight condition. They cause an increase in drag, vibration, and noise. In this study, the effect of blade tip planform on behavior of shock wave on the advancing rotor blade was investigated in detail using a calculation method which solves three–dimensional Euler equations by an implicit finite–difference method. The Newton iterative method was added to obtain the unsteady solution in forward flight. The calcula-

tions were performed for blades having the NACA0012 airfoil section along the entire blade span to investigate the planform effect alone. The parametric study clarified the effect of the sweep and the taper on shock wave behavior. In addition, a guideline of the blade planform design for the advancing blade was suggested, and a newly–devised tip planform which prevents shock wave generation was proposed. The effectiveness of the BERP and ONERA PF 2 planform which are examples of advanced tip planforms were also presented.
Author
Blade Tips; Computational Fluid Dynamics; Euler Equations of Motion; Finite Difference Theory; Horizontal Flight; Planforms; Rotary Wings; Shock Waves;

N96–23205*# Lockheed Martin Tactical Aircraft Systems, Fort Worth, TX.
Euler Technology Assessment for Preliminary Aircraft Design: Compressibility Predictions by Employing the Cartesian Unstructured Grid SPLITFLOW Code Progress Report, 1 Feb. – 30 Sep. 1995
Finley, Dennis B.; and Karman, Jr., Steve L.; et al1 Mar. 1996 102 p
Contract(s)/Grant(s): (NAS1–19000; RTOP 505–68–30–03)
Report No.(s): (NASA–CR–4710; NAS 1.26:4710; NIPS–96–37134) Avail: CASI HC A06/MF A02

The objective of the second phase of the Euler Technology Assessment program was to evaluate the ability of Euler computational fluid dynamics codes to predict compressible flow effects over a generic fighter wind tunnel model. This portion of the study was conducted by Lockheed Martin Tactical Aircraft Systems, using an in–house Cartesian–grid code called SPLITFLOW. The Cartesian grid technique offers several advantages, including ease of volume grid generation and reduced number of cells compared to other grid schemes. SPLITFLOW also includes grid adaption of the volume grid during the solution to resolve high–gradient regions. The SPLITFLOW code predictions of configuration forces and moments are shown to be adequate for preliminary design, including predictions of sideslip effects and the effects of geometry variations at low and high angles–of–attack. The transonic pressure prediction capabilities of SPLITFLOW are shown to be improved over subsonic comparisons. The time required to generate the results from initial surface data is on the order of several hours, including grid generation, which is compatible with the needs of the design environment.
Author (revised)
Cartesian Coordinates; Compressibility Effects; Computational Fluid Dynamics; Euler Equations of Motion; Transonic Flow; Unstructured Grids (mathematics); Vortices;

N96–23221* Ecole Polytechnique, Montreal (Quebec).
A Multi–Block Euler Method for the Complete Challenger Configuration Ph.D. Thesis
Kafyeke, Fassi; et al 1 Jan. 1993 287 p
Report No.(s): (ISBN–0–315–90020–2; NIPS–96–34387)
Avail: Univ. Microfilms Order No. DANN90020

The present work proposes a methodology for solving the Euler equations governing the flow of inviscid compressible fluids. This methodology was developed with the objective of predicting such flows around complex aircraft configurations. The main application sought is the modelling of Canadair's Challenger CL–601 aircraft featuring turbofan nacelle closely coupled with the wing. The particular Euler method proposed in this work was implemented in the MBTEC program (MultiBlock Transonic Euler Code). In the MBTEC model, the Euler equations are cast in their unsteady conservative form, indicating balances of mass, momentum and energy. The equations can be solved as an initial value problem. Starting with a uniform flow approximation, the final steady flow is obtained by integrating the equations in time until convergence is reached. The numerical solution is obtained by discretizing the equations using a finite volume explicit method. The discretization is made using a structured body–fitted grid defined around the aircraft. The spatial derivatives are centrally differenced. The scheme is stabilized by the addition of artificial viscosity, leading to the definition of shock waves without oscillations. The integration of the equations in time is made using a five–stage Runge–Kutta algorithm with excellent stability properties. To further improve the convergence of the computations, local time–stepping is used, advancing everywhere the solution at the largest time–step allowed by the Courant, Friedriechs and Lewy local condition. The application to complex three–dimensional configurations is by way of a particular multi–block technique which is original in the method that we have developed. The space around the aircraft is divided into subdomains or blocks, each simply connected and topologically equivalent to a cube, with six faces and eight corners. The Euler equations are solved in each block in sequence. The numerical information is transferred from block to block using an effective block interfacing scheme. The program uses one type of boundary condition per block face but any one of the following boundary conditions can be specified for any face of any block in the field: solid surface condition, symmetry condition, inflow and outflow conditions and, in particular, engine inlet and exhaust conditions. A progressive testing method was used in order to validate the multiblock code. Starting with simple isolated wing cases, we have adjusted the block interface boundary conditions, the convective flux accumulation, the addition of artificial viscosity in a multi–block grid and other numerical details to guarantee satisfactory convergence of the computations even in the most complex cases. The program was then used to model the isolated nacelle of the General Electric CF–34 engine powering the CL–601 Challenger. Calculations were made for the complete, powered CL–601.

This model, made of 600 blocks and 1,571,580 nodes yielded excellent comparisons with experimental data, demonstrating once more the excellent accuracy of the code in the most complex cases.
Dissert. Abstr.
Aircraft Configurations; Engine Inlets; Euler Equations of Motion; Finite Volume Method; Inviscid Flow; Multiblock Grids; Runge–kutta Method; Turbofans; Wings;

N96–23282* Maryland Univ., College Park, MD.
The effects of surface catalysis on the hypersonic shock wave/boundary layer interaction Ph.D. Thesis
Grumet, Adam Abraham; et al1 Jan. 1994 233 p
Report No.(s): (NIPS–96–08948) Avail: Univ. Microfilms Order No. DA9507959

To accurately determine the local heat loads that could occur on a hypersonic vehicle, this dissertation presents a realistic numerical calculation of a hypersonic nonequilibrium shock wave/boundary layer interaction (SWBLI) that includes the effects of surface catalysis. The catalysis model from Jumper, Seward, and Newman was used to calculate the atomic oxygen and nitrogen recombination on a reaction–cured glass (RCG) surface. Also, catalysis rates for recombination on copper oxide were used as well. Furthermore, the surface temperature was determined by coupling the thermal conduction inside the surface with the convective heat flow due to the external fluid dynamics, for a reasonable heat pipe configuration. Results demonstrate that RCG, though relatively benign with regard to oxygen, does catalyze the atomic nitrogen at the surface, enough to make an appreciable difference in the surface heating. Results have also shown that for highly catalytic surfaces, such as copper, nitric oxide formation is considerable, even though its production is neglected from the catalytic mechanisms. With regard to the coupling between catalytic heating and the separation region fo the SWBLI, a comparison of results obtained from both mildly and highly separated flow indicate that surface catalysis significantly increases the heat transfer downstream of the separation region. However, because the majority of the chemical recombination is contained inside the separation zone and away from the region of peak heating, the effects of surface catalysis on the peak heat transfer is not critically affected by the separation zone size.
Dissert. Abstr.
Boundary Layers; Catalysis; Conductive Heat Transfer; Convective Heat Transfer; Hypersonic Flow; Hypersonic Shock; Mathematical Models; Nonequilibrium Flow; Recombination Reactions; Separated Flow; Shock Wave Interaction;

N96–23337*# National Aerospace Lab., Tokyo (Japan).
Flat Spin of Axisymmetric Bodies Near the Critical Reynolds Number Region
Tate, Atsushi; Iwasaki, Akihito; Fujita, Toshimi; and Yoshinaga, Takashi; et al1 Jun. 1995 24 p In JAPANESE (ISSN 0389–4010)
Report No.(s): (NAL–TR–1271; NIPS–96–36137) Avail: CASI HC A03/MF A01

A series of flat spin experiments for recovering re–entering bodies have been conducted in a wind tunnel with cylinder, cone–cylinder, and bicone–cylinder models in the critical and supercritical Reynolds number regions. Using the free rotation method, the steady state spin rate was measured as a function of the freestream Reynolds number. Two modes of flat spin, a high spin mode, and a low spin mode were found to exist. The high spin mode was initiated in a fairly narrow freestream velocity region near the critical Reynolds number and continued in the supercritical Reynolds number region. During the high spin mode, the circumferential velocity of cylindrical models reached the magnitude of the freestream velocity, In the case of the bicone–cylinder, the spin rate was shown to be erratic, appearing sensitive to small irregularities in the nose shape. Slim triangular prisms on these cylinder surfaces, aligned with the body axis, are effective to reduce the steady state spin rate.
Author
Angle of Attack; Axisymmetric Bodies; Conical Bodies; Reynolds Number; Spin; Spin Reduction; Wind Tunnel Stability Tests;

N96–23339*# National Aerospace Lab., Tokyo (Japan).
The Effect of Time Lag on the Stability of HOPE Model in a Dynamic Wind Tunnel Test
Motoda, Toshikazu; Sasa, Shuichi; Yanagihara, Masaaki; and Tukamoto, Taro; et al1 Apr. 1995 20 p In JAPANESE (ISSN 0389–4010)
Report No.(s): (NAL–TR–1265; NIPS–96–36116) Avail: CASI HC A03/MF A01

The first dynamic wind tunnel experiment of the HOPE 16% scale model was conducted in 1992. In one experiment, the motion of the model plane became unstable when the elevon deflected suddenly and enormously. The mode change from altitude control to attitude control caused serious elevon deflection, but the attitude control system was theoretically stable and still worked at that time. The problem is that the unstable motion happened in spite of the theoretical expectation of stable model motion. The effect of time lag of the control system on the stability of the HOPE model was investigated using a Nyquist diagram and computer simulation. The aerodynamic data of the static wind tunnel test was used for these analyses. The time lag required to make the motion unstable was derived from the Nyquist diagram, and the results were confirmed by numerical simulation based on a linear motion equation. Also, non–linear simulation showed that the stability of the system is affected by non–linear characteristics of the model plane.
Author
Altitude Control; Attitude Control; Deflection; Elevons;

Hope Aerospace Plane; Nyquist Diagram; Time Lag; Wind Tunnel Tests;

03 AIR TRANSPORTATION AND SAFETY

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

N96–21672*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Wind Tunnel Measured Effects on a Twin–Engine Short–Haul Transport Caused by Simulated Ice Accretions
Reehorst, Andrew; Potapczuk, Mark; Ratvasky, Thomas; and Laflin, Brenda Gile; et al1 Jan. 1996 28 p Presented at 34th Aerospace Sciences Meeting and Exhibit, Reno, NV, United States, 15–18 Jan. 1996; Sponsored by American Inst. of Aeronautics and Astronautics,
Report No.(s): (NASA–TM–107143; NAS 1.15:107143; E–10073; AIAA PAPER 96–0871; NIPS–96–35611) Avail: CASI HC A03/MF A01

A series of wind tunnel tests were conducted to assess the effects of leading edge ice contamination upon the performance of a short–haul transport. The wind tunnel test was conducted in the NASA Langley 14 by 22 foot facility. The test article was a 1/8 scale twin–engine short–haul jet transport model. Two separate leading edge ice contamination configurations were tested in addition to the uncontaminated baseline configuration. Several aircraft configurations were examined including various flap and slat deflections, with and without landing gear. Data gathered included force measurements via an internal six–component force balance, pressure measurements through 700 electronically scanned wing pressure ports, and wing surface flow visualization measurements. The artificial ice contamination caused significant performance degradation and caused visible changes demonstrated by the flow visualization. The data presented here is just a portion of the data gathered. A more complete data report is planned for publication as a NASA Technical Memorandum and data supplement.
Author
Aircraft Configurations; Aircraft Icing; Aircraft Performance; Flow Visualization; Wind Tunnel Tests;

N96–22230*# Johns Hopkins Univ., Baltimore, MD. Center for Injury Research and Policy.
Crashes of Instructional Flights: Analysis of Cases and Remedial Approaches Final Report
Baker, Susan P.; Lamb, Margaret W.; Li, Guohua; and Dodd, Robert S.; et al1 Feb. 1996 46 p
Contract(s)/Grant(s): (FAA–93–G–045)
Report No.(s): (DOT/FAA/AM–96/3; NIPS–96–36173) Avail: CASI HC A03/MF A01

Instructional flights experience more than 300 crashes annually and are involved in more than one–third of all midair collisions. Research was undertaken to identify the circumstances of instructional crashes and describe factors related to pilots, aircraft, and the environment. NTSB data tapes were analyzed for crashes during 1989–1992 that involved a student pilot or a flight for instructional purposes. From this study it was found that a greater emphasis during flight training needs to be placed on avoiding stalls and midair collisions, managing crosswinds, and understanding the elements of takeoff and landing flight dynamics prior to solo touch–and–go practice. Instructors contribute to crashes both directly during dual instruction and, less directly, through failure to successfully monitor their students and convey the elements of safe and proficient flight. Problems identified in this study should be communicated to flight instructors in their initial training as instructors, during preparation for their biennial re–licensure, and through dissemination of materials to all instructors.
Author
Aircraft Control; Assessments; Crash Landing; Flight Safety; Flight Training; Instructors; Midair Collisions; Students;

N96–22572*# Wichita State Univ., Wichita, KS. National Inst. for Aviation Research.
FY95 annual report and strategic plan: FY96–FY2000
1 Oct. 1995 97 p
Report No.(s): (NIPS–95–07031) Avail: CASI HC A05/MF A02

The National Institute for Aviation Research (NIAR) presents an assessment of the work accomplished in FY 1995. This assessment includes progress made, goals met, milestones marked, budgets, and expenditures. The major areas concentrated on in FY95 included crash dynamics, composites, aerodynamics, and CAD/CAM. Also reported is the NIAR Faculty Fellows program, other cooperative programs, and technology applications. The Institute's proposed plan of action and goals for FY96 through FY2000 are summarized.
CASI
Aeronautics; Budgets; Management Planning; Project Management; Research Management; Technology Utilization;

N96–23048* Massachusetts Inst. of Tech., Cambridge, MA.
Multidisciplinary design of an integrated microburst alerting system Ph.D. Thesis
Wanke, Craig R.; et al 1 Jan. 1993
Report No.(s): (NIPS–96–07349) Avail: Issuing Activity (MIT Libraries, Rm. 14–0551, Cambridge, MA)

A user–centered approach was applied to identify and analyze critical system design issues in a series of multidisciplinary studies. This approach is designed to optimize the decision–making performance of the end user, and thereby optimize the operational efficiency of the microburst alerting

system. The primary end users of microburst alerts are flight crews, so the initial task was to determine which information is required by the crew for effective microburst alerting and the most effective presentation techniques for this information. This was done with a pilot survey and with two piloted part–task simulator experiments. Iconic graphical alerts were found to be significantly more useful than verbal or text communications, and several format and procedural issues for implementation of graphical alerts were examined. These studies included development of a part–task flight simulator, based on an advanced workstation with powerful graphics and rapid prototyping capabilities, which was found to be an exceptionally useful tool for preliminary evaluation of advanced cockpit information systems. Next, the issue of producing the required alert information — the alert generation task — was addressed. Possible hazard metrics for microburst intensity were compared, and an effective one selected based on a batch flight simulation technique. The energy–based 'F–factor' criterion averaged over 3000 ft of aircraft flight path was found to be a much better indicator of aircraft hazard than the 'delta–V' (total headwind–to–tailwind change) criterion currently used by the Terminal Doppler Weather Radar (TDWR) microburst detection system and the Low Level Windshear Alert System (LLWAS). A method was then developed for establishing a multilevel microburst alerting structure, using threshold values of a hazard metric based on measurable airmass parameters. The method was applied to determine three–level alerting thresholds for jet transports on approach to landing. Alert generation requires estimates of microburst characteristics; a model–based data assimilation technique for estimating microburst characteristics from multisensor measurements was therefore developed. The extended Kalman filter–based technique incorporates elementary fluid mechanics and statistical characteristics of microbursts to improve estimation accuracy, and to allow estimation of quantities which cannot be directly measured.
Dissert. Abstr.
Aviation Meteorology; Flight Crews; Flight Hazards; Graphical User Interface; Human Factors Engineering; Microbursts (meteorology); Warning Systems;

04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

N96–21715* Department of the Navy, Washington, DC.
Airborne System for Operation in Conjunction with a Marker Beacon Patent
Hiltz, Frederick F.; inventor.and Wilson, Charles E.; inventor. et al15 Aug. 1995 39 p
Report No.(s): (AD–D017702; US–PATENT–APPL–SN–216568; US–PATENT–5442356; NIPS–96–30048) Avail: US Patent and Trademark Office

An airborne radio system upon receipt of mode and code radio signals from a marker beacon that it is seeking, queries the marker beacon as to its slant range and direction. Upon receipt of information on the slant range and direction the airborne system and/or its operator make a determination whether to initiate a radio signal that would activate a flare on the marker beacon. Upon actuation the flare is usable for visual and infrared homing.
DTIC
Airborne Equipment; Interrogation; Landing Aids; Radio Beacons; Radio Transmitters;

N96–22149*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
Effects of ATC automation on precision approaches to closely space parallel runways
Slattery, R.; Lee, K.; (Sterling Software, Inc., Palo Alto, CA.)and Sanford, B.; (Sterling Software, Inc., Palo Alto, CA.) et al10 Aug. 1995 9 p Presented at AIAA Guidance, Navigation, and Control Conference, Baltimore, MD, United States, 7–10 Aug. 1995
Report No.(s): (NASA–TM–111255; NAS 1.15:111255; AIAA PAPER 95–3367; NIPS–96–07970) Avail: CASI HC A02/MF A01

Improved navigational technology (such as the Microwave Landing System and the Global Positioning System) installed in modern aircraft will enable air traffic controllers to better utilize available airspace. Consequently, arrival traffic can fly approaches to parallel runways separated by smaller distances than are currently allowed. Previous simulation studies of advanced navigation approaches have found that controller workload is increased when there is a combination of aircraft that are capable of following advanced navigation routes and aircraft that are not. Research into Air Traffic Control automation at Ames Research Center has led to the development of the Center–TRACON Automation System (CTAS). The Final Approach Spacing Tool (FAST) is the component of the CTAS used in the TRACON area. The work in this paper examines, via simulation, the effects of FAST used for aircraft landing on closely spaced parallel runways. The simulation contained various combinations of aircraft, equipped and unequipped with advanced navigation systems. A set of simulations was run both manually and with an augmented set of FAST advisories to sequence aircraft, assign runways, and avoid conflicts. The results of the simulations are analyzed, measuring the airport throughput, aircraft delay, loss of separation, and controller workload. Author
Air Traffic Control; Airborne Radar Approach; Aircraft Approach Spacing; Aircraft Landing; Automatic Control; Distance Measuring Equipment; Flight Simulation;

N96–22162*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

Knowledge–based scheduling of arrival aircraft

Krzeczowski, K.; Davis, T.; Erzberger, H.; Lev–Ram, I.; (Sterling Federal Systems, Inc., Palo Alto, CA.)and Bergh, C.; (Massachusetts Inst. of Tech., Lexington, MA.) et al10 Aug. 1995 12 p Presented at AIAA Guidance, Navigation, and Control Conference, Baltimore, MD, United States, 7–10 Aug. 1995

Report No.(s): (NASA–TM–111254; NAS 1.15:111254; AIAA PAPER 95–3366; NIPS–96–07969) Avail: CASI HC A03/MF A01

A knowledge–based method for scheduling arrival aircraft in the terminal area has been implemented and tested in real–time simulation. The scheduling system automatically sequences, assigns landing times, and assigns runways to arrival aircraft by utilizing continuous updates of aircraft radar data and controller inputs. The scheduling algorithms is driven by a knowledge base which was obtained in over two thousand hours of controller–in–the–loop real–time simulation. The knowledge base contains a series of hierarchical 'rules' and decision logic that examines both performance criteria, such as delay reduction, as well as workload reduction criteria, such as conflict avoidance. The objective of the algorithms is to devise an efficient plan to land the aircraft in a manner acceptable to the air traffic controllers. This paper will describe the scheduling algorithms, give examples of their use, and present data regarding their potential benefits to the air traffic system.

Author

Air Traffic Control; Artificial Intelligence; Automatic Landing Control; Command and Control; Control Systems Design; Controllers; Decision Making; Knowledge Based Systems; Knowledge Bases (artificial Intelligence); Scheduling; Self Adaptive Control Systems;

N96–22174*# Galaxy Scientific Corp., Atlanta, GA.

Design of a cooperative problem–solving system for en–route flight planning: An empirical evaluation

Layton, Charles; Smith, Philip J.; (Ohio State Univ., Columbus, OH.)and McCoy, C. Elaine; (Ohio Univ., Athens, OH.) et al1 Jan. 1994 26 p

Contract(s)/Grant(s): (NCC2–615)

Report No.(s): (NASA–CR–200217; NAS 1.26:200217; NIPS–96–08362) Avail: CASI HC A03/MF A01

Both optimization techniques and expert systems technologies are popular approaches for developing tools to assist in complex problem–solving tasks. Because of the underlying complexity of many such tasks, however, the models of the world implicitly or explicitly embedded in such tools are often incomplete and the problem–solving methods fallible. The result can be 'brittleness' in situations that were not anticipated by the system designers. To deal with this weakness, it has been suggested that 'cooperative' rather than 'automated' problem–solving systems be designed. Such cooperative systems are proposed to explicitly enhance the collaboration of the person (or a group of people) and the computer system. This study evaluates the impact of alternative design concepts on the performance of 30 airline pilots interacting with such a cooperative system designed to support enroute flight planning. The results clearly demonstrate that different system design concepts can strongly influence the cognitive processes and resultant performances of users. Based on think–aloud protocols, cognitive models are proposed to account for how features of the computer system interacted with specific types of scenarios to influence exploration and decision making by the pilots. The results are then used to develop recommendations for guiding the design of cooperative systems.

Author

Decision Making; Expert Systems; Flight Plans; Planning; Problem Solving;

N96–22224*# Colorado Univ., Boulder, CO.

A study of GPS measurement errors due to noise and multipath interference for CGADS Final Report

Axelrad, Penina; Macdoran, Peter F.; and Comp, Christopher J.; 31 Jan. 1996 21 p

Contract(s)/Grant(s): (NCC5–67)

Report No.(s): (NASA–CR–200249; NAS 1.26:200249; NIPS–96–08807) Avail: CASI HC A03/MF A01

This report describes a study performed by the Colorado Center for Astrodynamics Research (CCAR) on GPS measurement errors in the Codeless GPS Attitude Determination System (CGADS) due to noise and multipath interference. Preliminary simulation models fo the CGADS receiver and orbital multipath are described. The standard FFT algorithms for processing the codeless data is described and two alternative algorithms – an auto–regressive/least squares (AR–LS) method, and a combined adaptive notch filter/least squares (ANF–ALS) method, are also presented. Effects of system noise, quantization, baseband frequency selection, and Doppler rates on the accuracy of phase estimates with each of the processing methods are shown. Typical electrical phase errors for the AR–LS method are 0.2 degrees, compared to 0.3 and 0.5 degrees for the FFT and ANF–ALS algorithms, respectively. Doppler rate was found to have the largest effect on the performance.

Author

Algorithms; Attitude Control; Error Analysis; Fast Fourier Transformations; Global Positioning System; Least Squares Method; Multipath Transmission; Noise Propagation; Regression Analysis;

N96–22491* New Brunswick Univ., Fredericton (New Brunswick).

Composite GPS receiver modelling, simulations and applications Ph.D. Thesis

Zhuang, Weihua; et al1 Jan. 1993 262 p
Report No.(s): (ISBN–0–315–89235–8; NIPS–96–34444) Avail: Univ. Microfilms Order No. DANN89235

A global positioning system (GPS) receiver has been modeled, analyzed, and implemented in software. The receiver has the L1–C/A, L1–P, and L2–P channels, with the output of GPS observables including the pseudorange time delay, carrier beat phase, and Doppler frequency shift. Based on the fundamentals of the GPS system and the signal structure, various relationships among the input signal parameters, internal variables of the receiver, and the GPS observables have been modeled mathematically. A digital energy detector is designed for the initial pseudorandom noise (PRN) code coarse synchronization on the time and frequency uncertainty region with double–dwell, straight line, and expanding–window serial search strategies. A digital delay lock loop (DDLL) with full–time early–late high speed correlators is modeled to despread the input signal and to extract the input code phase delay. From the power spectral density analysis of both input signal and noise, the closed form expressions of the detection and false–alarm probabilities of the code phase acquisition process and the variance of the code phase tracking error are derived. The linear and nonlinear performance of the DDLL is analyzed for optimizing the DDLL parameters with the trade–off between the tracking errors due to receiver dynamics and input noise. A digital phase–locked loop (DPLL) is used to extract the input carrier phase from the code–free signals after the DDLL. Upon analysis of the characteristics of the input phase noise, stable second and third order DPLL's are designed and analyzed with emphasis on the performance of the noise suppression and dynamic tracking capability. The Doppler shift is estimated based on the DPLL residual phase error. The output data volume of the observables is compressed by polynomial fit. The receiver functions are implemented with source code written mostly in C language. Simulations with the software package are performed respectively under the UNIX and TSO programming environments, which verify the theoretical performance analysis of the modeled receiver. The software receiver has been applied to analyze the multipath interference effects on the GPS observables which is in accordance with theoretical analysis, and to study the effects of GPS antenna characteristics, including the antenna residual phase and antenna center (best–fit sphere) movement, on the GPS observables. The software receiver provides an additional approach to GPS research in positioning accuracy and is an important tool in designing the GPS receivers and in analyzing the effects of signal disturbances on GPS observables.
Dissert. Abstr.
Channel Noise; Global Positioning System; Mathematical Models; Navigation Instruments; Radio Receivers; Radio Signals; Signal Processing;

N96–22568*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
Descent advisor preliminary field test
Green, Steven M.; Vivona, Robert A.; (Sterling Software, Inc., Moffett Field, CA.)and Sanford, Beverly; (Sterling Software, Inc., Moffett Field, CA.) et al10 Aug. 1995 12 p
Presented at AIAA Guidance, Navigation, and Control Conference, Baltimore, MD, United States, 7–10 Aug. 1995
Report No.(s): (NASA–TM–111257; AIAA PAPER 95–3368; NAS 1.15:111257; NIPS–96–07977) Avail: CASI HC A03/MF A01

A field test of the Descent Advisor (DA) automation tool was conducted at the Denver Air Route Traffic Control Center in September 1994. DA is being developed to assist Center controllers in the efficient management and control of arrival traffic. DA generates advisories, based on trajectory predictions, to achieve accurate meter–fix arrival times in a fuel efficient manner while assisting the controller with the prediction and resolution of potential conflicts. The test objectives were to evaluate the accuracy of DA trajectory predictions for conventional– and flight–management–system–equipped jet transports, to identify significant sources of trajectory prediction error, and to investigate procedural and training issues (both air and ground) associated with DA operations. Various commercial aircraft (97 flights total) and a Boeing 737–100 research aircraft participated in the test. Preliminary results from the primary test set of 24 commercial flights indicate a mean DA arrival time prediction error of 2.4 sec late with a standard deviation of 13.1 sec. This paper describes the field test and presents preliminary results for the commercial flights.
Author
Air Traffic Control; Descent Trajectories; Flight Management Systems; Flight Paths; Flight Tests; Postflight Analysis;

N96–23209*# Advisory Group for Aerospace Research and Development, Neuilly–Sur–Seine (France). Mission Systems Panel.
Twenty–five Years of Contributions to Air Traffic Handling (Research, Development, Operations and History): A Bibliography [Vingt–cinq annees de contributions au controle du trafic aerien (recherches, developpement, operations et historique): Une bibliographie]
Benoit, Andre; ed. et al1 Feb. 1996 168 p
Report No.(s): (AGARD–R–811; ISBN–92–836–1029–6; NIPS–96–38180) Avail: CASI HC A08/MF A02

Over 25 years, the Guidance and Control Panel of the Advisory Group for Aerospace Research and Development to the North Atlantic Treaty Organization has devoted part of its activities to the fascinating field known historically as Air Traffic Control, covering also Air Traffic Management, and more generally Air Traffic Handling. This Report provides a list of the summaries of the papers which were pre-

sented at the symposia and included in the AGARDographs devoted to this wide and most challenging subject, covering essentially, Air Traffic Control Systems (1972); A Survey of Modern Air Traffic Control, Vols. 1 and 2 (1975); Plans and Developments for Air Traffic Systems (1975); Air Traffic Management (1979); Air Traffic Control in Face of Users' Demand and Economy Constraints (1982); Efficient Conduct of Individual Flights and Air Traffic (1986); Aircraft Trajectories, Vols. 1, 2 and 3 (1990); Machine Intelligence in Air Traffic Management (1993); and On–Line Handling of Air Traffic (1994). The Report is completed by two indexes, an extended subject Index, and an Authors and Contributors Index.
Author
Air Traffic; Air Traffic Control; Bibliographies; Control Systems Design; Management Methods;

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

N96–21477* Stanford Univ., CA.
New approaches to optimization in aerospace conceptual design Ph.D. Thesis
Gage, Peter James; et al1 Jan. 1995 188 p
Report No.(s): (NIPS–96–33233) Avail: Univ. Microfilms Order No. DA9516823

Aerospace design can be viewed as an optimization process. A multi–dimensional search is conducted, with the physical description modified to produce the best functional performance. Despite this character and the wide availability of optimization software, conceptual design is rarely performed using formal search algorithms. The failure to exploit the benefits of optimization is examined in this thesis, and three key issues that restrict the success of automatic search are found. New approaches are introduced to address the integration of analyses and optimizers, to avoid the need for accurate gradient information and a smooth search space (required for calculus based optimization), and to remove the restrictions imposed by complexity problem formulations. Conceptual design of aircraft is a difficult endeavour. The disciplines are tightly coupled and performance assessment must be precise, so a design system is a complex combination of large analysis modules. Optimization should be performed in a flexible, extensible environment that conveniently links these modules and automatically co–ordinates their execution. A quasi–procedural architecture provides such an environment, and its efficient control of a large–scale design task is demonstrated. Calculus–based optimizers use gradient information to search for performance improvement. For many design tasks, gradients cannot be accurately computed, because variables have discrete values, analyses are noisy, or the search space has discontinuous topology. A genetic algorithm that provides a search method for such domains is studied. Applications demonstrate the utility of genetic optimization. The relationship between the genetic algorithm use a complete a priori prescription of the search space, which, to a large degree, defines a design concept. The value of each variable is optimized, but the search scheme cannot alter the fixed set of parameters. A variable–complexity genetic algorithm is created to permit more flexible parameterization, so that the level of characteristics are identified in simple designs, and refined by increasing description details. Structural and aerodynamic applications prove that this optimizer can discover novel designs.
Dissert. Abstr.
Aerospace Industry; Aircraft Design; Optimization;

N96–21633* Maryland Univ., College Park, MD.
Aeroelastic optimization of advanced geometry and composite helicopter rotors Ph.D. Thesis
Ganguli, Ranjan; et al 1 Jan. 1994 398 p
Report No.(s): (NIPS–96–33234) Avail: Univ. Microfilms Order No. DA9514522

Using an analytical approach, sensitivity analyses and aeroelastic optimization procedures are developed for advanced geometry and composite rotors. Aeroelastic and sensitivity analyses of the rotor based on a finite element method in space and time are linked with automated optimization algorithms to perform optimization of a four–bladed, soft–in-plane hingeless rotor. For the advanced geometry rotor, design variables include nonstructural mass and its placement, blade bending stiffness (flap, lag and torsion) and blade geometry (sweep, droop and planform taper) at five spanwise stations. The objective function constitutes minimization of all six vibratory hub loads subject to constraints on frequency placement, autorotational inertia and aeroelastic stability of the blade in forward flight Optimization results show reduction in the 4/rev hub loads of 25–60 percent. In another part of this study, aeroelastic optimization is performed for a composite rotor with the blade span modeled as a single–cell as well as a two–cell box–beam. The design variables are the ply angles of the cross–section of the blade spar. Optimization is performed for several layups and configurations and it is concluded that elastic stiffnesses reduce the objective function by about 20–40 percent; composite couplings yield a further reduction in the objective of about 10–15 percent. Using vibratory hub loads alone in the objective function can cause an increase in the blade root bending moments leading to higher dynamic stresses. This issue is addressed by performing multi–objective optimization on the composite rotor by using a combination of vibratory hub loads and vibratory bending moments in the objective function. Optimum designs for the multi– objective optimization show a reduction in the objective function of about 30 percent from the starting design; 20 percent of this reduction is due to elastic stiffness and 10 percent due to composite coupling (flap

bending–torsion coupling). As compared to the starting design, the optimum solution results in a 15–60 percent reduction of the 4/rev hub loads as well as a reduction in the peak–to–peak flap and lag bending moments of 11 and 14 percent, respectively, compared to the starting design. Starting from an initially infeasible design with a 3 percent requirement on lag mode damping, the optimum solution with composite chordwise bending–torsion coupling results in an increase in lag mode damping of 130–200 percent, compared to the starting design.
Dissert. Abstr.
Aeroelasticity; Airfoil Profiles; Design Analysis; Finite Element Method; Rotary Wings;

N96–21635*# Arizona State Univ., Tempe, AZ. Dept. of Mechanical and Aerospace Engineering
Development of Continuous and Discrete Approaches for Aerodynamic Sensitivity Analysis Progress Report
Chattopadhyay, Aditi; Narayan, Johnny R.; and Xu, Wensheng; et al1 Jan. 1995 19 p
Contract(s)/Grant(s): (NCC2–5127)
Report No.(s): (NASA–CR–200626; NAS 1.26:200626; NIPS–96–36166) Avail: CASI HC A03/MF A01

A comparative study of discrete and continuous semi–analytical sensitivity analysis techniques for evaluating aerodynamic sensitivities in optimization procedures involving CFD solvers for accurate and detailed flow solutions, was proposed. Although there is extensive literature on the discrete and continuous approaches for calculating aerodynamic sensitivities, a study of the relative efficiencies of the approaches has not been performed. This study is crucial in selecting an appropriate sensitivity analysis technique for large scale, multidisciplinary design optimization problems using comprehensive analysis procedures. The study will compare the accuracy and computational efficiency of the two techniques using representative model optimization problems. The nature of the optimum solutions and the computational time (CPU hours) required for arriving at optimum designs are also of interest. The purpose of the present research is to extend the ongoing effort on semi–analytical sensitivity analysis techniques by performing this important comparative study of the two techniques. The proposed study will compare the accuracy and computational efficiency of the two techniques using representative model optimization problems. The nature of the optimum solutions and the CPU time required for convergence will also be of interest. Finally, parallelization of the developed sensitivity analysis procedures is proposed to improve the computational efficiency and the adaptability to a variety of CFD solvers.
Derived from text
Aerodynamic Coefficients; Aircraft Design; Computational Fluid Dynamics; Design Analysis; Flow Distribution; Multidisciplinary Design Optimization;

N96–21647*# Cleveland State Univ., OH. Dept. of Civil Engineering.
Probabilistic Fiber Composite Micromechanics M.S. Thesis, Final Report
Stock, Thomas A.; et al1 Jan. 1996 196 p
Contract(s)/Grant(s): (NAG3–550; RTOP 505–63–5B)
Report No.(s): (NASA–CR–198443; E–10082; NAS 1.26:198443; NIPS–96–34693) Avail: CASI HC A09/MF A03

Probabilistic composite micromechanics methods are developed that simulate expected uncertainties in unidirectional fiber composite properties. These methods are in the form of computational procedures using Monte Carlo simulation. The variables in which uncertainties are accounted for include constituent and void volume ratios, constituent elastic properties and strengths, and fiber misalignment. A graphite/epoxy unidirectional composite (ply) is studied to demonstrate fiber composite material property variations induced by random changes expected at the material micro level. Regression results are presented to show the relative correlation between predictor and response variables in the study. These computational procedures make possible a formal description of anticipated random processes at the intra–ply level, and the related effects of these on composite properties.
Author
Computerized Simulation; Fiber Composites; Graphite–epoxy Composites; Micromechanics; Monte Carlo Method; Probability Theory; Random Processes; Reinforcing Fibers;

N96–22151*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
Airbreathing hypersonic vehicle design and analysis methods
Lockwood, Mary Kae; Petley, Dennis H.; Hunt, James L.; and Martin, John G.; et al18 Jan. 1996 11 p Presented at 34th Aerospace Sciences Meeting and Exhibit, Reno, NV, United States, 15–18 Jan. 1996
Report No.(s): (NASA–TM–111249; NAS 1.15:111249; AIAA PAPER 96–0381; NIPS–96–07964) Avail: CASI HC A03/MF A01

The design, analysis, and optimization of airbreathing hypersonic vehicles requires analyses involving many highly coupled disciplines at levels of accuracy exceeding those traditionally considered in a conceptual or preliminary–level design. Discipline analysis methods including propulsion, structures, thermal management, geometry, aerodynamics, performance, synthesis, sizing, closure, and cost are discussed. Also, the on–going integration of these methods into a working environment, known as HOLIST, is described.
Author
Air Breathing Boosters; Air Breathing Engines; Design Analysis; Hypersonic Vehicles; Propulsion System Configurations; Structural Analysis;

N96–22161*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

Equivalent plate modeling for conceptual design of aircraft wing structures

Giles, Gary L.; et al 19 Sep. 1995 18 p Presented at 1st AIAA Aircraft Engineering Technology and Operations Congress, Los Angeles, CA, United States, 19–21 Sep. 1995

Report No.(s): (NASA–TM–111263; NAS 1.15:111263; AIAA PAPER 95–3945; NIPS–96–07979) Avail: CASI HC A03/MF A01

This paper describes an analysis method that generates conceptual–level design data for aircraft wing structures. A key requirement is that this data must be produced in a timely manner so that is can be used effectively by multidisciplinary synthesis codes for performing systems studies. Such a capability is being developed by enhancing an equivalent plate structural analysis computer code to provide a more comprehensive, robust and user–friendly analysis tool. The paper focuses on recent enhancements to the Equivalent Laminated Plate Solution (ELAPS) analysis code that significantly expands the modeling capability and improves the accuracy of results. Modeling additions include use of out–of–plane plate segments for representing winglets and advanced wing concepts such as C–wings along with a new capability for modeling the internal rib and spar structure. The accuracy of calculated results is improved by including transverse shear effects in the formulation and by using multiple sets of assumed displacement functions in the analysis. Typical results are presented to demonstrate these new features. Example configurations include a C–wing transport aircraft, a representative fighter wing and a blended–wing–body transport. These applications are intended to demonstrate and quantify the benefits of using equivalent plate modeling of wing structures during conceptual design.

Author

Aircraft Design; Aircraft Structures; Applications Programs (computers); Body–wing Configurations; Mathematical Models; Multidisciplinary Design Optimization; Plates (structural Members); Wing Profiles; Winglets;

N96–22287*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

Multidisciplinary aerospace design optimization: Survey of recent developments

Sobieszczanski–Sobieski, Jaroslaw; and Haftka, Raphael T.; et al1 Jan. 1995 38 p Presented at 34th Aerospace Sciences Meeting and Exhibit, Reno, NV, United States, 15–18 Jan. 1995

Report No.(s): (NASA–TM–111250; AIAA PAPER 96–0711; NAS 1.15:111250; NIPS–96–07965) Avail: CASI HC A03/MF A01

The increasing complexity of engineering systems has sparked increasing interest in multidisciplinary optimization (MDO). This paper presents a survey of recent publications in the field of aerospace where interest in MDO has been particularly intense. The two main challenges of MDO are computational expense and organizational complexity. Accordingly the survey is focussed on various ways different researchers use to deal with these challenges. The survey is organized by a breakdown of MDO into its conceptual components. Accordingly, the survey includes sections on Mathematical Modeling, Design–oriented Analysis, Approximation Concepts, Optimization Procedures, System Sensitivity, and Human Interface. With the authors' main expertise being in the structures area, the bulk of the references focus on the interaction of the structures discipline with other disciplines. In particular, two sections at the end focus on two such interactions that have recently been pursued with a particular vigor: Simultaneous Optimization of Structures and Aerodynamics, and Simultaneous Optimization of Structures Combined With Active Control.

Author

Active Control; Mathematical Models; Multidisciplinary Design Optimization;

N96–22443* Stanford Univ., CA.

Lifting surface design using multidisciplinary optimization Ph.D. Thesis

Wakayama, Sean Rikio; et al1 Jan. 1995 181 p

Report No.(s): (NIPS–96–33257) Avail: Univ. Microfilms Order No. DA9516930

Lifting surface design is affected by many considerations; drag, weight, and high–lift are particularly important. These effects place different and often opposite requirements on wing shape, complicating the selection of a best configuration. To assist this selection, a preliminary design method using nonlinear optimization has been developed. An isolated lifting surface design problem is formulated from aircraft mission parameters, typically to calculate the platform and twist minimizing cruise drag or maximizing range, subject to constraints such as structural weight and maximum section lift. Solving this with optimization requires very fast analyses that are capable of capturing the effects of detailed changes in wing shape. This motivated significant improvements that were made to structural calculations and maximum–lift prediction methods for preliminary design. A method was developed to evaluate wing weight and stiffness considering bending and buckling strength. A critical section method was modified to enable the prediction of flaps–down maximum lift, correcting for induced camber near the flap edge. The lifting surface optimization method performs platform design while accounting for many effects: static aeroelasticity, weight evaluated from multiple structural design conditions, induced drag, profile drag, compressibility drag, maximum lift, static stability, and control power constraints. The method was used to explore the influence of these effects on optimal wings, demonstrating how strongly lifting surface design is in-

fluenced by maximum–lift constraints. The method was also applied to studies of wing tip shape and optimal wing–tail configurations. In many cases, the optimizer exploits physical effects, creating design features that are easy to interpret in hindsight but difficult to predict in advance. In creating these designs, the method has demonstrated that optimization can be a valuable tool for lifting surface design.
Dissert. Abstr.
Aerodynamic Configurations; Lift; Lifting Bodies; Multidisciplinary Design Optimization; Stiffness; Structural Design; Surface Properties; Wings;

N96–22575*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
Navier–Stokes analysis of a delta wing in static and dynamic roll
Chaderjian, N.; and Schiff, L.; et al22 Jun. 1995 11 p Presented at 13th AIAA Applied Aerodynamics Conference, San Diego, CA, United States, 19–22 Jun. 1995
Report No.(s): (NASA–TM–111256; NAS 1.15:111256; AIAA PAPER 95–1868; NIPS–96–07977) Avail: CASI HC A03/MF A01

The three–dimensional, Reynolds–averaged, Navier–Stokes equations are used to numerically simulate non–steady high–incidence vortical flow about a 65 degree sweep delta wing under static roll and forced periodic roll motions. These computations have been previously reported in the literature, where emphasis was placed on validating the computational results with nonsteady experimental surface pressures, forces and moments. The emphasis of this research is to revisit these earlier computations and use nonsteady numerical flow visualization to analyze the nonlinear surface flow and vortex breakdown dynamics. Most notable are the periodic formation of surface–flow separation lines, and the periodic formation of vortex breakdown near the delta wing trailing edge.
Author
Delta Wings; Navier–stokes Equation; Numerical Flow Visualization; Roll; Vortex Breakdown; Vortices;

N96–22692* Maryland Univ., College Park, MD.
A design–oriented aeromechanical analysis for hingeless rotor helicopters in turning flight Ph.D. Thesis
Spence, Anne Marie oetting; et al1 Jan. 1994 343 p
Report No.(s): (NIPS–96–33252) Avail: Univ. Microfilms Order No. DA9514584

This dissertation describes a mathematical model for a hingeless rotor helicopter capable of flight in both steady, level and turning flight regimes. The rotor blade is modeled as a Bernoulli–Euler beam undergoing moderately large elastic deflections in coupled flap–lag–torsion. In turn, the fuselage is described by nonlinear Euler equations valid for large fuselage attitudes and rates. The combined effects of turn rate, aircraft speed, and flight path angle on the blade response, aeromechanical stability and flight dynamic stability are discussed. The results indicate that steady level turns tend to stabilize the lag mode, while descending turns are destabilizing and may limit the maneuver envelope of the helicopter due to instabilities in the progressive and differential lag modes. These instabilities, however, tend to be weak. Judicious choice of flap and lag fundamental frequencies is necessary to insure stability of the lag mode in descending flight. Minor modifications are made to the original aeromechanical analysis to provide frequency response information for comparison with the new helicopter handling qualities specifications. The effect of selected rotor design parameters on the handling qualities ratings, aeromechanic and night dynamic characteristics of a hingeless rotor helicopter are then analyzed. The results indicate that a decrease in the flapping frequency and a positive elastic axis/aerodynamic center offset have a degrading effect on handling qualities while forward center of gravity offset improves the overall handling qualities. Regressive lag mode stability is improved by a positive elastic axis/aerodynamic center offset and by decreasing the flapping frequency while a forward center of gravity offset causes the regressive lag mode to be destabilized. The addition of roll attitude feedback can also be used to stabilize an unstable regressive lag mode, although gains are limited by the stability of the coupled roll/regressive flap mode. A method is described for the calculation of the sensitivities of blade root loads, hub loads and modal loads to changes of blade design parameters using a chain rule differentiation approach. The algorithm exploits features of the formulation of the blade and fuselage equations of motion, and of the solution technique to calculate the sensitivities at a fraction of the cost of an aeroelastic analysis. The results indicate that the semi–analytical technique is very accurate and computationally efficient.
Dissert. Abstr.
Aerodynamic Stability; Aeroelasticity; Equations of Motion; Helicopter Control; Helicopters; Mathematical Models; Rotor Dynamics; Turning Flight;

N96–22700* Minnesota Univ., Duluth, MN.
Optimal helicopter operation from a clear heliport in the event of one engine failure Ph.D. Thesis
Sharma, Vivek; et al 1 Jan. 1994 200 p
Report No.(s): (NIPS–96–33251) Avail: Univ. Microfilms Order No. DA9514680

The Federal Aviation Administration (FAA) certifies a transport helicopter as either Category–A or Category–B. The Category–A certification applies to multiengine helicopters with independent engine systems, and requires that the helicopter can either continue flight or land safely in the event of single engine failure. The Category–B certification applies to either single engine or multiengine helicopters, and only requires that a safe landing be possible in the case of an engine failure. For a Category–A helicopter, the deci-

sion to land or to 'stay up' depends on the conditions at engine failure. If an engine fails during a normal takeoff before the helicopter reaches the takeoff decision point (TDP), the pilot must reject the takeoff (RTO). If an engine fails after passing the TDP, the pilot must continue the takeoff (CTO). If an engine fails during a normal landing approach before reaching the landing decision point (LDP), the pilot may either continue or balk the landing (BL). The pilot must continue the landing (CL) for an engine failure past the LDP. Optimal clear heliport operation of a Category–A helicopter is studied using nonlinear optimal control theory. The objectives are to maximize the payload capacity and to minimize the runway length requirements, subject to the FAA safety requirements. A point–mass model of the UH–60A helicopter is used for trajectory optimizations. The results reveal essential features of Category–A helicopter flight. In either CTO or BL, the helicopter needs to climb out. The rotor speed stays at its minimum limit for some time so that rotational energy is transformed to potential and kinetic energy. The maximum weight is determined by the OEI power available and the minimum height allowed. In either RTO or CL, the helicopter needs to land. The rotor speed stays at its maximum limit for some time so that the stored rotor energy can be used to cushion the touchdown. The helicopter weight does not affect the landing trajectories significantly. Optimal trajectories provide the minimum runway length requirement, and the maximum payload capacity of the helicopter, with guaranteed safety. The solutions are useful for choosing optimal critical decision points for specified conditions.
Dissert. Abstr.
Control Theory; Engine Failure; Helicopter Control; Helicopter Engines; Helicopters; Heliports; Multiengine Vehicles; Takeoff;

N96–22822*# Naval Air Warfare Center, Patuxent River, MD. Aircraft Div.
Crewstation Technology Transition Evaluation Tools
Zielinski, Richard; Kahle, Walter; and Parkinson, Robert; et al19 Oct. 1995 35 p
Report No.(s): (AD–A300968; NIPS–96–30852) Avail: CASI HC A03/MF A01

This paper discusses the development of a core set of technology demonstration tools to enhance and shorten the process of transitioning technology to products. The process is explained, along with associated issues and current capability, focusing on the shortfalls of the transition process. It then describes the core set of tools, a demonstration architecture, that span all of the stages of technology insertion with emphasis on the advanced stages of the technology transition process: fixed simulation sites, mobile demonstration, and flight demonstration. Central to the paper is the description of the tool set of demonstration architecture to be hosted in a mobile demonstration (MDS), manned flight simulators, and a combat system test bed (CSTB) aircraft. A baseline hardware set intended for 'quick–on/quick–off' aircraft demonstration consists of a high–throughput processor interface unit, a 'state–of–the–art' color flat panel display compatible with current aircraft cockpits, and a 1553 'cockpit bus' connecting the processor, display and technology in demonstration as appropriate. The case is made for the ability of this quick–on/quick–off core set of tools to minimize the need for dedicated technology demonstration aircraft in the RDT&E inventory.
DTIC
Aircraft Equipment; Cockpits; Flight Simulation; Flight Tests;

N96–22833*# Naval Air Warfare Center, Patuxent River, MD. Aircraft Div.
Developing Flight Test Techniques to Ensure Proper Rigging of Highly Augmented Aircraft
Traven, Ricardo; and Whitley, Susan E.; et al5 Sep. 1995 12 p
Report No.(s): (AD–A300965; NIPS–96–30855) Avail: CASI HC A03/MF A01

Uncommanded rolling moments have been considered a natural part of the aging process of some F/A–18 airplanes. These rolling moments can range from an annoyance requiring constant trimming to a serious degradation in handling qualities which can cause premature departures during maneuvering flight. Uncommanded rolling moments in flight can generally be eliminated with rigging if the surface which is causing the roll is known. Due to the highly augmented flight control architecture of the F/A–18, it is very difficult to isolate the actual control surface that is causing the uncommanded rolling moment since so many surfaces are active. NAWC–AD has developed techniques to identify the flight control surface causing uncommanded rolling moments. These techniques have been used successfully on four F/A–18 airplanes to identify which flight control surface was causing uncommanded roll rates. Additional flight tests are planned to further refine the techniques described in this paper. These techniques have been demonstrated to reduce uncommanded rolling moments in the F/A–18 and can be applied to all aircraft.
DTIC
Control Systems Design; Flight Control; Flight Tests; Rigging; Roll;

N96–22842*# Naval Air Warfare Center, Patuxent River, MD. Aircraft Div.
US Navy T–45A Departure and Spin Evaluation
Mortensen, Joseph A.; et al3 Aug. 1995 19 p
Report No.(s): (AD–A300964; NIPS–96–30856) Avail: CASI HC A03/MF A01

U.S. Navy T–45A departure and spin evaluation was conducted from 8 July to 30 September 1994. The initial T–45A flight manual departure and spin recovery proce-

dures evaluated proved unsatisfactory in providing consistent recoveries from inverted spin modes. Specifically, the procedures allowed the rudder to blow–out in the pro–spin direction during recovery, resulting in spin mode transitions and delayed recoveries. Furthermore, a third sustained inverted spin mode was discovered during flight tests. The initial flight manual procedures were successfully modified to reduce the occurrence of rudder blow–out during recovery attempts and provided more consistent recovery characteristics.
DTIC
Aircraft Control; Aircraft Maneuvers; Aircraft Performance; Flight Tests; Turboprop Engines;

N96–22887*# Defence Science and Technology Organisation, Canberra (Australia). Airframes and Engines Div.
Vibration Test on a Nomad N24A Aircraft Fitted with One Modified Aileron
Farrell, P. A.; Dunn, S. A.; and Rider, C. D.; et al 1 Jun. 1995 41 p
Report No.(s): (AD–A301189; DSTO–TN–0010; DODA–AR–009–262; NIPS–96–30706) Avail: CASI HC A03/MF A01

Following doubt raised about the loads experienced on the flap and aileron of Nomad aircraft in flight, a flight test program was formulated to measure these loads. An aileron fitted with strain gauges and the associated wiring was installed on a Nomad N24A aircraft but this rendered the aircraft non–standard. To verify the aeroelastic stability of the aircraft when fitted with the instrumented aileron, a flight flutter trial was proposed. An abbreviated Ground Vibration Test (GVT) was conducted on the aircraft to support the flutter trial, and this report describes the GVT and presents the results.
DTIC
Ailerons; Flaps (control Surfaces); Flight Stability Tests; Flight Tests; Ground Tests; Research Aircraft; Vibration Tests;

N96–22895*# Army Aeromedical Research Lab., Fort Rucker, AL.
Utilization of Visual Ports in U.S. Army Rotary–Wing Aircraft Final Report
Ivey, Rebecca H.; Rash, Clarence E.; Levine, Richard R.; Wentworth, Sean L.; and McGowin, III, Everette; et al1 Aug. 1995 192 p
Report No.(s): (AD–A301143; NIPS–96–30739) Avail: CASI HC A09/MF A02

This report documents the location and extent of visual ports (windows) in U.S. Army rotary–wing aircraft and assesses utilization and associated problems. The study was conducted in three parts: First, the visual ports of each aircraft type were documented through visual plots and photography. Second, questionnaire data for 333 aviators and crewmen addressing the use of and problems with each visual port were collected and analyzed. Third, a search of the U.S. Army Safety Center accident database was collected to identify the frequency of accidents in which impaired vision was a possible factor.
DTIC
Aircraft Pilots; Position (location); Rotary Wing Aircraft; Visual Flight; Visual Observation;

N96–22927*# Naval Air Warfare Center, Patuxent River, MD.
Integrated New Test Aircraft Capability (INTAC)
Carico, Dean; et al11 Aug. 1995 11 p Presented at ITEA International Symposium, Huntsville, AL, United States, 2–5 Oct. 1995
Report No.(s): (AD–A300966; NIPS–96–30854) Avail: CASI HC A03/MF A01

The current and projected emphasis on declining budgets, reduced staffs, and tightened schedules, while trying to maintain or improve productivity, dictates a new approach to T&E that takes advantage of the ongoing technology explosion. Automation and standardization, combined with analysis and high technology simulation options, permit a new look at traditional Developmental Testing (DT). This proposed concept, called Integrated New Test Aircraft Capability (INTAC), involves using a high–fidelity, physical model based, generic structure simulation to certify the aircraft in a virtual environment, and using the aircraft to certify the simulation model. INTAC includes supporting, enhancing, augmenting, and ultimately automating traditional T&E and making this capability available at the pilot/engineer work area. INTAC promises to reinvent T&E by allowing test team members to do testing better, faster, cheaper, and safer. A high fidelity virtual air vehicle life cycle simulation capability, like INTAC, also gives the program manager better information on how to optimize the application of scarce future test dollars.
DTIC
Aircraft Performance; Flight Simulation; Flight Tests; Performance Tests;

N96–22952*# Naval Air Warfare Center, Patuxent River, MD. Aircraft Div.
E–6A Precipitation Static Assessments
Haines, Joel; Clelland, Mike; Whitaker, Mike; Depasquale, William; (Dual, Inc., Lexington Park, MD.)and Lubosch, Bernd; (Dual, Inc., Midwest City, OK.) et al27 Sep. 1995 33 p
Report No.(s): (AD–A300960; NIPS–96–30860) Avail: CASI HC A03/MF A01

Electromagnetic Environmental Effects (E3) is a serious concern in today's Navy. As part of the E3 life–cycle effort, P–Static Assessments of TACAMO Fleet aircraft being conducted. These assessments are used to monitor aircraft

bonding integrity and maintenance procedures throughout the aircraft life–cycle. To minimize the problems associated with E3, aircraft bonding integrity must be maintained. A P–Static assessment is a quick–look method for finding bonding inconsistencies on the skin of the aircraft. Working hand in hand with the Fleet, problem areas can be identified and maintenance actions initiated to correct them. In the future, the P–Static assessments will be incorporated into the Enhanced Phase Maintenance (EPM) procedures. The P–Static assessments consist of power off testing along with dc bonding measurements of the static discharging system. The Fleet receives a brief report describing problems found during the assessment with recommended fixes. A database will be developed to document all problem areas and note any similarities between aircraft.
DTIC
Aircraft Reliability; Electronic Aircraft; Flight Tests; Life Cycle Costs;

N96–23163* Defence Science and Technology Organisation, Melbourne (Australia). Airframes and Engines Div.
Orion P3C Horizontal Stabiliser Strain Survey and Corrosion Repair Development
Kaye, Robert H.; Jones, R.; and Hayes, Peter; et al 1 Nov. 1995 50 p
Report No.(s): (DSTO–TR–0196; AR–009–445; NIPS–96–39544) Copyright Avail: Issuing Activity (DSTO Aeronautical and Maritime Research Lab., PO Box 4331, Melbourne, Victoria 3001, Australia)

This report presents results of an experimental investigation into the stress/strain field at the lower skin root region of the P3 horizontal stabilizer. Thermo–elastic and strain gauge methods were used with a bare structure P3 tail–plane loaded under laboratory conditions. Applied load was restricted to 60 percent of design limit by the nature of the test article and the loading rig. The results show that the stresses in the region of interest are predominantly spanwise in direction. Stress concentrations consisting typically of 30 percent in–plane shear stress and 70 percent spanwise stress were found to occur near the inboard corners of each of the three lower skin planks. The largest of these was found at the forward corner of the forward plank. The load transfer between the skin panels and the spars was found to take place over the inboard 100 mm of the stabilizer. A bonded repair to corrosion damage has been presented on the basis of the bonded joints in the repair being stronger than the surrounding parent material. This repair design is not in any way dependent on the stress/strain test results and falls within the requirements of the recently produced RAAF Engineering Standard C5033. The region has a complex stress distribution due to the stabilizer skin panels terminating at the fuselage. Laboratory investigation of this stress distribution has been brought about by the availability of a suitable test article and has provided valuable ancillary information.
Author
Aircraft Structures; Bonded Joints; Corrosion; Horizontal Tail Surfaces; Load Tests; P–3 Aircraft; Skin (structural Member); Stress Distribution; Stress–strain Relationships;

N96–23188*# Virginia Univ., Charlottesville, VA. School of Engineering and Applied Science.
NASA–UVA Light Aerospace Alloy and Structures Technology Program (LA2ST) Progress Report, 1 Jul. – 31 Dec. 1995
Scully, John R.; Shiflet, Gary J.; Stoner, Glenn E.; and Wert, John A.; et al1 Jan. 1996 168 p
Contract(s)/Grant(s): (NAG1–745)
Report No.(s): (NASA–CR–200723; NAS 1.26:200723; UVA/528266/MSE96/119; NIPS–96–39511) Avail: CASI HC A08/MF A02

The NASA–UVA Light Aerospace Alloy and Structures Technology (LA2ST) Program was initiated in 1986 and continues with a high level of activity. The objective of the LA2ST Program is to conduct interdisciplinary graduate student research on the performance of next generation, light–weight aerospace alloys, composites and thermal gradient structures in collaboration with NASA–Langley researchers. Specific technical objectives are presented for each research project. We generally aim to produce relevant data and basic understanding of material mechanical response, environmental/corrosion behavior, and microstructure; new monolithic and composite alloys; advanced processing methods; new solid and fluid mechanics analyses; measurement and modeling advances; and a pool of educated graduate students for aerospace technologies. Three research areas are being actively investigated, including: (1) Mechanical and environmental degradation mechanisms in advanced light metals, (2) Aerospace materials science, and (3) Mechanics of materials for light aerospace structures.
Author
Aircraft Construction Materials; Aircraft Structures; Corrosion Resistance; Crack Propagation; Fracture Strength; Light Alloys; Microstructure; Spacecraft Construction Materials;

N96–23246*# National Aerospace Lab., Tokyo (Japan).
Simulation Study for a Fire Helicopter
Okuno, Yoshinori; Funabiki, Kohei; Saito, Shigeru; and Harada, Masashi; et al1 May 1995 30 p In JAPANESE (ISSN 0389–4010)
Report No.(s): (NAL–TR–1269; NIPS–96–36114) Avail: CASI HC A03/MF A01

The feasibility of the concept of using a helicopter to suppress fires in high–rise buildings was investigated by means of flight simulations and flight tests. The piloted simulations using a flight simulator were performed to investi-

gate the safety and effectiveness of the fire fighting operation. The results demonstrated that nearly 90% of the discharged water can be hit on the target window at wind speeds of up to 7 m/s when the operator of the water discharge boom cooperates with the helicopter pilot. On the other hand, flight tests were conducted, in which the pilots performed hovering at a distance of 20 m from a real high–rise building and tried to keep the searchlight, which was mounted on the helicopter, fixed on a target window. It was pointed out that the fire helicopter should be equipped with an indicator of the distance to the building wall to improve the safety and efficiency during the fire fighting operation. The results of these experiments validated the feasibility of the fire helicopter and also clarified the problems to be solved to realize this concept.
Author
Fire Fighting; Flight Simulation; Helicopters;

N96–23340*# National Aerospace Lab., Tokyo (Japan).
Wing Rock of Delta Wings with an Analysis by the Phase Plane Method
Tate, Atsushi; Noda, Junichi; and Yoshinaga, Takashi; et al1 Apr. 1995 22 p In JAPANESE (ISSN 0389–4010)
Report No.(s): (NAL–TR–1266; NIPS–96–36115) Avail: CASI HC A03/MF A01

Experimental investigation of the rolling motion of thin delta wings with varying sweep angles, using using a free–to–roll method was conducted. The boundaries of dynamically stable and unstable regions of the delta wings were obtained and compared with vortex symmetry and vortex burst curves on a plane of angle of attack of the roll axis vs. delta wing sweep angle. An analytical expression of the rolling moment using a phase plane method was found to be satisfactory for generating the limit cycle similar to the one experimentally obtained. Using this expression, energy transfer in the unsteady motion was calculated.
Author
Angle of Attack; Delta Wings; Rolling Moments; Sweep Angle; Thin Wings; Wing Oscillations;

06 AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

N96–22180*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
Human–Centered Aviation Automation: Principles and Guidelines
Billings, Charles E.; et al1 Feb. 1996 222 p
Contract(s)/Grant(s): (NAG2–810)
Report No.(s): (NASA–TM–110381; A–961056; NAS 1.15: 110381; NIPS–96–36711) Avail: CASI HC A10/MF A03

This document presents principles and guidelines for human–centered automation in aircraft and in the aviation system. Drawing upon operational experience with highly automated aircraft, it describes classes of problems that have occurred in these vehicles, the effects of advanced automation on the human operators of the aviation system, and ways in which these problems may be avoided in the design of future aircraft and air traffic management automation. Many incidents and a few serious accidents suggest that these problems are related to automation complexity, autonomy, coupling, and opacity, or inadequate feedback to operators. An automation philosophy that emphasizes improved communication, coordination and cooperation between the human and machine elements of this complex, distributed system is required to improve the safety and efficiency of aviation operations in the future.
Author
Aircraft Accidents; Aircraft Safety; Automation; Complex Systems; Human Factors Engineering; Operator Performance;

N96–22424* Michigan Univ., Ann Arbor, MI.
Computing range maps for low–altitude rotorcraft flight using computer vision and a hierarchical framework Ph.D. Thesis
Leblanc, David J.; et al1 Jan. 1994 203 p
Report No.(s): (NIPS–96–34479) Avail: Univ. Microfilms Order No. DA9500979

Computer vision is one of many sensing modalities suited for obstacle detection onboard autonomous vehicles navigating in unknown or only partially known environments. For rotorcraft flying at very low altitudes, the use of image sequences from cameras mounted to the vehicle is desirable because vision is passive and provides rapid sensing of the environment with near infinite range and a wide field of view. Unfortunately, the processing of visual images to generate range maps of the nearby environment is computationally expensive, and currently cannot be performed in real time, even using relatively low–performance cameras. Furthermore, this problem will be exacerbated by the use of new high–performance cameras whose high resolution is necessary to provide the range map denseness required for safe navigation. We propose a hierarchical set of computations that guarantees that range maps based on feature points can be computed in real time. This is achieved by selecting, at regular intervals in time, a subset of features to track, such that the onboard computing resources are not exceeded. This is enabled and enhanced by an efficient multirate, multiresolutional approach to tracking features. A high level computation determines which features to track, then assigns each feature to one of many parallel slave processors, allocating a maximum amount of computing resources for the feature. Features are chosen to improve overall range map accuracy feature density, as required for the navigation ob-

jectives. Computations at the feature level select image data from a multirate and multiresolution image data structure to produce the best range estimates while using only the available computing resources. The result is a more efficient and more focused processing of image data, more control over the distribution of features in the range map, and a guarantee of real time computing performance.
Dissert. Abstr.
Computer Vision; Image Processing; Nap–of–the–earth Navigation; Navigation Aids; Optical Range Finders; Parallel Processing (computers); Rangefinding; Real Time Operation;

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.

N96–21499* Washington Univ., Seattle, WA.
Effects of rotation on impinging jets for turbine cooling Ph.D. Thesis
Aronstein, David Claude; et al1 Jan. 1994 128 p
Report No.(s): (NIPS–96–33348) Avail: Univ. Microfilms Order No. DA9504590

The effects of background rotation on impinging–jet flows are studied using flow visualization in a rotating water tank. Implications on impingement cooling of rotating turbine blades are inferred based on established properties of jets and the vortical structures they generate. The problem is divided into two parts, depending upon the orientation of the jet relative to the rotation axis. An axial jet is parallel to the rotation axis, while a transverse jet is perpendicular or at a substantial angle to the rotation axis. In the case of axial jets, all of the jet flow may be absorbed by Ekman layers on the boundaries, if the Rossby number is low. This will occur on the impingement plate directly in the path of the jet if the Rossby number is less than the square root of the Ekman number; or in an area surrounding the jet nozzle if the Rossby number is higher, up to approximately one. The first case is trivial. An analytical solution is presented for the second case, including the starting transient, and observations of the flow are made. At higher Rossby numbers, the near–field flow resembles that of an impinging jet in an inertial frame of reference, but a transition to columnar, rotation–dominated flow is observed within a few jet–diameters from the impingement point. Vortical structures are suppressed in this columnar regime so the implication is that the radial extent of effective cooling will be limited. Transverse jets in the same range of Rossby number also exhibit the transition to columnar Row within a few jet–diameters from the impingement point, and the radial flow on the impingement plate breaks up into a pair of planar wall currents proceeding outward in opposite directions. Vortical structures are changed from a radial pattern to a columnar pattern. An interesting asymmetry is observed. One of the wall currents is prone to separation because of a low pressure region close to the wall, while the other is very persistent due to a high pressure region along the wall. Implications on turbine cooling are discussed.
Dissert. Abstr.
Jet Flow; Jet Impingement; Rotating Fluids; Turbine Blades; Wall Flow;

N96–21587* Stanford Univ., CA.
An adaptive optimal combustion control strategy Ph.D. Thesis
Padmanabhan, Krishnan Turlough; et al1 Jan. 1994 189 p
Report No.(s): (NIPS–96–08996) Avail: Univ. Microfilms Order No. DA9508425

A strategy for optimizing the performance of a laboratory–scale combustor with respect to volumetric heat release (increase) and pressure fluctuations (decrease) has been developed. This strategy utilizes (1) actuation techniques that simultaneously control volumetric heat release and pressure fluctuations; (2) sensing techniques that measure combustor performance; and (3) an adaptive optimal control strategy. Actuation techniques were chosen for their ability to alter the unsteady flow associated with the shear layer and recirculating flow regions of the combustor. Periodic spanwise forcing of the inlet boundary layer is used to reduce combustion–induced pressure fluctuations. Crossflow jets upstream of the inlet are used to control volumetric heat release. Sensing techniques were selected to measure or estimate the two performance parameters to be controlled. A fast–response piezoelectric pressure transducer measures the magnitude of the pressure fluctuations. A streamwise array of photodiodes measures light emission from the flame and enables estimation of volumetric heat release. Combustor performance is explicitly defined in terms of a cost function that is a weighted combination of the rms pressure fluctuation level and the mean volumetric heat release. The control strategy performs an on–line minimization of the cost function by continuously seeking the optimal combination of actuator settings and subsequently maintaining the cost at a minimum when the combustor is subject to unknown inlet condition changes. The strategy has been experimentally tested with unknown inlet condition changes, such as flow disturbances, changes in equivalence ratio, and changes in inlet velocity. Sample optimization results show the control strategy to be capable of indirectly sensing these inlet condition changes and to be effective at finding the new optimal actuator settings that reminimize the cost function within thirty seconds to four minutes of large and small inlet condition changes.
Dissert. Abstr.
Adaptive Control; Combustion Chambers; Combustion Control; Combustion Temperature; Optimal Control; Pressure Oscillations;

N96–22129*# NYMA, Inc., Brook Park, OH.

An Experimental Determination of Losses in a 3–Port Wave Rotor Final Report

Wilson, Jack; et al1 Feb. 1996 20 p Presented at Turbo Expo 1996, Birmingham, England , United States, 10–13 Jun. 1996

Contract(s)/Grant(s): (NAS3–27186; RTOP 505–62–75)

Report No.(s): (NASA–CR–198456; E–10079; NAS 1.26:198456; NIPS–96–35620) Avail: CASI HC A03/MF A01

Wave rotors, used in a gas turbine topping cycle, offer a potential route to higher specific power and lower specific fuel consumption. In order to exploit this potential properly, it is necessary to have some realistic means of calculating wave rotor performance, taking losses into account, so that wave rotors can be designed for good performance. This in turn requires a knowledge of the loss mechanisms. The experiment reported here was designed as a statistical experiment to identify the losses due to finite passage opening time, friction, and leakage. For simplicity, the experiment used a 3–port, flow divider, wave cycle, but the results should be applicable to other cycles. A 12 inch diameter rotor was used, with two different lengths, 9 inches and 18 inches, and two different passage widths, 0.25 inch and 0.54 inch, in order to vary friction and opening time. To vary leakage, moveable end–walls were provided so that the rotor to end–wall gap could be adjusted. The experiment is described, and the results are presented, together with a parametric fit to the data. The fit shows that there will be an optimum passage width for a given wave rotor, since, as the passage width increases, friction losses decrease, but opening–time losses increase, and vice–versa. Leakage losses can be made small at reasonable gap sizes.

Author

Energy Storage; Friction Factor; Gas Turbines; Leakage; Losses; Ports (openings); Rotors;

N96–22153*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

Macroscopic balance model for wave rotors

Welch, Gerard E.; 1 Jan. 1996 22 p Presented at 34th Aerospace Sciences Meeting and Exhibit, Reno, NV, United States, 15–18 Jan. 1996; Sponsored by American Inst. of Aeronautics and Astronautics,

Contract(s)/Grant(s): (DA PROJ. IL1–61102–AH–45)

Report No.(s): (NASA–TM–107114; ARL–TR–925; AIAA PAPER 96–0243; E–10022; NAS 1.15:107114; NIPS–96–08119) Avail: CASI HC A03/MF A01

A mathematical model for multi–port wave rotors is described. The wave processes that effect energy exchange within the rotor passage are modeled using one–dimensional gas dynamics. Macroscopic mass and energy balances relate volume–averaged thermodynamic properties in the rotor passage control volume to the mass, momentum, and energy fluxes at the ports. Loss models account for entropy production in boundary layers and in separating flows caused by blade–blockage, incidence, and gradual opening and closing of rotor passages. The mathematical model provides a basis for predicting design–point wave rotor performance, port timing, and machine size. Model predictions are evaluated through comparisons with CFD calculations and three–port wave rotor experimental data. A four–port wave rotor design example is provided to demonstrate model applicability. The modeling approach is amenable to wave rotor optimization studies and rapid assessment of the trade–offs associated with integrating wave rotors into gas turbine engine systems.

Author

Balance; Gas Turbine Engines; Mathematical Models; Rotors; Tradeoffs;

N96–22181*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

An integration of the turbojet and single–throat ramjet

Trefny, C. J.; and Benson, T. J.; et al1 Nov. 1995 14 p Presented at 1995 Airbreathing Propulsion Subcommittee Meeting, Tampa, FL, United States, 5–9 Dec. 1995

Report No.(s): (NASA–TM–107085; E–9963; NAS 1.15:107085; NIPS–96–07897) Avail: CASI HC A03/MF A01

A turbine–engine–based hybrid propulsion system is described. Turbojet engines are integrated with a single–throat ramjet so as to minimize variable geometry and eliminate redundant propulsion components. The result is a simple, lightweight system that is operable from takeoff to high Mach numbers. Non–afterburning turbojets are mounted within the ramjet duct. They exhaust through a converging–diverging (C–D) nozzle into a common ramjet burner section. At low speed the ejector effect of the C–D nozzle aerodynamically isolates the relatively high pressure turbojet exhaust stream from the ramjet duct. As the Mach number increases, and the turbojet pressure ratio diminishes, the system is biased naturally toward ramjet operation. The common ramjet burner is fueled with hydrogen and thermally choked, thus avoiding the weight and complexity of a variable geometry, split–flow exhaust system. The mixed–compression supersonic inlet and subsonic diffuser are also common to both the turbojet and ramjet cycles. As the compressor face total temperature limit is approached, a two–position flap within the inlet is actuated, which closes off the turbojet inlet and provides increased internal contraction for ramjet operation. Similar actuation of the turbojet C–D nozzle flap completes the enclosure of the turbojet. Performance of the hybrid system is compared herein to that of the discrete turbojet and ramjet engines from takeoff to Mach 6. The specific impulse of the hybrid system falls below that of the non–integrated turbojet and ramjet because of ejector and Rayleigh losses. Unlike the discrete turbojet or ramjet however, the hybrid system produces thrust over the entire

Mach number range. An alternate mode of operation for takeoff and low speed is also described. In this mode the C–D nozzle flap is deflected to a third position, which closes off the ramjet duct and eliminates the ejector total pressure loss. Author

Convergent–divergent Nozzles; Hybrid Propulsion; Ramjet Engines; Throats; Turbojet Engines;

N96–22560*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

Quantification of Gear Tooth Damage by Optimal Tracking of Vibration Signatures

Choy, F. K.; (Akron Univ., Akron, OH.)Veillette, R. J.; (Akron Univ., Akron, OH.)Polyshchuk, V.; (Akron Univ., Akron, OH.)Braun, M. J.; (Akron Univ., Akron, OH.)and Hendricks, R. C.; et al1 Mar. 1996 22 p Presented at 6th International Symposium on Transport Phenomena and Dynamics of Rotating Machinery, Honolulu, HA, United States, 25–29 Feb. 1996

Report No.(s): (NASA–TM–107100; E–10029; NAS 1.15:107100; NIPS–96–35665) Avail: CASI HC A03/MF A01

This paper presents a technique for quantifying the wear or damage of gear teeth in a transmission system. The procedure developed in this study can be applied as a part of either an onboard machine health–monitoring system or a health diagnostic system used during regular maintenance. As the developed methodology is based on analysis of gearbox vibration under normal operating conditions, no shutdown or special modification of operating parameters is required during the diagnostic process. The process of quantifying the wear or damage of gear teeth requires a set of measured vibration data and a model of the gear mesh dynamics. An optimization problem is formulated to determine the profile of a time–varying mesh stiffness parameter for which the model output approximates the measured data. The resulting stiffness profile is then related to the level of gear tooth wear or damage. The procedure was applied to a data set generated artificially and to another obtained experimentally from a spiral bevel gear test rig. The results demonstrate the utility of the procedure as part of an overall health–monitoring system.

Author

Damage Assessment; Gear Teeth; Structural Vibration; Systems Health Monitoring; Time Dependence;

N96–22613* Cornell Univ., Ithaca, NY.

An analytical and numerical study of passive enhancement of stability margin in axial flow compression systems Ph.D. Thesis

West, Jr., William E; et al1 Jan. 1993 121 p

Report No.(s): (NIPS–96–07490) Avail: Univ. Microfilms Order No. DA9401876

The provision of adequate stability margin allowing maximum performance of axial flow compression systems is of great importance to the engine designer. It is shown that these systems initially lose stability to nonaxisymmetric disturbances as the throttle is closed past the peak of the steady performance curve. The growth of these disturbances may eventually lead to surge or rotating stall depending primarily on the plenum parameter. Passive control strategies based on variation of inlet and compressor geometry to inhibit nonaxisymmetric disturbance growth are evaluated. A parallel shear flow inlet distortion model is developed. The parameter representing reciprocal blade passage fluid inertia is found to significantly effect stability margin and steady performance losses for the case of constant amplitude distortion. In addition, a study of circumferential variation of reciprocal passage lag yields further improvements in distortion tolerance implying that stator stagger may be varied to minimize the compatibility problems associated with particular inlet and compressor combinations. A survey of numerical methods applied to the compression system analysis is presented. The limitations of Spectral and Pseudospectral methods in the representation of nonlinearity induced by the compressor characteristic is discussed. A Point Collocation method is developed that avoids these problems. The numerical method is validated by application to the calculation of equilibrium rotating stall performance. The reciprocal passage lag parameter is shown to be influential in the determination of stall cell shape and steady performance. A two mode analysis is presented that gives good agreement with numerical results suggesting that the influence of reciprocal passage lag is primarily due to inhibition and phase shifting of higher harmonic stall cell components. An analysis is presented suggesting that stagnation of circumferential velocity in the inlet duct would inhibit nonaxisymmetric disturbances. A singularity distribution method based on thin–airfoil theory is developed to model the unsteady inlet flow due to a finite chord divider placed upstream of the compressor. The reciprocal passage lag parameter is again found to be influential in determination of optimum stall inhibiting divider chord and gap combinations.

Dissert. Abstr.

Axial Flow; Compressors; Flow Distortion; Systems Analysis; Systems Stability; Tolerances (mechanics); Unsteady Flow;

N96–22744*# Allison Engine Co., Indianapolis, IN. Engineering Dept.

Advanced Turbine Technology Applications Project (ATTAP) Annual Report, 1992

1 Dec. 1993 106 p

Contract(s)/Grant(s): (DEN3–336; DE–A101–90CE– 50300; RTOP 778–32–21)

Report No.(s): (NASA–CR–195446; E–9499; NAS 1.26:195446; DOE/NASA/0336–5; EDR–17038; NIPS–

96–36717) Avail: CASI HC A06/MF A02

The Advanced Turbine Technologies Application Project (ATTAP) is in the fifth year of a multi–year development program to bring the automotive gas turbine engine to a state at which industry can make commercialization decisions. Activities during the past year included reference powertrain design updates, test–bed engine design and development, ceramic component design, materials and component characterization, ceramic component process development and fabrication, ceramic component rig testing, and test–bed engine fabrication and testing. Engine design and development included mechanical design, combustion system development, alternate aerodynamic flow testing, and controls development. Design activities included development of the ceramic gasifier turbine static structure, the ceramic gasifier rotor, and the ceramic power turbine rotor. Material characterization efforts included the testing and evaluation of five candidate high temperature ceramic materials. Ceramic component process development and fabrication, with the objective of approaching automotive volumes and costs, continued for the gasifier turbine rotor, gasifier turbine scroll, extruded regenerator disks, and thermal insulation. Engine and rig fabrication, testing, and development supported improvements in ceramic component technology. Total test time in 1992 amounted to 599 hours, of which 147 hours were engine testing and 452 were hot rig testing.

Author

Automobile Engines; Ceramics; Design Analysis; Engine Design; Engine Tests; Gas Turbine Engines; Refractory Materials;

N96–23121* Georgia Inst. of Tech., Atlanta, GA.

An investigation into the influence of mistuning on the forced response of bladed disk assemblies Ph.D. Thesis

Watson, Brian Christopher; et al1 Jan. 1993 168 p

Report No.(s): (NIPS–96–07627) Avail: Univ. Microfilms Order No. DA9400442

The bladed disk assembly is an important component of modern turbomachinery. Vibrations of the blades can pose severe limits on system performance and component service life. The combination of physical coupling of blade motions with mistuning of blade properties leads to very complicated forced response characteristics. This investigation has led to a systematic development of the mistuned bladed disk assembly problem. Unique to this development is a straightforward inclusion of both structural and aerodynamic coupling and a general method of characterizing both the mistuning strength and pattern through the introduction of a set of mistuning modes. A computational model has been created to allow parametric and sensitivity studies of bladed disk assemblies. These studies have revealed some of the interdependencies of the mistune mode, mistune strength, coupling, and excitation mode and frequency. Perturbation methods have been developed in an attempt to find general relationships among the excitation, the mistuning, and the response. An important outcome from these perturbation analyses is the identification of additional response modes contributing to the response of the mistuned system as a function of the mistune mode and the excitation mode. Finally, an optimization procedure has been developed to provide a logical method for selecting an arrangement of a given set of blades on an assembly.

Dissert. Abstr.

Coupled Modes; Dynamic Response; Forced Vibration; Rotating Disks; Rotor Dynamics; Turbine Blades;

N96–23137*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

Performance Benefits for Wave Rotor–Topped Gas Turbine Engines

Jones, Scott M.; and Welch, Gerard E.; et al1 Mar. 1996 16p Presented at 41st Turbo Expo 1996, Birmingham , United Kingdom, 10–13 Jun. 1996; Sponsored by American Society of Mechanical Engineers,

Report No.(s): (NASA–TM–107193; E–10168; NAS 1.15: 107193; ARL–TR–1065; NIPS–96–39338) Avail: CASI HC A03/MF A01

The benefits of wave rotor–topping in turboshaft engines, subsonic high–bypass turbofan engines, auxiliary power units, and ground power units are evaluated. The thermodynamic cycle performance is modeled using a one–dimensional steady–state code; wave rotor performance is modeled using one–dimensional design/analysis codes. Design and off–design engine performance is calculated for baseline engines and wave rotor–topped engines, where the wave rotor acts as a high pressure spool. The wave rotor–enhanced engines are shown to have benefits in specific power and specific fuel flow over the baseline engines without increasing turbine inlet temperature. The off–design steady–state behavior of a wave rotor–topped engine is shown to be similar to a conventional engine. Mission studies are performed to quantify aircraft performance benefits for various wave rotor cycle and weight parameters. Gas turbine engine cycles most likely to benefit from wave rotor–topping are identified. Issues of practical integration and the corresponding technical challenges with various engine types are discussed.

Author

Propulsion System Performance; Rotors; Thermodynamic Cycles; Turbofan Engines; Turbomachinery; Turboshafts;

N96–23138*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

Two–Dimensional Computational Model for Wave Rotor Flow Dynamics

Welch, Gerard E.; et al1 Mar. 1996 14 p Presented at 41st Turbo Expo 1996, Birmingham, United Kingdom, 10–13 Jun. 1996; Sponsored by American Society of Mechanical

Engineers,
Report No.(s): (NASA–TM–107192; E–10164; NAS 1.15: 107192; ARL–TR–924; NIPS–96–39339) Avail: CASI HC A03/MF A01

A two–dimensional (theta,z) Navier–Stokes solver for multi–port wave rotor flow simulation is described. The finite–volume form of the unsteady thin–layer Navier–Stokes equations are integrated in time on multi–block grids that represent the stationary inlet and outlet ports and the moving rotor passages of the wave rotor. Computed results are compared with three–port wave rotor experimental data. The model is applied to predict the performance of a planned four–port wave rotor experiment. Two–dimensional flow features that reduce machine performance and influence rotor blade and duct wall thermal loads are identified. The performance impact of rounding the inlet port wall, to inhibit separation during passage gradual opening, is assessed.
Author
Computational Fluid Dynamics; Finite Volume Method; Gas Turbine Engines; Multiblock Grids; Navier–stokes Equation; Rotor Dynamics; Two Dimensional Flow; Two Dimensional Models;

08 AIRCRAFT STABILITY AND CONTROL

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

N96–21572* Stanford Univ., CA.
Inverse and optimal control for aircraft maneuvers Ph.D. Thesis
Bryson, Arthur E.; et al1 Jan. 1995 176 p
Report No.(s): (NIPS–96–33241) Avail: Univ. Microfilms Order No. DA9516871

This dissertation determines control input histories for flying 3–D precision aerobatic and minimum time 180 deg turning maneuvers using inverse–control and optimization methods. Inverse control involves determining the input histories that produce the desired output histories. Choosing cylindrical coordinates for the position vector and spherical coordinates for the velocity vector yields very simple inverse solutions for most of the standard aerobatic maneuvers. The inverse solutions are nonlinear feedback laws i.e. one finds the controls as functions of the states and parameters of the maneuver. Two coordinate systems are used. The first treats motions along a horizontal helix, which includes barrel rolls, loops, Immelman turns, and split–S maneuvers. The second treats motions along a vertical helix, which includes steep turns, Chandelles, and wing–overs. In some cases, the inverse control histories or secondary output histories (e.g. normal load factor) may violate constraints, and/or the final states may be far from those desired. Optimal control methods may be used to modify the inverse control histories to satisfy the constraints at the expense of small deviations from the desired path. The dynamic model used has six states (three position, three velocity) with thrust, angle of attack, and bank angle as the control variables. There are bounds on the maximum angle of attack, thrust, and normal load factor. This dissertation also presents numerical results for loop, barrel roll, and minimum time turning maneuvers with three different sets of terminal conditions for an F–4H aircraft. The results of this study could be used in evaluation of pilot performance and in improving pilot training.
Dissert. Abstr.
Aircraft Maneuvers; Angle of Attack; Pilot Performance; Pilot Training; Spherical Coordinates; Thrust;

N96–22331*# California Univ., Los Angeles, CA.
A study of aeromechanical problems with active controls Final Report, 15 Nov. 1987 – 30 Sep. 1994
Friedmann, Peretz P.; et al30 Sep. 1994 4 p
Contract(s)/Grant(s): (NAG2–477)
Report No.(s): (NASA–CR–200213; NAS 1.26:200213; NIPS–96–08365) Avail: CASI HC A01/MF A01

The principal accomplishments, under the grant were the development of the first sophisticated aeroelastic simulation of higher harmonic control (HHC) using time domain aerodynamics. The principal finding in this study was that vibration reduction in hingeless rotors using HHC is much more difficult than in articulated rotors. In addition, the first rotor/flexible fuselage model including HHC was developed. A four bladed hingeless rotor, with nonlinear coupled flap–lag–torsional dynamics was combined with a flexible fuselage represented by four bending and two torsional modes. The principal findings of this study were: vibration reduction at the hub due to HHC is not equivalent to acceleration reduction at specific locations in the flexible fuselage; simultaneous reduction of hub vibratory loads and fuselage acceleration requires a combination of 2, 3, 4, and 5/rev. pitch inputs in the rotating reference frame.
CASI
Rigid Rotors; Rotary Wing Aircraft; Vibration Damping; Vibratory Loads;

N96–23145*# Lockheed Martin Engineering and Sciences Co., Hampton, VA.
Performance Validation of Version 152.0 ANSER Control Laws for the F–18 HARV
Messina, Michael D.; et al1 Jan. 1996 176 p
Contract(s)/Grant(s): (NAS1–19000; RTOP 505–68–30–05)
Report No.(s): (NASA–CR–198250; NAS 1.26:198250; NIPS–96–39657) Avail: CASI HC A09/MF A02

The Actuated Nose Strakes for Enhanced Rolling (ANSER) Control Laws were modified as a result of Phase 3 F/A–18 High Alpha Research Vehicle (HARV) flight testing. The control law modifications for the next software release were designated version 152.0. The Ada implementation was tested in the Hardware–In–the–Loop (HIL)

simulation and results were compared to those obtained with the NASA Langley batch Fortran implementation of the control laws which are considered the 'truth model.' This report documents the performance validation test results between these implementations for ANSER control law version 152.0.
Author
Ada (programming Language); F–18 Aircraft; Lateral Control; Longitudinal Control; Research Aircraft;

N96–23230*# National Aerospace Lab., Tokyo (Japan).
Inverse Dynamics Control for Aircraft Take Off and Landing in Windshear
Wang, Lixin; et al1 Apr. 1995 16 p (ISSN 0389–4010)
Report No.(s): (NAL–TR–1274T; NIPS–96–36119) Avail: CASI HC A03/MF A01

This paper is concerned with the guidance of an aircraft flight in the presence of windshear. Based on following a nominal approach path relative to the ground, and subject to a minimum airspeed constraint, two guidance laws are synthesized by inverse dynamics technique for takeoff and landing respectively. Simulation tests are performed in a six–degree–of–freedom flight simulator for different windshear histories and different flight conditions, these results illustrate that the controlled aircraft could takeoff and safely and follow the nominal landing path approximately in windshear, and the designed robust controllers are insensitive to both external windshear disturbance and the model parameters variation with change in flight conditions. The different results between manual operations and autopilot control for against windshear are also compared.
Author
Aircraft Control; Aircraft Landing; Flight Control; Inverse Kinematics; Wind Shear;

N96–23247*# National Aerospace Lab., Tokyo (Japan).
H(sub infinity) Control for Aircraft Take off in Windshear
Wang, Lixin; et al1 Jul. 1995 12 p (ISSN 0389–4010)
Report No.(s): (NAL–TR–1273T; NIPS–96–36117) Avail: CASI HC A03/MF A01

Results are presented from an application of the most recently developed H(sub infinity) control design methodology to a stabilizing controller for an aircraft during take off in a windshear. The emphasis is on the formulation of H(sub infinity) optimal control synthesis problem in the state space. Simulation tests are performed in a six degree–of–freedom flight simulator for different windshear histories and different takeoff conditions, these results demonstrate that the controlled aircraft could take off in windshear safely, and the designed controller provides stability robustness to both external windshear disturbance as well as the model parameters variation with changes in flight conditions.
Author
Aircraft Control; Aircraft Stability; Optimal Control; Wind Shear;

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.

N96–21640*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Mach–6 Integrated Systems Tests of the NASA Lewis Research Center Hypersonic Tunnel Facility
Thomas, Scott R.; Woike, Mark R.; and Pack, William D.; et al1 Jan. 1996 18 p Presented at 1995 Airbreathing Propulsion Subcommittee Meeting, Tampa, FL, United States, 5–8 Dec. 1995
Report No.(s): (NASA–TM–107083; E–9960; NAS 1.15: 107083; NIPS–96–36145) Avail: CASI HC A03/MF A01

This report documents the results for a series of 15 Integrated Systems Tests which were conducted at the NASA Lewis Research Center's Hypersonic Tunnel Facility (HTF) with test conditions simulating up to Mach–6 flight conditions. Facility stagnation conditions up to 3050 R and 1050 psia were obtained with typical test times of 20 to 45 sec. The HTF is a free–jet, blowdown propulsion test facility that can simulate up to Mach–7 flight conditions with true air composition. Mach–5, –6, and –7 facility nozzles, each with a 42–in. exit diameter, are available. The facility, without modifications, can accommodate models approximately 10 ft long. Nitrogen is heated using a graphite core induction heater, ambient oxygen is added downstream to produce simulated air. The combination of clean–air, large–scale, and Mach–7 capabilities is unique to the HTF. Reactivation of the HTF was accomplished between 1990 and May 1994. This activity included refurbishing the graphite heater, the steam generation plant, the gaseous oxygen system, and all control systems. All systems were checked out and recertified, and environmental systems were upgraded to meet current standards. The data systems were also upgraded to current standards and a communication link with NASA–wide computers was added. In May 1994 a short–duration integrated systems test (approx. 2 sec) was conducted to verify facility operability. This test activity identified several modifications and corrections to the HTF which were required to improve overall facility performance. From the end of 1994 to April 1995 these items were completed, and the 3000–ft long, 30–in.–diam. steam supply line was insulated to improve system efficiency and allow operation in all weather conditions. Through May 1995 the test series which will be described in this report were conducted. During this activity, significant test experience was gained. The graphite storage heater was used at up to the maximum operating temperature of 5000 R, several improvements were made to various facil-

ity systems and test procedures, and some operational problems experienced in the past were resolved (i.e., elimination of water backflow during shutdown). The HTF was operated with significant run times for the first time since being reactivated, and for the first time in more than 20 yr. Overall this test program resulted in smooth, relatively trouble–free facility operation and served to successfully demonstrate the operating capability and reliability of the HTF.
Author
Flight Simulation; Hypersonic Speed; Hypersonic Wind Tunnels; Performance Tests; System Effectiveness; Systems Integration; Test Facilities;

N96–21663*# NYMA, Inc., Brook Park, OH.
High Response Dew Point Measurement System for a Supersonic Wind Tunnel Final Report
Blumenthal, Philip Z.; et al1 Feb. 1996 16 p Presented at 42nd International Instrumentation Symposium, San Diego, CA, United States, 5–9 May 1996
Contract(s)/Grant(s): (NAS3–27186; RTOP 505–62–82)
Report No.(s): (NASA–CR–198453; E–10111; NAS 1. 26: 198453; NIPS–96–35670) Avail: CASI HC A03/MF A01

A new high response on–line measurement system has been developed to continuously display and record the air stream dew point in the NASA Lewis 10 x 10 supersonic wind tunnel. Previous instruments suffered from such problems as very slow response, erratic readings, and high susceptibility to contamination. The system operates over the entire pressure level range of the 10 x 10 SWT, from less than 2 psia to 45 psia, without the need for a vacuum pump to provide sample flow. The system speeds up tunnel testing, provides large savings in tunnel power costs and provides the dew point input for the data–reduction subroutines which calculate test section conditions.
Author
Air Flow; Dew Point; Hygrometers; On–line Systems; Real Time Operation; Supersonic Wind Tunnels;

N96–22504* George Washington Univ., Washington, DC.
An automated maintenance management system for international airports Ph.D. Thesis
Khozeimeh, Issa D.; et al1 Jan. 1994 297 p
Report No.(s): (NIPS–96–33276) Avail: Univ. Microfilms Order No. DA9512248

This study was undertaken to develop and document the functional requirements for an automated maintenance management system (AMMS) suitable for international airports. The need for such a system was identified in 1990 by the Maintenance Committee of the Airport Association Council International (AACI). As an integral part of this research, an in–depth investigation was made concerning the availability, adaptability, and feasibility of modifying any commercially available AMMS that might have been developed for a similarly sized industry. To develop the detailed requirements for the maintenance management module, a formal questionnaire was created and distributed worldwide to international airports. The survey inquired about the automation level of their maintenance management efforts, the specific requirement for various modules, and management information reports. To validate the questionnaire, a pilot study was conducted by reviewing the questions during interviews with personnel at other U.S. airports. Consequently, the final questionnaire was modified and sent to international airports worldwide. The survey results were analyzed using descriptive statistical techniques including frequency distribution of responses; central tendency and dispersion measures such as mean, standard deviation, and range of criterion variable; and the maintenance management functional requirements developed. Analysis of the returned questionnaire identified several factors considered minimum requirements for the AMMS and for types of management information reports that would contribute to more efficient and effective operation. The respondents were also asked to provide additional comments concerning maintenance procedures at their facilities and possible improvement in particular areas. These participants were commonly concerned about management budgetary problems, staff and equipment management problems, inadequate computer systems and software for maintenance management applications, inadequate training on current management systems, inadequate level of standardized training for maintenance staff, imbalance of funds allocation, improper methods for evaluating existing equipment depreciation, and difficulties in upgrading maintenance management systems to interface with the older fragmented systems in place. The study also examined organizational structure of the Engineering and Maintenance Division of Washington Dulles International Airport and compared it with airports of similar size as well as with other complex maintenance organizations. This examination revealed a need for realignment of various maintenance branches for more effective management in allocation of labor and resources.
Dissert. Abstr.
Aircraft Maintenance; Airports; Management Information Systems; Surveys; User Requirements;

N96–22698* Dayton Univ., OH.
Design in aeroelastically scaled wind tunnel models using sensitivity–based parameter identification Ph.D. Thesis
French, Richard Mark; et al1 Jan. 1993 220 p
Report No.(s): (NIPS–96–07614) Avail: Univ. Microfilms Order No. DA9333076

Designing aeroelastically scaled wind tunnel models is a common task in flight vehicle development programs. Model design methods, however, often rely heavily on repeated analysis, experience and intuition. This work presents a procedure which uses numerical optimization techniques to automate the model design process. The proposed method

offers many advantages over current ones. The model structure can be made as complex as necessary. Also, no unrealistic structural assumptions are required of the designer; any structure which can be discretized using a finite element approximation may be considered. The method uses readily available flexibility and modal response data from the full scale structure to size elements in the wind tunnel model structure automatically, eliminating repeated analysis. Several variations on the optimization–based approach are evaluated here using a low–aspect ratio fighter wing as a sample problem. Desired flutter characteristics are compared to those calculated for the final model design. To verify the numerical work, a sample model structure has been fabricated and tested using laser metrology techniques. Results of static and modal tests compare well with numerical predictions.
Dissert. Abstr.
Aeroelasticity; Aircraft Models; Finite Element Method; Parameter Identification; Scale Models; Wind Tunnel Models;

N96–22757*# NYMA, Inc., Brook Park, OH.
Enhancing the Capabilities of NASA Lewis' 8x6/9x15 Wind Tunnel Complex Through Drive System Modifications Final Report
Becks, Edward A.; et al1 Feb. 1996 20 p Presented at 42nd International Instrumentation Symposium, San Diego, CA, United States, 5–9 May 1996
Contract(s)/Grant(s): (NAS3–27186; RTOP 505–62–82)
Report No.(s): (NASA–CR–198455; NAS 1.26:198455; E–10121; NIPS–96–34680) Avail: CASI HC A03/MF A01

This paper describes the conclusions to date derived from a series of activities that began in January 1995 to determine the potential power savings from running a three motor tunnel drive system on less than a full complement of three motors. This paper also discusses the now proven fact that one motor's minimum operating speed in this type of drive train is inherently slower than the minimum speed of three motors running at the same set of operating characteristics, as well as the benefits derived from this method of operation. The tunnel drive consists of three mechanically–coupled 29,000 HP wound rotor induction motors driving an axial flow compressor. Liquid rheostats are used to vary the impedance of the individual motor rotor circuits, thus varying the speed of the drive system. The resistance of the electrolyte in the rheostat tanks is inversely proportional to temperature. This paper discusses the manipulation of these factors to enhance the overall operation of the facility.
Author
Control Systems Design; Mechanical Drives; Subsonic Flow; Subsonic Wind Tunnels; Supersonic Wind Tunnels; Wind Tunnel Drives;

N96–22848*# Aircraft Research Association Ltd., Bedford (England).
Reinventing T and E Internationally: The View from an Independent European Wind Tunnel
Green, J. E.; et al1 Oct. 1995 22 p Presented at ITEA 1995 Symposim, Huntsville, AL, United States, 2–5 Oct. 1995
Report No.(s): (ARA–TM–418; NIPS–96–39309) Avail: CASI HC A03/MF A01

The paper discusses the current status and future outlook for wind tunnel testing from an international perspective. More particularly, it presents the view of an independent, commercial, European wind tunnel operator. The technical, economic, and political factors influencing the future evolution of wind tunnel testing are considered and the challenge from computational fluid dynamics and the importance of continued investment in facility enhancement are highlighted. The present and future balance between supply and demand is discussed and efforts by the European research establishments to deal with problems of overcapacity are noted. Finally, an appeal is made to accelerate progress towards an end state, which the author believes to be inevitable, in which most wind tunnel testing is done in facilities which are free of government restraint and operate without government subsidy.
Author
Commerce; Constraints; Economic Factors; Europe; Politics; Technological Forecasting; Technology Assessment; Wind Tunnels;

N96–23150*# Federal Aviation Administration, Oklahoma City, OK. Civil Aeromedical Inst.
Qualification Guidelines for Personal Computer–Based Aviation Training Devices: Instrument Training Final Report
Williams, Kevin W.; et al1 Feb. 1996 80 p
Report No.(s): (DOT/FAA/AM–96/8; NIPS–96–39527) Avail: CASI HC A05/MF A01

This is a report of the analytical development of qualification guidelines for personal computer–based aviation training devices (PCATD's) for use in instrument flight training. The report includes a task analysis of instrument flight tasks, along with baseline and task–specific guidelines that were developed as a result of the analysis. In addition a PCATD qualification tool is presented in the appendix for use in approving a Part 141 flight school curriculum that incorporates a PCATD for use as a ground training aid. The purpose of this paper is to provide the reader with an understanding of the process and reasoning behind the development of the PCATD qualification guidelines.
Author

Aircraft Control; Flight Instruments; Flight Training; Pilot Performance; Pilot Training; Training Devices;

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.

N96–22697* Michigan Univ., Ann Arbor, MI.
Optimal trajectories of reentry vehicle by serial and asymptotic matching Ph.D. Thesis
Han, Dongsuk; et al 1 Jan. 1993 115 p
Report No.(s): (NIPS–96–07616) Avail: Univ. Microfilms Order No. DA9332078

With the advent of aeroassist technology for orbital transfers, it is of interest to have explicit optimal control laws for aerodynamic control during atmospheric passage of the space vehicle. Due to the nonlinearity of the equations of motion the exact analytic solutions are not available. Previously, analytic solutions were available only for the simplified problems, usually separated into two different regions namely, for the orbital flight and atmospheric flight. In this thesis, an analytic optimal control law uniformly valid in both regions is obtained. The differential equations for the optimal lift control coupled with the state equations can be fully integrated analytically by neglecting either the gravity or the aerodynamic force terms. A serial matching technique for the skip trajectory is proposed using the two controls obtained in these two separate regions. The switching condition between the two controls is derived and the solution is compared with the exact solution for a sample trajectory. This technique shows a good estimation of the cost function and provides a good physical explanation of the lift control as well. A matched asymptotic expansion method is used, coupled with the full knowledge of the physical properties of the exact integrals of motion, to derive the explicit optimal control laws for lift and bank modulation during the entry phase. The results from this control strategy by the matched asymptotic expansion method are compared with the exact numerical solutions for a variety of skip and glide entry trajectories. Its performance is excellent in the sense that the control exhibits the same characteristic behavior as the exact solution and it also leads to nearly the same cost function. Dissert. Abstr.
Asymptotic Series; Differential Equations; Equations of State; Lift; Optimal Control; Reentry Vehicles; Series Expansion; Trajectory Control; Transfer Orbits;

11 CHEMISTRY AND MATERIALS

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

N96–21485* Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.
Optimization of composite structures by genetic algorithms Ph.D. Thesis
leriche, Rodolphe Gilles; et al1 Jan. 1994 214 p
Report No.(s): (NIPS–96–33240) Avail: Univ. Microfilms Order No. DA9514632

The design of composite laminated panels is a combinatorial problem when the orientation of the fibers in each layer is restricted to a discrete pool of angles. Additionally, composite laminates often have many optimal and near–optimal designs, and the designer may benefit by knowing many of those designs. Genetic algorithms are well suited for laminate design because they can handle the combinatorial nature of the problem and they permit the designer to obtain many near– optimal designs. However, their computational cost is high for most structural optimization problems. This work describes several attempts to reduce the cost of optimizing composite laminates using genetic algorithms. First, the use of a genetic algorithm to maximize the buckling load of a fixed thickness composite laminate is studied. Various genetic parameters, including population size, probability of mutation, and probability of crossover are optimized by numerical experiments. A new genetic operator–stack swap–is proposed and shown to be effective in reducing the cost of the optimization. Second, the genetic algorithm is revised and improved for minimum thickness design of composite laminated plates. The influence on the genetic search of the penalty functions enforcing failure constraints is studied. Combining fixed and proportional penalty functions is found to be the most efficient strategy. Improved selection, mutation, and stack swap operators are proposed. The use of an operator called scaling mutation that projects designs towards the feasible domain is investigated. The improvements in the genetic algorithm are shown to reduce the average price of the search by more than 50% Next, the improved genetic algorithm for minimum thickness laminate design is applied to a more complex wing box–beam optimization problem. Tuning the genetic algorithm on this problem shows that, because the maximum length of a search is limited, the optimal population size does not grow with the size of the design space. If the probability of applying stack swap is reduced with the number of independent laminates in the wing box, stack swap enhances the performance of the genetic search on the wing box–beam problem. Finally, the possibility of running many searches is investigated. It is empirically shown that several short searches can be more efficient than a long one, especially when high levels of reliability are required. An example is given where a genetic algorithm is

specifically modified for better efficiency in the context of repeated short runs. A procedure is studied that enables predicting reliability at later stages of the search.
Dissert. Abstr.
Composite Structures; Design Analysis; Genetic Algorithms; Laminates; Optimization;

N96–21597* Michigan Univ., Ann Arbor, MI.
An experimental study of a generic supersonic combustor Ph.D. Thesis
Yoon, Youngbin; et al 1 Jan. 1994 149 p
Report No.(s): (NIPS–96–34464) Avail: Univ. Microfilms Order No. DA9501073

The overall objectives of the present study were to measure the general properties of a hydrogen jet flame in supersonic air stream, and to compare the supersonic results to subsonic trends and a one dimensional analysis. The general properties measured were blowout stability limits, heat release distributions, thermal choking limits, stagnation pressure loss, static pressure profiles, and NO(x) emission index. While supersonic flame properties were of primary interest, subsonic flame blowout limits and NO(x) levels also were measured for comparison. A supersonic (Mach 2.2) combustor was designed which provided a wide range of conditions, including stagnation temperature from 294 K to the auto–ignition temperature of 900 K. It was found that the flame blowout curves display two distinct stable regions which are bounded by the far–field blowout limit and nearfield blowout limit. Supersonic flame stability requires fuel tube lip thickness and sufficient stagnation temperature to extend the nearfield blowout limit curve into the supersonic regime. It was determined from the data and a one–dimensional analysis that a supersonic flame has a heat release distribution with a log–normal shape. Using this lognormal shape, the one–dimensional supersonic analysis does adequately predict the measured loss of stagnation pressure and the amount of heat addition that causes the onset of thermal choking. Measurements quantify the wall divergence half angle that is required to avoid thermal choking. The NO(x) emission index was measured for numerous subsonic and supersonic cases. In the subsonic cases, the global residence time and the deviations from chemical equilibrium (i.e. the Damkohler number) were varied and the resulting effects were compared with the thermal NO(x) theory. In particular, a unique jet flame was studied that is composed of helium–diluted hydrogen fuel, and the NO(x) data of this helium–diluted hydrogen flame was found to be correlated successfully by the use of a Damkohler number. In the supersonic cases, the global residence time was varied for a hydrogen jet diffusion flame and it was found that the measured NO(x) emission index data increased with the global residence time, which is the same trend as that observed in the subsonic cases.
Dissert. Abstr.
Combustion Chambers; Diffusion Flames; Flame Stability; Gas Jets; Hydrogen Fuels; Jet Flow; Supersonic Combustion; Supersonic Flow;

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.

N96–21492* California Univ., Davis, CA.
Development of a finite–difference time–domain solver for Maxwell's equations with application to radar signature prediction Ph.D. Thesis
Vinh, Hoang; et al1 Jan. 1994 113 p
Report No.(s): (NIPS–96–33256) Avail: Univ. Microfilms Order No. DA9521529

The development and application of a finite–difference time–domain solver for Maxwell's equations are presented. The work described here is the result of a research effort aimed at developing an accurate and efficient numerical method for simulating electromagnetic scattering from arbitrarily–shaped objects in order to predict their radar signatures. The current algorithm solves the time–dependent Maxwell's equations on non–staggered, body–fitted grids using the explicit, second–order accurate Lax–Wendroff scheme which has been developed and used extensively in Computational Fluid Dynamics (CFD). This formulation offers the advantages of the time–domain approach to modeling electromagnetic scattering while avoiding the drawbacks associated with the use of staggered Cartesian grids employed by the traditional FDTD (Finite Difference Time Domain) method. In addition, the use of a CFD–based finite–difference scheme allows a synergistic approach to solve the multidisciplinary problem of shape design for aerodynamic efficiency and low observability. The finite–difference formulation, including the implementation of boundary conditions for scattering problems, and procedures for transforming field solutions of Maxwell's equations into radar cross–section (RCS) are described in detail. The accuracy of the Maxwell solver is demonstrated through several two– and three–dimensional validation studies which include both standard test cases (infinite circular cylinder and sphere) and test cases involving more realistic geometries (airfoil and aircraft wing). The capability of the Maxwell solver as a design and analysis tool is also illustrated through several two–and three–dimensional parametric studies which show the effects of shaping on the radar signatures of airfoils and aircraft wings.
Dissert. Abstr.
Design Analysis; Electromagnetic Scattering; Finite Difference Theory; Maxwell Equation; Radar Signatures; Time Dependence;

N96–21509* Illinois Univ., Urbana–Champaign, IL.
Development of an improved multi–dimensional upwind scheme for Euler/Navier–Stokes computations Ph.D. Thesis
Huang, Weicheng; et al1 Jan. 1994 262 p
Report No.(s): (NIPS–96–33387) Avail: Univ. Microfilms Order No. DA9512405

Modern upwind schemes employ an upwind–biased stencil to solve covective terms in order to satisfy the domain of dependence of the hyperbolic system. They demonstrate a superior capability of capturing flow discontinuities in one–dimensional computations. However, in multi–dimensional computations, the high resolution of upwind schemes might be lost, due to the direct extension of the one–dimensional analogy, which is not compatible with flow physics under such circumstances. The primary goal of present research is to improve the solution accuracy of conventional upwind schemes for multi–dimensional calculations. The way the upwind schemes are applied to the multi–dimensional computations is responsible for the degrading of the solution resolution. That being said, most of the conventional upwind schemes are applied in a direction–split manner, specifically speaking, a one–dimensional solver is applied to each spatial dimension separately. This method not only ignores the interaction between different coordinate directions but also applies the upwind stencil to the grid–aligned direction, which violates the multi–dimensional physics when discontinuities are not aligned with the grid. This problem can be resolved by employing a more physically meaningful multi–dimensional upwind solver. The present research employs a true multi–dimensional wave model to the flux–difference–splitting scheme. In addition, a multi–dimensional reconstruction is developed to formulate the left and right states of the cell face. These reconstructed states are then used to calculate various waves propagating along the dominate upwind direction. The current aproach is applied to two–dimensional Euler calculations as well as to the Navier–Stokes computations. Results of the present study indicate that this approach is highly promising in respect to improve solution accuracy. Specifically, through the application of the current method, the resolution of shocks is improved over the first–order grid–aligned scheme, especially when the discontinuities are oblique over the grid. Moreover, the odd–even decoupling phenomena, such as those in the results of the Navier–Stokes computation of the transonic airfoil flow, are eliminated. In addition, the three–dimensional results demonstrate that although twice as many grids are used, the first–order grid–aligned scheme can not provide the same resolution as the present method. However, since nonlinear feedback of the multi–dimensional wave model degrades the convergence, additional research must be conducted to control the nonlinear feedback of the wave model in order to accelerate the convergence. Furthermore, due to its oscillatory nature, multi–dimensional limiters are required for the development of the high order multi–dimensional wave model. Dissert. Abstr.
Airfoils; Computational Grids; Difference Equations; Feedback Control; Fluid Dynamics; Flux Difference Splitting; Navier–stokes Equation; Transonic Flow;

N96–21517* Ohio State Univ., Columbus, OH.
Stability analysis of three–dimensional boundary layers with parabolized stability equations Ph.D. Thesis
Wang, Mengjie; et al 1 Jan. 1994 200 p
Report No.(s): (NIPS–96–09006) Avail: Univ. Microfilms Order No. DA9505321

The hydrodynamic stability of flows over a rotating disk and a swept wing are investigated. To give a clear picture of the transition, the aim of this study is to relate a variety of experimental results to several theories of stability. For the rotating disk flow, the classical linear stability theory is applied to obtain the basic structure of primary instability. Nonparallel effects are analyzed using local expansions in the streamwise direction by considering their hierarchical orders. The neutral curve for stationary disturbances is computed in each approach. Since the local analysis is confined to a fixed location and the upstream effects do not influence the calculation, the approach of the parabolized stability equations (PSE) is employed to overcome these shortcomings. The PSE study provides the spatial streamwise evolution of the disturbance which yields good understanding of the stability phenomena. The wave packet computation produces a more realistic instability process. The results of this study provide understanding of the transition mechanism for the rotating disk flow. The stability and receptivity characteristics of the low–speed flow over a swept wing are investigated in curvilinear coordinates with the PSE approach. The untapered wing has a chord of 1.83 m and a sweep angle of 45 degrees. The basic flows are computed using the Kaups–Cebeci boundary layer code. The analysis covers the first three phases of boundary layer transition through crossflow vortices: receptivity, linear growth, and nonlinear evolution. The calculations provide the linear stability characteristics including the neutral curve and the effects of curvature, wavenumber, and frequency. The computed neutral point for the onset of instability and the frequency effects agree with experimental observations. The nonlinear analysis shows that stationary and traveling crossflow vortices approach equilibrium states of finite amplitudes. The equilibrium state is largely independent of the initial amplitude. Nonlinear effects are found to play an important role in the transition process. The study of the interaction between steady and unsteady modes yields an explanation for experimental results at different free–stream turbulent levels. The receptivity study shows the influence of different roughness locations,

spacings between roughness elements, and frequencies of unsteady excitations on transition tendencies.
Dissert. Abstr.
Boundary Layer Equations; Boundary Layer Flow; Boundary Layer Stability; Boundary Layer Transition; Rotating Disks; Swept Wings; Three Dimensional Boundary Layer;

N96–21602* Washington State Univ., Pullman, WA.
Computer and Optical Simulations of Radar Imaging Systems Ph.D. Thesis
Andrews, Aaron Keith; et al1 Jan. 1994 205 p
Report No.(s): (NIPS–96–34662) Avail: Univ. Microfilms Order No. DA9512728

A method for simulating radar range profiles from computer models of three–dimensional conducting targets is explored. The backscattered fields from a target, used to form its profile, are approximated using physical optics. Ray tracing is employed to determine the illuminated target surface required by physical optics. A database of simulated range profiles is created from computer models of five commercial aircraft. Simulated radar range profiles from five different commercial aircraft models are used to investigate an aircraft identification algorithm based upon correlation filters. The effects of correlation filter width, multiple profiles, and target aspect information are examined. Reliable identification appears possible if both narrow correlation filters and several profiles are used in an identification. Additive system noise has little impact on the identification rate until the noise fluctuations become comparable to the inherent speckle fluctuations. An iterative method for focusing inverse synthetic aperture radar (ISAR) images is studied using the database of simulated aircraft profiles. Blurring in ISAR images occurs when the target aspect does not vary linearly in time. Nine different target aspect scenarios are examined for each of the five aircraft. In most of the cases tested, the iterative method correctly, or nearly correctly, focuses the ISAR image even in presence of significant amounts of additive noise. An experimental laser radar is constructed and tested which is designed to simulate delay–Doppler images from asteroids. Delay–Doppler data from this system will be used to test asteroid shape reconstruction methods. This laser radar is based upon a Michelson interferometer and uses a short coherence length laser diode to achieve a range resolution of 0.1 mm on targets up to 1.5 cm in diameter. The effectiveness of this system is demonstrated by examining a sphere, bolt, and two small stones.
Dissert. Abstr.
Aircraft Detection; Commercial Aircraft; Computerized Simulation; Imaging Techniques; Optical Radar; Radar Imagery; Radar Targets; Radar Tracking; Ray Tracing; Synthetic Aperture Radar;

N96–21624* Oklahoma Univ., Norman, OK.
Oblique detonation waves, with application to oblique detonation wave engines, and comparison of hypersonic propulsion engines Ph.D. Thesis
Ashford, Sandra Anderson; et al1 Jan. 1994 273 p
Report No.(s): (NIPS–96–33377) Avail: Univ. Microfilms Order No. DA9513753

The flow field of an oblique detonation wave is examined. A Taylor wave is found to exist behind the detonation when operating in the weak, underdriven regime. This regime, which does not violate the second law of thermodynamics, has previously not been recognized by the aerospace community. Unsteady, normal detonations are also examined, since experimental evidence of the Taylor wave in this case provides the basis of the Taylor wave for steady oblique detonations. The oblique detonation wave is applied to hypersonic propulsion, the oblique detonation wave engine (ODWE). A calculation technique is described that determines the performance of the ODWE and comparable diffusive scramjet engines. Diffusive scramjet performance is predicted for both constant–area and constant–pressure combustion. The calculations are performed with a calorically imperfect gas for both frozen and equilibrium flow through the subsequent expansive flow field. Performance parameters are calculated for H2 and CH4, a range of free-stream Mach numbers and fuel flow rates, and various inlet configurations. Results are for specific thrust, a thrust coefficient, and transverse engine size. The ODWE analysis shows the importance of including the Taylor wave, done here for the first time. An ODWE gives comparable performance to diffusive engines, and offers several advantages. The more compact size of the ODWE produces less drag, and less cooling is required. It offers considerably more design flexibility, since the wedge angle that generates the detonation can be varied to provide optimum performance over an entire flight envelope. Moreover, wedge angle variation allows easy restart capability for the ODWE.
Dissert. Abstr.
Detonation Waves; Hypersonic Flight; Specific Impulse; Supersonic Combustion Ramjet Engines;

N96–21641*# Textron Bell Helicopter, Fort Worth, TX.
Feasibility Study of a Rotorcraft Health and Usage Monitoring System (HUMS): Usage and Structural Life Monitoring Evaluation Final Report
Dickson, B.; Cronkhite, J.; Bielefeld, S.; Killian, L.; and Hayden, R.; et al1 Feb. 1996 72 p
Contract(s)/Grant(s): (NAS3–25455; DTFA03– 89– A–00019; RTOP 505–62–36; DA PROJ. 1L1–62211–A–47–A)
Report No.(s): (NASA–CR–198447; E–10093; NAS 1.26: 198447; ARL–CR–290; DOT/FAA/AR–95/9; NIPS–96–34689) Avail: CASI HC A04/MF A01

The objective of this study was to evaluate two techniques, Flight Condition Recognition (FCR) and Flight Load Synthesis (FLS), for usage monitoring and assess the potential benefits of extending the retirement intervals of life–lim-

ited components, thus reducing the operator's maintenance and replacement costs. Both techniques involve indirect determination of loads using measured flight parameters and subsequent fatigue analysis to calculate the life expended on the life–limited components. To assess the potential benefit of usage monitoring, the two usage techniques were compared to current methods of component retirement. In addition, comparisons were made with direct load measurements to assess the accuracy of the two techniques. The data that was used for the evaluation of the usage monitoring techniques was collected under an independent HUMS Flight trial program, using a commercially available HUMS and data recording system. The usage data collect from the HUMS trial aircraft was analyzed off–line using PC–based software that included the FCR and FLS techniques. In the future, if the technique prove feasible, usage monitoring would be incorporated into the onboard HUMS.
Author
Aircraft Reliability; Component Reliability; Fatigue (materials); Fatigue Life; Feasibility Analysis; Helicopter Performance; Systems Health Monitoring;

N96–21654*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Progress in Modeling of Laminar to Turbulent Transition on Turbine Vanes and Blades
Simon, Frederick F.; and Ashpis, David E.; et al1 Mar. 1996 32 p Presented at International Conference on Turbulent Heat Transfer, San Diego, CA, United States, 10–15 Mar. 1996
Report No.(s): (NASA–TM–107180; NAS 1.15:107180; E–10143; NIPS–96–35610) Avail: CASI HC A03/MF A01

The progress in modeling of transition on turbine vanes and blades performed under the sponsorship of NASA Lewis Research Center is reviewed. Past work in bypass transition modeling for accurate heat transfer predictions, show that transition onset can be reasonably predicted by modified k – epsilon models, but fall short of predicting transition length. Improvements in the predictions of the transition region itself were made with intermittency models based on turbulent spot dynamics. Needs and proposals for extending the modeling to include wake passing and separation effects are outlined.
Author
Boundary Layer Flow; Boundary Layer Transition; Gas Turbine Engines; Reynolds Number; Turbine Blades; Turbulence Models; Vanes;

N96–21674*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Research Strategy for Modeling the Complexities of Turbine Heat Transfer
Simoneau, Robert J.; et al1 Mar. 1996 30 p Presented at International Conference on Turbulent Heat Transfer, San Diego, CA, United States, 10–15 Mar. 1996
Report No.(s): (NASA–TM–107161; NAS 1.15:107161; E–10109; NIPS–96–35617) Avail: CASI HC A03/MF A01

The subject of this paper is a NASA research program, known as the Coolant Flow Management Program, which focuses on the interaction between the internal coolant channel and the external film cooling of a turbine blade and/or vane in an aircraft gas turbine engine. The turbine gas path is really a very complex flow field. The combination of strong pressure gradients, abrupt geometry changes and intersecting surfaces, viscous forces, rotation, and unsteady blade/vane interactions all combine to offer a formidable challenge. To this, in the high pressure turbine, we add the necessity of film cooling. The ultimate goal of the turbine designer is to maintain or increase the high level of turbine performance and at the same time reduce the amount of coolant flow needed to achieve this end. Simply stated, coolant flow is a penalty on the cycle and reduces engine thermal efficiency. Accordingly, understanding the flow field and heat transfer associated with the coolant flow is a priority goal. It is important to understand both the film cooling and the internal coolant flow, particularly their interaction. Thus, the motivation for the Coolant Flow Management Program. The paper will begin with a brief discussion of the management and research strategy, will then proceed to discuss the current attack from the internal coolant side, and will conclude by looking at the film cooling effort – at all times keeping sight of the primary goal the interaction between the two. One of the themes of this paper is that complex heat transfer problems of this nature cannot be attacked by single researchers or even groups of researchers, each working alone. It truly needs the combined efforts of a well–coordinated team to make an impact. It is important to note that this is a government/industry/university team effort.
Author
Coolants; Film Cooling; Gas Turbine Engines; Heat Transfer; Internal Flow; Turbines;

N96–21700* Illinois Univ., Urbana–Champaign, IL.
Direct Numerical Simulations of Separated and Separated–Reattaching Flows on Massively Parallel Processing Computers Ph.D. Thesis
Najjar, Fady Michel; et al1 Jan. 1994 321 p
Report No.(s): (NIPS–96–34393) Avail: Univ. Microfilms Order No. DA9503282

Direct numerical simulations of separated–reattaching and separated flows have been performed on massively parallel processing computers. Two basic geometrical configurations have been studied: the separated–reattaching flow past a normal flat plate with an attached downstream splitter plate and the separated flow past a flat plate held normal to a uniform stream. A high–order finite–difference formulation on collocated grids has been developed to perform unsteady fluid flow simulations in rectangular geometries. The

numerical procedure is based on a fifth–order upwind–biased scheme for the convective terms and a fourth–order accurate stencil for the diffusive terms. A direct solver based on eigenvalue decomposition has been developed for the pressure–Poisson equation. A mixed Fourier–spectral/finite–difference formulation is used for the spanwise discretization, and a data–parallel algorithm has been developed for the CM–S. The performance of the algorithm has been evaluated on various grid sizes in model flow problems and for different partition sizes. The characteristics of the separated–reattaching flow have been investigated through two–dimensional simulations in the steady and unsteady regimes. The shedding mechanism is characterized by two major modes at Re = 250 and a single mode at Re = 375 and 500. Further, the instability of the separated shear layer is found to be consistent with inviscid theory. For the two–dimensional study of the separated flow past a normal flat plate, the time–mean flow quantities are observed to be over–estimated compared to the experiments. The time–mean drag coefficient is also over–predicted by a factor of up to 2. This is attributed to the high coherence of the vortices predicted by the two–dimensional simulations. Two interaction regions have been identified in the far wake for Re = 500 and 1000 and are observed to occur pseudo–periodically. Large–scale computations of the three–dimensional separated flow have also been carried out. The flow is seen to break down into smallscale structures and the spanwise development of these structures has been studied. Streamwise ribs and spanwise rolls are identified in the near wake through visualization techniques. The presence of these coherent structures corroborates the experimental observations and numerical calculations for mixing layers and wakes of circular cylinders. The time–mean velocities and Reynolds stresses are found to agree well with the experiments conducted at higher Reynolds numbers.
Dissert. Abstr.
Digital Simulation; Eigenvalues; Finite Difference Theory; Massively Parallel Processors; Poisson Equation; Three Dimensional Flow; Two Dimensional Models;

N96–22134*# Toledo Univ., OH. Dept. of Mechanical Engineering.
Development of a Prototype Simulation Executive with Zooming in the Numerical Propulsion System Simulation
Reed, John A.; and Afjeh, Abdollah A.; et al1 Jul. 1995 72p
Contract(s)/Grant(s): (NCC3–207)
Report No.(s): (NASA–CR–200613; NAS 1.26:200613; NIPS–96–35652) Avail: CASI HC A04/MF A01

A major difficulty in designing aeropropulsion systems is that of identifying and understanding the interactions between the separate engine components and disciplines (e.g., fluid mechanics, structural mechanics, heat transfer, material properties, etc.). The traditional analysis approach is to decompose the system into separate components with the interaction between components being evaluated by the application of each of the single disciplines in a sequential manner. Here, one discipline uses information from the calculation of another discipline to determine the effects of component coupling. This approach, however, may not properly identify the consequences of these effects during the design phase, leaving the interactions to be discovered and evaluated during engine testing. This contributes to the time and cost of developing new propulsion systems as, typically, several design–build–test cycles are needed to fully identify multidisciplinary effects and reach the desired system performance. The alternative to sequential isolated component analysis is to use multidisciplinary coupling at a more fundamental level. This approach has been made more plausible due to recent advancements in computation simulation along with application of concurrent engineering concepts. Computer simulation systems designed to provide an environment which is capable of integrating the various disciplines into a single simulation system have been proposed and are currently being developed. One such system is being developed by the Numerical Propulsion System Simulation (NPSS) project. The NPSS project, being developed at the Interdisciplinary Technology Office at the NASA Lewis Research Center is a 'numerical test cell' designed to provide for comprehensive computational design and analysis of aerospace propulsion systems. It will provide multi–disciplinary analyses on a variety of computational platforms, and a user–interface consisting of expert systems, data base management and visualization tools, to allow the designer to investigate the complex interactions inherent in these systems. An interactive programming software system, known as the Application Visualization System (AVS), was utilized for the development of the propulsion system simulation. The modularity of this system provides the ability to couple propulsion system components, as well as disciplines, and provides for the ability to integrate existing, well established analysis codes into the overall system simulation. This feature allows the user to customize the simulation model by inserting desired analysis codes. The prototypical simulation environment for multidisciplinary analysis, called Turbofan Engine System Simulation (TESS), which incorporates many of the characteristics of the simulation environment proposed herein, is detailed.
Derived from text
Computer Programming; Computerized Simulation; Concurrent Engineering; Engine Tests; Graphical User Interface; Propulsion System Configurations; Propulsion System Performance; Sequential Analysis;

N96–22150*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
Euler/Navier–Stokes flow computations on flexible configurations for stability analysis
Guruswamy, G.; and Tu, E.; et al12 Apr. 1995 9 p Presented

at 36th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, New Orleans, LA, United States, 10–12 Apr. 1995
Report No.(s): (NASA–TM–111253; NAS 1.15:111253; AIAA PAPER 95–1292; NIPS–96–07968) Avail: CASI HC A02/MF A01

Longitudinal dynamic stability derivatives required for design of aircraft are computed by using the state–of–the–art numerical methods for wing–body configurations. The flow is modeled using the Euler/Navier–Stokes equations with turbulence models and solved using an efficient finite–difference scheme suitable for patched structured grids. Computations are made at a flow regime that is beyond the limits of the current linear methods mostly used for computing stability derivatives. Flow conditions include shockwaves and viscous dominated vortical flows. Effect of Mach number and angle–of–attack on stability derivatives are demonstrated for a typical wing–body configuration. For the same configuration the effects of wing flexibility on the magnitude and phase angles of stability derivatives are also demonstrated.
Author
Aerodynamic Stability; Body–wing Configurations; Computational Fluid Dynamics; Longitudinal Stability; Navier–stokes Equation; Turbulence Models; Viscous Flow; Wings;

N96–22186*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Detecting Gear Tooth Fatigue Cracks in Advance of Complete Fracture
Zakrajsek, James J.; and Lewicki, David G.; et al1 Jan. 1996 18 p Presented at 1996 Technology Showcase on Integrated Monitoring, Diagnostics and Failure Prevention, Mobile, AL, United States, 22–26 Apr. 1996
Contract(s)/Grant(s): (DA PROJ. 1L1–62211–A–47–A)
Report No.(s): (NASA–TM–107145; E–10075; NAS 1.15: 107145; ARL–TR–970; NIPS–96–35618) Avail: CASI HC A03/MF A01

Results of using vibration–based methods to detect gear tooth fatigue cracks are presented. An experimental test rig was used to fail a number of spur gear specimens through bending fatigue. The gear tooth fatigue crack in each test was initiated through a small notch in the fillet area of a tooth on the gear. The primary purpose of these tests was to verify analytical predictions of fatigue crack propagation direction and rate as a function of gear rim thickness. The vibration signal from a total of three tests was monitored and recorded for gear fault detection research. The damage consisted of complete rim fracture on the two thin rim gears and single tooth fracture on the standard full rim test gear. Vibration–based fault detection methods were applied to the vibration signal both on–line and after the tests were completed. The objectives of this effort were to identify methods capable of detecting the fatigue crack and to determine how far in advance of total failure positive detection was given. Results show that the fault detection methods failed to respond to the fatigue crack prior to complete rim fracture in the thin rim gear tests. In the standard full rim gear test all of the methods responded to the fatigue crack in advance of tooth fracture; however, only three of the methods responded to the fatigue crack in the early stages of crack propagation.
Author
Bending Fatigue; Cracks; Fatigue Tests; Fault Detection; Gear Teeth; Gears; Vibration Measurement;

N96–22218*# Rutgers Univ., Piscataway, NJ. Dept. of Mechanical and Aerospace Engineering.
Numerical Simulation of 3–D Shock Wave Turbulent Boundary Layer Interaction Using a Two Equation Model of Turbulence, Volume 2 Thesis, Final Report, 1 Jul. 1992 – 31 Oct. 1995
Knight, Doyle D.; et al 31 Oct. 1995 129 p
Contract(s)/Grant(s): (NAG2–798)
Report No.(s): (NASA–CR–200645; NAS 1.26:200645; NIPS–96–36720) Avail: CASI HC A07/MF A02

A computational study of the crossing shock wave–turbulent boundary layer interaction is presented. The shock waves are generated by a pair of fins which are mounted normal to a flat plate and form a converging channel. The focus of the study is to investigate the ability of the theoretical turbulence model to provide for improvement in the predictions of adiabatic wall temperature and heat transfer rates during the interaction of the shock waves with the turbulent boundary layer on the flat plate. Three configurations with fin angles of 15 deg x 15 deg, 7 deg x 11 deg and 7 deg x 7 deg have been examined at Mach 3.9. Experimental data available for comparison includes surface pressure, heat transfer, adiabatic wall temperature and surface flow visualization. Computations solve the 3–D Reynolds–averaged compressible Navier–Stokes equations incorporating the new low Reynolds number correction of Knight to the two equation k–epsilon turbulence model. The computed surface pressure displays good agreement with experiment. The computed adiabatic wall temperature exhibits excellent agreement with experiment. The computed and experimental surface and flowfield flow visualization are in general agreement. The computed surface heat transfer displays significant disagreement with experiment for some cases. The flowfield manifests a complex shock wave system, and a pair of counter–rotating vortices.
Author
Aerodynamic Configurations; Computerized Simulation; Flat Plates; K–epsilon Turbulence Model; Nose Fins; Shock Wave Interaction; Shock Wave Propagation; Shock Waves; Three Dimensional Boundary Layer; Three Dimensional Flow; Turbulent Boundary Layer; Turbulent Flow;

N96–22320*# City Coll. of the City Univ. of New York, NY.

The Stability of Particulate Ladden Laminar Boundary–Layer Flows Final Report

Acrivos, Andreas; et al 19 Mar. 1996 9 p

Contract(s)/Grant(s): (NAG1–1159)

Report No.(s): (NASA–CR–200676; NAS 1.26:200676; NIPS–96–38014) Avail: CASI HC A02/MF A01

During the course of this investigation, the following two topics were studied theoretically: (1) forced convection and sedimentation past a flat plate, and (2) the effect of rain on airfoil performance. The prototype of the first topic is that of air flowing past the wing section of an aircraft under heavy rain and high windshear. The long–range objective of this project was to identify the various factors determining the dynamics of the flow and then to develop a theoretical framework for modeling such systems. The second topic focused on the idea that the presence of the gas–liquid interface (being the air flow around the airfoil and the thin liquid film created by the rain) accelerates flow separation and thus induces performance losses.

Derived from text

Air Flow; Airfoils; Boundary Layer Separation; Fluid Films; Forced Convection; Gas–liquid Interactions; Liquid–vapor Interfaces; Separated Flow;

N96–22333*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

Wing Twist Measurements at the National Transonic Facility

Burner, Alpheus W.; Wahls, Richard A.; and Goad, William K.; et al1 Feb. 1996 28 p

Report No.(s): (NASA–TM–110229; NAS 1.15:110229; NIPS–96–37773) Avail: CASI HC A03/MF A01

A technique for measuring wing twist currently in use at the National Transonic Facility is described. The technique is based upon a single camera photogrammetric determination of two dimensional coordinates with a fixed (and known) third dimensional coordinate. The wing twist is found from a conformal transformation between wind–on and wind–off 2–D coordinates in the plane of rotation. The advantages and limitations of the technique as well as the rationale for selection of this particular technique are discussed. Examples are presented to illustrate run–to–run and test–to–test repeatability of the technique in air mode. Examples of wing twist in cryogenic nitrogen mode are also presented.

Author

Aerodynamic Loads; Photogrammetry; Transonic Wind Tunnels; Twisting; Wings;

N96–22390* Georgia Inst. of Tech., Atlanta, GA.

An improved hybrid Navier–Stokes/full–potential method for computation of unsteady compressible viscous flows Ph.D. Thesis

Mello, Olympio Achilles def; et al1 Jan. 1994 157 p

Report No.(s): (NIPS–96–33243) Avail: Univ. Microfilms Order No. DA9517135

An improved hybrid method for computing unsteady compressible viscous flows is presented. This method divides the computational domain into two zones. In the outer zone, the unsteady full–potential equation (FPE) is solved. In the inner zone, the Navier–Stokes equations are solved using a diagonal form of an alternating–direction implicit (ADI) approximate factorization procedure. The two zones are tightly coupled so that steady and unsteady flows may be efficiently solved. Characteristic–based viscous/inviscid interface boundary conditions are employed to avoid spurious reflections at that interface. The resulting CPU times are less than 60% of the required for a full–blown Navier–Stokes analysis for steady applications and about 60% of the full Navier–Stokes CPU times for unsteady flows in non–vector processing machines. Applications of the method are presented for a rectangular NACA 0012 wing in low subsonic steady flow at moderate and high angles of attack, and for a F–5 wing in steady and unsteady subsonic and transonic flows. Steady surface pressures are in very good agreement with experimental data and are essentially identical to the full Navier–Stokes predictions. Density contours show that shocks cross the viscous/inviscid interface smoothly, so that the accuracy of full Navier–Stokes equations can be retained with a significant savings in computational time.

Dissert. Abstr.

Alternating Direction Implicit Methods; Compressible Flow; Computational Fluid Dynamics; Navier–stokes Equation; Subsonic Flow; Transonic Flow; Unsteady Flow; Viscous Flow;

N96–22422* Syracuse Univ., Utica, NY.

Triple–layer structure of vorticity amplification in the stagnation–point flow and its effect on heat transfer Ph.D. Thesis

Dou, Xinyu; et al1 Jan. 1994 128 p

Report No.(s): (NIPS–96–33283) Avail: Univ. Microfilms Order No. DA9516443

The present work investigates the dependence of stagnation–point heat transfer rate on freestream turbulence. The stagnation flow is shown to be linearly stable to a three–dimensional disturbance. A triple–layer theory is proposed, revealing the structure of nonlinear amplification of freestream disturbances carried into the stagnation region. The heat transfer rate is calculated based on the triple–layer velocity distribution to show that the heat transfer can be enhanced by the freestream disturbance while the friction is kept at the same level. The linear stability is concluded by examining boundary conditions at the outer edge of the boundary layer. It is argued that of two asymptotic branches of eigenfunctions at the outer edge, only the one that decays

exponentially satisfies the homogeneous boundary condition in physical space and represents a disturbance of the stability problem. The other branch represents the amplification of a disturbance that is persistently generated from outside the boundary layer as the stagnation point is approached. The triple–layer theory shows that the disturbance will be subjected to a nonlinear amplification process in a nonlinear buffer layer before it is carried into the boundary–layer region. The nonlinear buffer layer formed between linear outer layer and the boundary layer has a thickness of square root of epsilon, with epsilon being the disturbance amplitude. The double–layer structure proposed by Sutera applies only if the boundary–layer thickness, Re(exp –1/2), matches with square root of epsilon so that epsilon Re is approximately 1. The triple–layer theory predicts a dependence of heat transfer on the Reynolds number based on the disturbance velocity, which agrees with the experiments by Van der Hegge Zijnen. It also predicts some experimental observations of Van Fossen and coworkers.
Dissert. Abstr.
Aerodynamic Heat Transfer; Boundary Layers; Stagnation Flow; Stagnation Point; Turbulence Effects; Vorticity;

N96–22473* Georgia Inst. of Tech., Atlanta, GA.
A unified computational fluid dynamics–aeroacoustics analysis of high–speed propeller Ph.D. Thesis
Lim, Teck–Bin Arthur; et al1 Jan. 1994 178 p
Report No.(s): (NIPS–96–34454) Avail: Univ. Microfilms Order No. DA9434831

A combined computational aerodynamics/computational aeroacoustics methodology for the analysis of high speed propellers is developed. In this methodology, the flow field around a propeller is first solved by a computational fluid dynamics (CFD) analysis using the compressible Navier–Stokes equations, and its related acoustic behavior then analyzed through a novel computational aeroacoustics (CAA) analysis using a linearized form of Euler equations. This method contains no user–input constants except for the empirical constants in the turbulence model, grid spacing, and time step, and can predict both the aerodynamic and aeroacoustic features from first principles, with the CFD solution providing the acoustic strength for sound propagation to the CAA analysis. This formulation obeys the physics of acoustic propagation and can handle the nonreflective behavior at the far–field boundary of the computational domain in a very natural manner. In addition, the present CAA analysis also allows for easy incorporation of nonlinear effects of wave propagation as a separate entity. The results of the CFD analysis for the viscous flow field around a two–bladed single rotating high speed propeller, SR7L, show good agreement with experiment for a number of cases ranging from simulated takeoff flight to cruise flight condition. Both the surface pressure and integrated quantities such as thrust and torque are predicted. The CFD solution also demonstrates an ability to capture complex flow features like leading edge vortex formation, centrifugally pumped radial flow pattern, etc. The CAA analysis was done for several cases, ranging from linear wave propagation problems of monopoles, dipole, and pulsating spheres to nonlinear plane wave propagation of a moving piston. These calculations show good agreement with exact solutions and demonstrates the ability of the CAA scheme to capture the nonlinear wave steepening effect. Finally, the combined CFD/CAA methodology was applied to two cases of flight conditions, one simulating takeoff and another simulating cruise, for an eight–bladed single propeller model, SR7A. The solutions show good agreement with wind tunnel data in the prediction of the sound pressure level up to three diameters away from the propeller.
Dissert. Abstr.
Acoustic Propagation; Aeroacoustics; Compressible Flow; Computational Fluid Dynamics; Noise Prediction (aircraft); Propeller Noise; Propellers; Viscous Flow;

N96–22483* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
Rotary latch Patent
Kramer, Joel M.; inventor. et al7 Nov. 1995 8 p
Report No.(s): (US–PATENT–CLASS–403–322; US–PATENT–CLASS–403–325; US–PATENT–CLASS–403–327; US–PATENT–CLASS–403–79;US–PATENT– CLASS – 244–161; INT–PATENT–CLASS–F16B–7/00;US–PATENT–5,464,301;NASA–CASE–MSC–33231–1; NIPS–96–08507) Avail: US Patent and Trademark Office

A rotary latch is disclosed, including a hollow, cylindrical outer member and a concentrically arranged inner rotor. The rotor is rotatable within the outer cylindrical member. The outer cylindrical member includes a pair of aligned openings as a cylinder first end facing a latch pin. The rotor includes a pair of aligned slots at a rotor first end facing the latch pin. Slot extensions are provided in the rotor, the slot extensions extending generally perpendicularly to the slots and generally parallel to the rotor first end. In a first position, the outer cylindrical member openings and the rotor slots are aligned to allow receipt of the latch pin. In a second position, the openings and the slot extensions are aligned thereby engaging the latch pin within a closed area defined by the rotor slot extensions and the outer cylinder openings.
Official Gazzette of the U.S. Patent and Trademark
Cylindrical Bodies; Latches; Pins; Rotors;

N96–22498* Old Dominion Univ., Hampton, VA.
Finite element analysis for nonlinear flutter suppression of composite panels at elevated temperatures using piezoelectric materials Ph.D. Thesis
Zhou, Run Chen; et al 1 Jan. 1994 165 p
Report No.(s): (NIPS–96–33361) Avail: Univ. Microfilms Order No. DA9514750

Nonlinear coupled finite element equations of motion are derived for composite panels with embedded piezoelectric layers subjected to aerodynamic, thermal loads, and applied electric fields. The nonlinear equations of motion describe the coupling between a structure and an electrical network through the piezoelectric effect. The von Karman large–deflection strain–displacement relations, quasi–steady first–order piston theory aerodynamics, quasi–steady thermal stress theory, and linear piezoelectricity theory are used to formulate the nonlinear coupled panel flutter finite element equations of motion in nodal displacements. The governing equations, which are referred to actuator and sensor equations, form a basis for piezoelectric actuation and sensing. Following a modal transformation and reduction in structural degrees–of–freedom, a set of nonlinear coupled modal equations of motion with much smaller degrees–of–freedom is derived. The modal equations are then employed for time domain simulation and controller design. A self–sensing piezoelectric actuator is used as a sensor and actuator simultaneously. An optimal control design is developed based on the linearized modal equations while the numerical simulations are obtained based upon the nonlinear modal equations. An optimal shape and location of small–size or patched piezoelectric actuators are determined by using the norms of the optimal feedback control gains (NFCG). The strain rate feedback control design is also investigated due to its more practical usage. The strain rate signal is detected from piezoelectric sensor, and then amplified and fed back to the same piece of element to actively suppress the panel limit–cycle oscillations. The shape and location of the self–sensing actuator are still obtained based on the NFCG. The nonlinear flutter characteristics of composite panels with embedded piezoelectric elements at elevated temperatures are first determined from the actuator equation without activating the piezoelectric material. The performance of panel flutter controller design can be evaluated by the value of maximum flutter–free dynamic pressures which is defined that a flight vehicle can fly without experiencing flutter with piezoelectric actuation. Numerical simulations show that the maximum flutter–free dynamic pressure can be increased as high as six times of the critical dynamic pressure by using the linear optimal control design. The panel flutter large amplitude limit–cycle motions as well as periodic and chaotic motions at moderate temperatures are shown to be able to be completely suppressed within the maximum flutter–free dynamic pressure. Panels with different aspect ratios, boundary conditions, and thermal effects on flutter suppression are also investigated. The results reveal that the piezoelectric actuators are effective in nonlinear panel flutter suppression.
Dissert. Abstr.
Composite Structures; Control Systems Design; Equations of Motion; Finite Element Method; Flutter Analysis; Panel Flutter; Piezoelectric Transducers; Smart Structures; Thermal Stresses; Vibration Damping;

N96–22715* Washington Univ., Seattle, WA.
The effect of large–scale vortical structures on the heat transfer from a surface Ph.D. Thesis
Fox, Michael Dennison; et al1 Jan. 1994 1 p
Report No.(s): (NIPS–96–34489) Avail: Univ. Microfilms

Here three flow–fields of import to hot section cooling in turbine engines are studied: subsonic impinging jets, supersonic impinging jets, and hairpin vortices found in turbulent boundary layers. First the effect of unsteady vortical structures on the adiabatic wall temperature distribution in a subsonic impinging jet is explored. A conceptual model is introduced for the separation of the total temperature into regions of higher and lower total temperature, appealing to the dynamics of particle pathlines and vortex rings in the free jet. The predictions of the model compare favorably with experimental results for both free and impinging jets, and with numerical simulations of free jets. Self–sustaining acoustic resonance, when it occurs, alters significantly the wall temperature distribution, causing unwanted heating as well as increasing the cooling. When the Mach number of the jet is greater than sonic, a new mechanism for total temperature separation becomes dominant: the shock–vortex interaction. Here the otherwise steady shock structure of the jet is set into motion by the passage of vortex rings; fluid particles passing through these moving shock waves experience a drop in total temperature. This pronounced effect shows up as a region of very low wall temperature when a flat plate is inserted into the flow. Finally, the effect on heat transfer of hairpin, or arch–like vortices in a turbulent boundary layer is studied by generating artificial hairpin vortices in a laminar boundary layer and measuring the unsteady wall heat transfer. It is found that the previously confirmed mechanism of corewise transport, through the legs of the vortices, increases the heat transfer from the wall; in other words, the vortices act as miniature 'vacuum cleaners', drawing hot air directly away from the wall region, thus cooling the wall.
Dissert. Abstr.
Flow Distribution; Heat Transfer; Horseshoe Vortices; Jet Impingement; Laminar Boundary Layer; Temperature Distribution; Turbine Engines; Turbulent Boundary Layer; Vortex Rings; Vortices; Wall Temperature;

N96–22716* Arizona State Univ., Flagstaff, AZ.
Effect of surface roughness on local film cooling effectiveness and heat transfer coefficients Ph.D. Thesis
Barlow, Douglas Neal; et al1 Jan. 1994 319 p
Report No.(s): (NIPS–96–34445) Avail: Univ. Microfilms Order No. DA9500711

In high temperature gas turbine engines, the life cycle of the hot section is extremely dependent on accurate design prediction of component temperature distribution. Particular attention must be paid to the film cooling performance of the first stage turbine stator vanes where the highest heat loads are encountered. Recent investigations have determined

during operation the smooth surface of high pressure turbine vanes become rough due to corrosion, oxidation and particulate impact. A transient experimental method has been developed to obtain both local heat transfer and cooling effectiveness information downstream of a row of film cooling holes on a rough flat plate. The investigation provides information on the effects of roughness on film cooling heat transfer for a Reynolds number and dimensionless boundary layer momentum thickness which match conditions applicable to the pressure side of the first stage turbine vane of the Pratt and Whitney F–100–PW229 engine. Data for film cooling on rough surfaces are extremely limited in the literature. However, comparison with the available data is made. The transient experimental procedure employed here uses encapsulated liquid crystal coatings and an automated computer vision data acquisition system to obtain detailed local data. In order to access the method's success, detailed heat transfer data are also reported for smooth surface configurations. Comparison with available data shows good agreement indicating successful development of the technique. The test procedures and data acquisition methods are reported. Finite difference work is included to assess the rough surface model. 8.5% mainstream turbulence levels approach those found in actual first stage turbine stator vanes.
Dissert. Abstr.
Film Cooling; Flat Plates; Gas Turbine Engines; Heat Transfer Coefficients; Hole Distribution (mechanics); Life (durability); Surface Roughness; Temperature Distribution; Vanes;

N96–22760* Texas Univ., Austin, TX.
The augmentation of stagnation point heat transfer by quasi–periodic freestream fluctuations Ph.D. Thesis
Hanford, Anthony James; et al1 Jan. 1994 291 p
Report No.(s): (NIPS–96–08985) Avail: Univ. Microfilms Order No. DA9505993

A phenomenological model is presented that relates freestream turbulence to the augmentation of stagnation–point surface flux quantities. The model requires the turbulence intensity, the longitudinal scale of the turbulence, and the energy spectra as inputs for the unsteady velocity at the edge of the near–wall viscous region. The form of the edge velocity contains both pulsations of the incoming flow and oscillations of the streamline. The unsteady response within the near–wall viscous region, or boundary layer, is determined by solving the instantaneous momentum and energy equations. The solution approach analytically decomposes the nondimensional governing equations into time–independent and time–dependent expressions. The time–dependence is modeled with a few frequencies and is defined using a finite Fourier expansion in time. The individual time–dependent expressions are further simplified for the current application by using a high–frequency approximation. Both incompressible and compressible formulations are presented. Compressible and incompressible results using a single fluctuating component are presented within the stagnation region of a two–dimensional cylinder. The time–averaged skin friction and Froessling number are determined from the computations. The incompressible predictions are compared to existing incompressible experimental data. Additionally, the variations in the surface flux quantities with the longitudinal scale of the incoming freestream turbulence, the Reynolds number, and the freestream turbulence intensity are considered. The compressible predictions are compared both with standard correlations and comparable incompressible predictions. Further compressible work predicts the variation in the surface flux quantities with the freestream turbulence intensity and the far field Mach number. Additionally, the case at a far field Mach number of 3.0 is presented in detail.
Dissert. Abstr.
Aerodynamic Heat Transfer; Compressible Flow; Free Flow; Incompressible Flow; Stagnation Point; Turbulence Effects; Turbulent Boundary Layer; Turbulent Heat Transfer; Unsteady Flow;

N96–22850*# Aircraft Research Association Ltd., Bedford (England).
Balance Design and Balance Calibration
Tusar, Liz; et al1 Jan. 1995 38 p
Report No.(s): (ARA–TM–412; NIPS–96–39307) Avail: CASI HC A03/MF A01

The relationship between balance design and balance calibration has been discussed. Some alternative methods to that already in use at Aircraft Research Association Limited (ARA) for the calibration of six component balances have been described. Some of these methods have been investigated further using the ETW aircraft performance balance no 3 calibration data. Significant improvements in the fit of the calibration data have been obtained with the use of a cubic fit starting with the assumption that the loads are a function of the balance signals rather than starting with the assumption that the readings are a function of the loads which is the traditional approach used at ARA. It is proposed that this method is implemented in parallel with the current method used at ARA and the performance monitored for a number of balances. More investigations are required to explore other potential improvements in the calibration method used at ARA.
Author
Aircraft Design; Aircraft Performance; Loads (forces); Weight Indicators; Wind Tunnel Apparatus; Wind Tunnel Calibration;

N96–22924*# Iowa Univ., Iowa City, IA.
The Fluid Mechanics of Vortex Cutting by a Blade Final Report, 1 Aug. 1992 – 31 Jul. 1995
Marshall, Jeffrey S.; et al24 Sep. 1995 40 p

Contract(s)/Grant(s): (DAAH04–93–G–0378)
Report No.(s): (AD–A300513; NIPS–96–31161) Avail: CASI HC A03/MF A01

A study of the fluid dynamics associated with impact of a vortex on a body (such as a blade) moving normal to the vortex axis was performed. The physical features of the flow evolution were categorized in terms of two dimensionless parameters which represent a ratio of length scales and a ratio of velocity scales associated with the vortex core and with the body. Models of various features of the flow evolution are constructed and compared against experimental and detailed computational data. Primary features of interest in the study include vortex deflection and axial flow in the vortex core resulting from stretching by the blade, intense vorticity deformation resulting from penetration of the body into the vortex core (and resulting force on the body), traveling vortex breakdown formed immediately following vortex cutting by the body, and interaction of shed vorticity from the body with the primary vortex.
DTIC
Axial Flow; Blade–vortex Interaction; Helicopters; Interactional Aerodynamics; Rotor Dynamics; Vortex Breakdown;

N96–23037* Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.
Kinetic algorithms for non–equilibrium gas dynamics Ph.D. Thesis
Eppard, William Marcus; et al1 Jan. 1993 193 p
Report No.(s): (NIPS–96–07361) Avail: Univ. Microfilms Order No. DA9323771

New upwind kinetic–difference schemes have been developed for flows with non–equilibrium thermodynamics and chemistry. These schemes are derived from the Boltzmann equation with the resulting Euler schemes developed as moments of the discretized Boltzmann scheme with a locally Maxwellian velocity distribution. Application of a directionally–split Courant–Isaacson–Rees (CIR) scheme at the Boltzmann level results in a flux–vector splitting scheme at the Euler level and is called Kinetic Flux–Vector Splitting (KFVS). Computational examples are presented comparing KFVS with the schemes of Van–Leer and Roe for quasi–one–dimensional flow through a supersonic diffuser, inviscid flow through a two–dimensional inlet, viscous flow over a cone at zero angle–of–attack, and shock–induced combustion/detonation in a premixed hydrogen–air mixture. The results show that even though the KFVS scheme is a Riemann solver at the kinetic level, its behavior at the Euler level is more similar to the existing flux–vector splitting algorithms than to the flux–difference splitting scheme of Roe. A new approach toward the development of a genuinely multidimensional Riemann solver is also presented. The approach taken in the present work is to apply new multi–dimensional upwind schemes for the scalar advection equation at the Boltzmann level. The resulting Euler schemes are obtained as moments of the fluctuations in the Maxwellian distribution function. The theoretical issues have been solved through analytic quadrature and Euler schemes have been developed. Encouraging preliminary results have been obtained for perfect gases on uniform Cartesian meshes with first–order spatial accuracy. Finally, methods for obtaining accurate gas–dynamic simulations in the continuum transition regime are considered. In particular, large departures from translational equilibrium are modeled using algorithms based on the Burnett equations instead of the Navier–Stokes equations. Here, the same continuum formulation of the governing equations is retained, but new constitutive relations based on higher–order Chapman–Enskog theory are introduced. Both a rotational relaxation model and a bulk–viscosity model have been considered for simulating rotational non–equilibrium. Results are presented for hypersonic normal shock calculations in argon and diatomic nitrogen and comparisons are made with Direct Simulation Monte Carlo (DSMC) results.
Dissert. Abstr.
Combustible Flow; Computational Fluid Dynamics; Flux Vector Splitting; Inlet Flow; Inviscid Flow; Nonequilibrium Flow; One Dimensional Flow; Supersonic Diffusers; Viscous Flow;

N96–23038* Mississippi State Univ., Mississippi State, MS.
Two dimensional and axisymmetric radiative heat transfer for hypersonic flows in chemical nonequilibrium Ph.D. Thesis
Elbert, Gregory Joseph; et al1 Jan. 1992 129 p
Report No.(s): (NIPS–96–07360) Avail: Univ. Microfilms Order No. DA9331613

This study details the development of numerical techniques for the accurate predictions of radiative heat transfer for two dimensional and axisymmetric hypersonic flows in chemical nonequilibrium. A Full Radiative model is developed by applying numerical integration formulae directly to the expression for the radiative source term. The methodology requires that a radiation grid be superimposed on the flowfield grid such that integrations over length and direction of propagation can be performed, thus calculating the radiative source term without any simplifying assumptions as to the flowfield geometry. The resulting algorithm is not restricted to particular (geometric) regions of the flowfield. The radiative transport calculations are fully coupled to the flowfield simulations via the modification of an existing thermo–chemical nonequilibrium flow solver. The new Full Radiative model is compared to the Quasi–One–Dimensional and Emission Dominated models as well as a baseline no radiation case. The test cases involve a cylinder/sphere with a 1.5 meter radius, a velocity of 15 km/sec and an altitude of 60 kilometers. The effects from three thermo–chemical models, viscosity and two absorptivity coefficient models are inves-

tigated. The maximum radiative heating loads at the stagnation point are strongly affected by the choice of thermo–chemical model and the absorptivity coefficient model. Among the three radiative models, non–negligible differences in the stagnation point radiative heating loads are predicted, with the new Full Radiative model providing the smallest values. The results indicate that 'truly' two dimensional and axisymmetric capabilities are an important issue for the accurate predictions of aerothermodynamic heating loads, and suggest that the same will hold for three dimensional problems.
Dissert. Abstr.
Aerothermodynamics; Axisymmetric Flow; Chemical Equilibrium; Hypersonic Flow; Hypersonic Heat Transfer; Radiative Heat Transfer; Two Dimensional Flow;

N96–23076* Missouri Univ., Columbia, MO.
Navier–Stokes simulation for waveriders including turbulence, heat transfer, and wake Ph.D. Thesis
Tsai, Bor–Jang; et al 1 Jan. 1992 263 p
Report No.(s): (NIPS–96–07653) Avail: Univ. Microfilms Order No. DA9400067

This thesis presents the results of a computational fluid dynamics study of the three–dimensional, turbulent, supersonic flowfield about the forebody of a conical waverider at zero angle–of–attack. The numerical method uses the flux difference splitting algorithm, as embodied in the Navier–Stokes code entitled CFL3D, developed by the NASA–Langley Research Center, and the Baldwin–Lomax algebraic turbulence model. The grid selected and overall correctness of the turbulent flow computations are validated by comparison to the corresponding flat plate results. Specific calculations on the turbulent waverider are compared to previous results for the laminar flow about the same configuration, as well as to available experimental and analytical results. Even though the primary emphasis in this study was on the forebody turbulent flow predictions for the waverider, several laminar cases and some initial wake region cases were run by the author. The laminar heat transfer for the waverider cases was investigated to familiarize with the code CFL3D. Then the turbulent flat plate cases as well as the zero angle–of–attack turbulent waverider case for the forebody only were considered. The flow in the afterbody–wake region for the waverider proved to be quite complicated. Accordingly, the wake of the two–dimensional wedge and the three–dimensional axisymmetric cone cases were considered as background cases for the wake of the conical waverider. In these two wake cases, flux vector splitting was used instead of flux difference splitting. Multi–block with patched boundary grid topology was also employed with these wake region cases. Computed results and the accompanying graphical displays of the base pressure distribution and wake region flow patterns reveal some very useful information related to eventually computing the wake region for the conical waverider.
Author
Angle of Attack; Computational Fluid Dynamics; Flow Distribution; Laminar Heat Transfer; Mathematical Models; Navier–stokes Equation; Turbulence; Turbulence Models; Wakes; Waveriders;

N96–23079* Virginia Univ., Charlottesville, VA.
A stability based method for selecting bearing locations in rotor–bearing systems Ph.D. Thesis
Srinivasan, Sriram; et al1 Jan. 1993 258 p
Report No.(s): (NIPS–96–07519) Avail: Univ. Microfilms Order No. DA9402625

A method for quickly evaluating the effect of changes in bearing location on bearing design for stability of rotating machinery is proposed in this dissertation. This method is intended for use by rotating machinery designers to select the 'best' bearing locations prior to the bearing design process. The purpose of the method is to improve the design process by separating the problem of determining the 'best' bearing locations from that of determining the actual bearing design. The method is independent of the type of bearing employed. For each candidate bearing configuration, the method provides a scalar measure of the relative ability of bearings to meet stability specifications. Within certain limits, the stability specifications are defined by the designer and involve moving the damped eigenvalues of the rotor–bearing system into an acceptable region of the left half plane. The scalar measure is used to rank the candidate bearing locations and thereby select the best one. The scalar measure is compared to practical scalar measures of bearing design such as the infinity norm of the controller for magnetic bearings and the magnitude of the stiffness coefficients for hydrodynamic bearings. Two examples designs of multi–stage centrifugal compressors are also presented.
Dissert. Abstr.
Computer Aided Design; Controllers; Magnetic Bearings; Position (location); Scalars; Structural Stability;

N96–23140*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A Numerical Investigation of the Startup Transient in a Wave Rotor
Paxson, Daniel E.; et al1 Mar. 1996 14 p Presented at 41st Turbo Expo 1996, Birmingham , United Kingdom, 10–13 Jun. 1996; Sponsored by American Society of Mechanical Engineers,
Report No.(s): (NASA–TM–107196; E–10175; NAS 1.15:107196; NIPS–96–39653) Avail: CASI HC A03/MF A01

The startup process is investigated for a hypothetical four–port wave rotor, envisioned as a topping cycle for a small gas turbine engine. The investigation is conducted nu-

merically using a multi–passage, one–dimensional CFD–based wave rotor simulation in combination with lumped volume models for the combustor, exhaust valve plenum, and rotor center cavity components. The simulation is described and several startup transients are presented which illustrate potential difficulties for the specific cycle design investigated. In particular it is observed that, prior to combustor light–off, or just after, the flow through the combustor loop is reversed from the design direction. The phenomenon is demonstrated and several possible modifications techniques are discussed which avoid or overcome the problem.
Author
Gas Turbine Engines; Rotor Aerodynamics; Rotors; Starting; Topping Cycle Engines; Unsteady Flow;

N96–23141*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
Computational Methods for Frictional Contact With Applications to the Space Shuttle Orbiter Nose–Gear Tire
Tanner, John A.; et al 1 Apr. 1996 54 p
Report No.(s): (NASA–TP–3574; L–17211B; NAS 1.60:3574; NIPS–96–39891) Avail: CASI HC A04/MF A01

A computational procedure is presented for the solution of frictional contact problems for aircraft tires. A Space Shuttle nose–gear tire is modeled using a two–dimensional laminated anisotropic shell theory which includes the effects of variations in material and geometric parameters, transverse–shear deformation, and geometric nonlinearities. Contact conditions are incorporated into the formulation by using a perturbed Lagrangian approach with the fundamental unknowns consisting of the stress resultants, the generalized displacements, and the Lagrange multipliers associated with both contact and friction conditions. The contact–friction algorithm is based on a modified Coulomb friction law. A modified two–field, mixed–variational principle is used to obtain elemental arrays. This modification consists of augmenting the functional of that principle by two terms: the Lagrange multiplier vector associated with normal and tangential node contact–load intensities and a regularization term that is quadratic in the Lagrange multiplier vector. These capabilities and computational features are incorporated into an in–house computer code. Experimental measurements were taken to define the response of the Space Shuttle nose–gear tire to inflation–pressure loads and to inflation–pressure loads combined with normal static loads against a rigid flat plate. These experimental results describe the meridional growth of the tire cross section caused by inflation loading, the static load–deflection characteristics of the tire, the geometry of the tire footprint under static loading conditions, and the normal and tangential load–intensity distributions in the tire footprint for the various static vertical loading conditions. Numerical results were obtained for the Space Shuttle nose–gear tire subjected to inflation pressure loads and combined inflation pressure and contact loads against a rigid flat plate. The experimental measurements and the numerical results are compared.
Author
Aircraft Tires; Contact Loads; Finite Element Method; Friction; Lagrange Multipliers; Landing Gear; Shell Theory; Static Loads; Variational Principles;

N96–23148*# MCAT Inst., San Jose, CA.
CFD Research, Parallel Computation and Aerodynamic Optimization Final Report, Jul. 1989 – Jan. 1995
Ryan, James S.; et al 1 Jan. 1995 7 p
Contract(s)/Grant(s): (NCC2–505; NCC2–796)
Report No.(s): (NASA–CR–200760; NAS 1.26:200760; REPT–95–18; NIPS–96–39654) Avail: CASI HC A02/MF A01

During the last five years, CFD has matured substantially. Pure CFD research remains to be done, but much of the focus has shifted to integration of CFD into the design process. The work under these cooperative agreements reflects this trend. The recent work, and work which is planned, is designed to enhance the competitiveness of the US aerospace industry. CFD and optimization approaches are being developed and tested, so that the industry can better choose which methods to adopt in their design processes. The range of computer architectures has been dramatically broadened, as the assumption that only huge vector supercomputers could be useful has faded. Today, researchers and industry can trade off time, cost, and availability, choosing vector supercomputers, scalable parallel architectures, networked workstations, or heterogenous combinations of these to complete required computations efficiently.
Author
Aerodynamics; Architecture (computers); Computational Fluid Dynamics; Parallel Computers; Supercomputers;

N96–23175*# National Aerospace Lab., Tokyo (Japan). Airframe Div.
Analysis of Fatigue Fractographic Data of a Rod End Housing Using Monte Carlo Simulation
Shimokawa, Toshiyuki; and Kakuta, Yoshiaki; et al1 May 1995 18 p (ISSN 0389–4010)
Report No.(s): (NAL–TR–1270T; NIPS–96–39535) Avail: CASI HC A03/MF A01

This paper presents a new method that uses Monte Carlo simulation to estimate a life distribution of fatigue crack propagation on the basis of crack length versus striation spacing data. Moreover, to compare with the results obtained by this method, simple stochastic crack growth models using Monte Carlo simulation and other probabilistic methods without a simulation procedure provide the life distributions. The proposed method uses the distributions of two parameter estimates of a regression line with a reasonable correlation between the two parameter estimates. One cycle of the

Monte Carlo scheme generates a set of the two parameter estimates and they give a life of crack propagation. In this study, these methods are applied for the striation spacing data measured on the fatigue fracture surface of a rod end housing of a hydraulic actuator used for a main landing gear of a transport aircraft. The life distributions predicted are discussed and compared to clarify the features of each method. The proposed method approximates the true fatigue life as the B allowable life when the initial crack length is assumed to be 0 mm.

Author

Aluminum Alloys; Crack Propagation; Fatigue Life; Landing Gear; Monte Carlo Method; Probability Density Functions; Regression Analysis; Transport Aircraft;

N96–23184*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

Structural Optimization Methodology for Rotating Disks of Aircraft Engines

Armand, Sasan C.; et al1 Nov. 1995 24 p

Report No.(s): (NASA–TM–4693; NAS 1.15:4693; E–9598; NIPS–96–38624) Avail: CASI HC A03/MF A01

In support of the preliminary evaluation of various engine technologies, a methodology has been developed for structurally designing the rotating disks of an aircraft engine. The structural design methodology, along with a previously derived methodology for predicting low–cycle fatigue life, was implemented in a computer program. An interface computer program was also developed that gathers the required data from a flowpath analysis program (WATE) being used at NASA Lewis. The computer program developed for this study requires minimum interaction with the user, thus allowing engineers with varying backgrounds in aeropropulsion to successfully execute it. The stress analysis portion of the methodology and the computer program were verified by employing the finite element analysis method. The 10th–stage, high–pressure–compressor disk of the Energy Efficient Engine Program (E3) engine was used to verify the stress analysis; the differences between the stresses and displacements obtained from the computer program developed for this study and from the finite element analysis were all below 3 percent for the problem solved. The computer program developed for this study was employed to structurally optimize the rotating disks of the E3 high–pressure compressor. The rotating disks designed by the computer program in this study were approximately 26 percent lighter than calculated from the E3 drawings. The methodology is presented herein.

Author

Aircraft Engines; Computer Programs; Finite Element Method; Gas Turbine Engines; Rotating Disks; Structural Design; Turbocompressors;

N96–23202*# Kyushu Univ., Fukuoka (Japan). Dept. of Aeronautics and Astronautics.

Computational and Experimental Studies of Unsteady Viscous Nozzle Flows

Lee, Min Gyoo; Murakami, Tsutomu; and Nishida, Michio; et al1 Jan. 1995 8 p

Report No.(s): (NIPS–96–36708) Avail: CASI HC A02/MF A01

The present paper describes the numerical and experimental results on unsteady nozzle flows induced by nonstationary shock waves. The two–dimensional Navier–Stokes equations are numerically solved using the upwind TVD finite difference scheme of the Harten–Yee type. For the purpose of computational visualization of shock waves in transient nozzle starting process, computer shadowgraphs are developed based on the principle of the optical shadowgraph. Visualization experiments employing a conventional shock tube are also performed. Comparison of numerical and experimental results shows satisfactory agreement. Furthermore, the steady flow establishment process around an airfoil model installed inside the nozzle is numerically investigated. The simulated results successfully reveal the unsteady viscous flow structure around the model.

Author

Computational Fluid Dynamics; Computerized Simulation; Finite Difference Theory; Navier–stokes Equation; Nozzle Flow; Shadowgraph Photography; Shock Waves; Unsteady Flow; Viscous Flow;

N96–23242*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A Cascade Optimization Strategy for Solution of Difficult Multidisciplinary Design Problems

Patnaik, Surya N.; Coroneos, Rula M.; Hopkins, Dale A.; and Berke, Laszlo; et al 1 Mar. 1996 12 p Presented at 37th Structures, Structural Dynamics and Materials Conference, Salt Lake City, UT , United States, 15–17 Apr. 1996

Report No.(s): (NASA–TM–107189; AIAA–96–1628; E–10161; NAS 1.15:107189; NIPS–96–39890) Avail: CASI HC A03/MF A01

A research project to comparatively evaluate 10 nonlinear optimization algorithms was recently completed. A conclusion was that no single optimizer could successfully solve all 40 problems in the test bed, even though most optimizers successfully solved at least one–third of the problems. We realized that improved search directions and step lengths, available in the 10 optimizers compared, were not likely to alleviate the convergence difficulties. For the solution of those difficult problems we have devised an alternative approach called cascade optimization strategy. The cascade strategy uses several optimizers, one followed by another in a specified sequence, to solve a problem. A pseudorandom scheme perturbs design variables between the optimizers. The cascade strategy has been tested successfully in the de-

sign of supersonic and subsonic aircraft configurations and air–breathing engines for high–speed civil transport applications. These problems could not be successfully solved by an individual optimizer. The cascade optimization strategy, however, generated feasible optimum solutions for both aircraft and engine problems. This paper presents the cascade strategy and solutions to a number of these problems.
Author
Aircraft Configurations; Aircraft Design; Aircraft Engines; Algorithms; Engine Design; Multidisciplinary Design Optimization; Nonlinear Programming;

N96–23310* Stanford Univ., CA.
Implementation and performance of a particle simulation method suited to MIMD parallel computer architectures Ph.D. Thesis
Fallavollita, Michael Alfred; et al1 Jan. 1994 160 p
Report No.(s): (NIPS–96–08258) Avail: Univ. Microfilms Order No. DA9429921

Particle methods are useful for a wide range of problems of current interest to the scientific community. In addition to the usual application to hypersonic rarefied flows, particle methods can also be useful for modeling other flows in the rarefied regime such as the forces on the read/write head of a modern disk drive. The major drawback of particle simulation methods is the large amount of computer resources that they require, both in terms of processor time and memory. The current trend for supercomputer architectures toward large–scale MIMD (multiple–instruction multiple–data) parallel computers has provided an impetus for implementing a particle method which is well suited to these architectures. A simulation code has been developed for the Intel Gamma and Delta computers which is capable of computing three–dimensional flow fields in multiple–species gasses that exhibit thermo–chemical nonequilibrium. Details of the implementation are presented that focus on those issues which arise from the parallel nature of the computers. Important aspects of the Intel Gamma and Delta architectures are presented in as much as they affect the implementation decisions. A very thorough study of the performance of the method is also presented which relates the efficiency of the implementation to the number of processors that are used. This is very important in order to predict the usefulness of this method, or similar methods on future computers which contain more processors. The study was also very useful for identifying those areas of the simulation which required additional optimization. Finally, some results are presented which demonstrate the capabilities of the method. A study on how the number of particles in a simulation affect the simulation cost and accuracy shows that the computational cost of a simulation of a given accuracy may actually be reduced by increasing the number of particles. A comparison between particle simulation results and the solution of the Burnett equations is made for supersonic flow over a circular cylinder, and three–dimensional flow calculations about a blunted cone at varying angles of attack are also presented.
Dissert. Abstr.
Architecture (computers); Computational Fluid Dynamics; Computerized Simulation; Flow Distribution; Mimd (computers); Parallel Processing (computers); Particle Motion; Rarefied Gas Dynamics; Three Dimensional Flow;

N96–23342*# Petroleum Helicopters, Inc., Lafayette, LA.
Feasibility Study of a Rotorcraft Health and Usage Monitoring System (HUMS): Results of Operator's Evaluation Final Report
Romero, Raylund; Summers, Harold; and Cronkhite, James; et al1 Feb. 1996 56 p
Contract(s)/Grant(s): (NAS3–25455; RTOP 505–62–36; DA PROJ. 1L1–62211–A–47–A)
Report No.(s): (NASA–CR–198446; E–10092; NAS 1.26: 198446; ARL–CR–289; DOT/FAA/AR–95/50; NIPS–96–35621) Avail: CASI HC A04/MF A01

The objective was to evaluate the feasibility of a state–of–the–art health and usage monitoring system (HUMS) to provide monitoring of critical mechanical systems on the helicopter, including motors, drive train, engines, and life–limited components. The implementation of HUMS and cost integration with current maintenance procedures was assessed from the operator's viewpoint in order to achieve expected benefits from these systems, such as enhanced safety, reduced maintenance cost, and increased availability. An operational HUMS that was installed and operated under an independent flight trial program was used as a basis for this study. The HUMS equipment and software were commercially available. Based on the results of the feasibility study, the HUMS used in the flight trial program generally demonstrated a high level of reliability in monitoring the rotor system, engines, drive train, and life–limited components. The system acted as a sentinel to warn of impending failures. A worn tail rotor pitch bearing was detected by HUMS, which had the capability for self testing to diagnose system and sensor faults. Examples of potential payback to the operator with HUMS were identified, including reduced insurance cost through enhanced safety, lower operating costs derived from maintenance credits, increased aircraft availability, and improved operating efficiency. The interfacing of HUMS with current operational procedures was assessed to require only minimal revisions to the operator's maintenance manuals. Finally the success in realizing the potential benefits from HUMS technology was found to depend on the operator, helicopter manufacturer, regulator (FAA), and HUMS supplier working together.
Author (revised)
Aircraft Maintenance; Fault Detection; Feasibility; Helicopters; In–flight Monitoring; Systems Health Monitoring;

N96–23344*# Aircraft Research Association Ltd., Bedford (England).

The Importance of Fluid Dynamics in Wind Tunnel Testing

Green, J. E.; et al1 May 1995 70 p Presented at Lecture, Bandung, Indonesia, Apr. 1995

Report No.(s): (ARA–TM–416; NIPS–96–39311) Avail: CASI HC A04/MF A01

This lecture is concerned with the influence of fluid dynamics in wind tunnel testing, particularly with the importance of understanding and making allowance for the effects of the difference in Reynolds number between wind tunnel and flight. It begins with an outline of the general features and capabilities of a modern industrial transonic wind tunnel, the 2.74 m x 2.44 m transonic tunnel at ARA (Aircraft Research Association), and of the facilities and techniques which have been developed to meet the test requirements of ARA customers. It then considers the various factors which cause aerodynamic differences between wind tunnel and flight and highlights the specific question of the scale effect that arises from the difference between Reynolds numbers in wind tunnel and flight. It discusses the new wind tunnel facilities that have been built in the past 20 years to reduce the uncertainty arising from this effect. Finally, it reviews the experimental techniques that have been used in the ARA wind tunnel to enable confident extrapolation from wind tunnel to flight for aircraft of the Airbus family and discusses the underlying fluid dynamics which make these techniques successful.

Author

Boundary Layer Transition; Fluid Dynamics; Reynolds Number; Transition Flow; Transonic Wind Tunnels; Wind Tunnel Tests;

N96–23345*# Aircraft Research Association Ltd., Bedford (England).

The Place of Fluid Dynamics in Aircraft Design

Green, J. E.; et al1 May 1995 60 p Presented at Lecture, Bandung, Indonesia, Apr. 1995

Report No.(s): (ARA–TM–415; NIPS–96–39310) Avail: CASI HC A04/MF A01

This lecture is concerned with those aspects of fluid dynamics which are important to flight and which have to be taken into account in the aerodynamic design of aircraft. It begins with a review of the historical development of the subject and of the fundamental advances in understanding at the beginning of this century which provide the foundations for modern aerodynamics. It identifies the concepts of the boundary layer and of aerodynamic scale, measured by Reynolds number, as two of the most important of the early advances and discusses their significance in modern aerodynamics. The main aspects of boundary layer behavior and of the interaction between the boundary layer and the external flow are discussed and our present ability to model this behavior theoretically is assessed. The lecture concludes with an outline of the aerodynamic tools currently available for use in aircraft design offices. In particular, it considers the present limitations of these tools in dealing with critical aspects of the fluid dynamics and underlines the continuing need, in the foreseeable future, for the final assessment of an aerodynamic design to be a wind tunnel test.

Author

Aerodynamic Configurations; Aerodynamics; Aircraft Design; Computational Fluid Dynamics;

13 GEOSCIENCES

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

N96–22187*# Harvard Univ., Cambridge, MA. Dept. of Chemistry.

Aircraft–borne, laser–induced fluorescence instrument for the in situ detection of hydroxyl and hydroperoxyl radicals

Wennberg, P. O.; Cohen, R. C.; Hazen, N. L.; Lapson, L. B.; Allen, N. T.; Hanisco, T. F.; Oliver, J. F.; Lanham, N. W.; Demusz, J. N.; and Anderson, J. G.; et al 1 Jan. 1994 19 p

Contract(s)/Grant(s): (NCC2–693)

Report No.(s): (NASA–CR–200206; NAS 1.26:200206; NIPS–96–08373) Avail: CASI HC A03/MF A01

The odd–hydrogen radicals OH and HO2 are central to most of the gas–phase chemical transformations that occur in the atmosphere. Of particular interest is the role that these species play in controlling the concentration of stratospheric ozone. This paper describes an instrument that measures both of these species at volume mixing ratios below one part in 10(exp 14) in the upper troposphere and lower stratosphere. The hydroxyl radical (OH) is measured by laser induced fluorescence at 309 nm. Tunable UV light is used to pump OH to the first electric state near 282 nm. the laser light is produced by a high–repetition rate pulsed dye–laser powered with all solid–state pump lasers. HO2 is measured as OH after gas–phase titration with nitric oxide. Measurements aboard a NASA ER–2 aircraft demonstrate the capability of this instrument to perform reliably with very high signal–to–noise ratios (greater than 30) achieved in short integration times (less than 20 sec).

Author

Airborne Equipment; Gas Detectors; Hydroxyl Radicals; Laser Induced Fluorescence; Measuring Instruments; Ozone; Stratosphere; Troposphere;

N96–22259*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

Latitudinal distribution of black carbon soot in the upper troposphere and lower stratosphere

Blake, David F.; and Kato, Katharine; et al1 Jan. 1995 8 p (ISSN 0148–0227)
Report No.(s): (NASA–CR–199992; PAPER–94JD03118; NAS 1.26:199992; NIPS–96–07094) Avail: CASI HC A02/MF A01

Black carbon soot from the upper troposphere and lower stratosphere has been systematically collected at latitudes from 90 deg N to 45 deg S. The measured latitudinal distribution of this soot at 10 to 11 km altitude is found to covary with commercial air traffic fuel use, suggesting that aircraft fuel combustion at altitude is the principal source. In addition, at latitudes where the commercial air traffic is high, measured black carbon soot values are high even at 20 km altitude, suggesting that aircraft–generated soot injected just above the tropopause may be transported to higher altitudes. During the volcanically influenced period in which these samples were collected, the number abundances, total mass, and calculated total surface area of black carbon soot are 2–3 orders of magnitude lower than similar measures of sulfuric acid aerosol. During volcanically quiescent periods, the calculated total surface area of black carbon soot aerosol is of the same order of magnitude as that of the background sulfuric acid aerosol. It appears from this comparison that black carbon soot is only capable of influencing lower stratosphere or upper troposphere chemistry during periods when the aerosol budget is not dominated by volcanic activity. It remains to determine the extent to which black carbon soot particles act as nuclei for sulfuric acid aerosol formation. However, mass balance calculations suggest that aircraft soot injected at altitude does not represent a significant source of condensation nuclei for sulfuric acid aerosols.
Author
Altitude; Atmospheric Chemistry; Atmospheric Composition; Carbon; Concentration (composition); Soot; Stratosphere; Troposphere;

N96–22315*# Denver Univ., Denver, CO. Dept. of Engineering.
Counting Particles Emitted by Stratospheric Aircraft and Measuring Size of Particles Emitted by Stratospheric Aircraft Final Report, 1 May 1990 – 31 Dec. 1992
Wilson, James Charles; et al19 Apr. 1994 28 p
Contract(s)/Grant(s): (NCC2–666)
Report No.(s): (NASA–CR–200689; NAS 1.26:200689; NIPS–96–38001) Avail: CASI HC A03/MF A01

There were two principal objectives of the cooperative agreement between NASA and the University of Denver. The first goal was to modify the design of the ER–2 condensation nuclei counter (CNC) so that the effective lower detection limit would be improved at high altitudes. This improvement was sought because, in the instrument used prior to 1993, diffusion losses prevented the smallest detectable particles from reaching the detection volume of the instrument during operation at low pressure. Therefore, in spite of the sensor's ability to detect particles as small as 0.008 microns in diameter, many of these particles were lost in transport to the sensing region and were not counted. Most of the particles emitted by aircraft are smaller than 0.1 micron in diameter. At the start date of this work, May 1990, continuous sizing techniques available on the ER–2 were only capable of detecting particles larger than 0.17 micron. Thus, the second objective of this work was to evaluate candidate sizing techniques in an effort to gain additional information concerning the size of particles emitted by aircraft.
Derived from text
Condensation Nuclei; Detection; Measurement; Particles; Size (dimensions); Stratosphere; U–2 Aircraft;

N96–23057* Wisconsin Univ., Madison, WI.
Shallow cumulus processes deduced from subcloud flux measurements and parameterization schemes Ph.D. Thesis
Otles, Zekai; et al1 Jan. 1993 159 p
Report No.(s): (NIPS–96–07455) Avail: Univ. Microfilms Order No. DA9326047

The purposes of this study are to improve understanding of shallow cumulus in the planetary boundary layer (PBL), to quantitatively measure their subcloud root processes, and to link those measurements to estimates of cloud layer processes. To achieve those goals, two approaches are used. Firstly, subcloud aircraft turbulence data for three days from the 1986 HAPEX project in southwest France is extensively analyzed. Secondly, various parameterizations of cloud layer processes are used to estimate cumulus layer effects by employing the subcloud fluxes as boundary conditions. Case 1 (5/21/1986) had active cumuli; over the forest they were deep and large in diameter (called as strong active), but clouds over farmland were shallow and small in diameter (called as weak active). Case 2 (5/9/1986) has also weak active cumulus with a smaller vertical depth and case 3 (6/13/1986) had only forced cumuli. Four methods of decomposition of turbulence data have been employed: by land surface–cumulus regime, by proximity to clouds and clear areas (conditional sampling), by scale (frequency separation), and by turbulence process types (process partitioning). In the presence strong active cumuli from case 1, the turbulent fluxes and energy are intensified, due to the cloud 'root' effects. The strong active cumuli are initiated by warm–moist thermals. Since cumulus layer flux measurements were not made during the HAPEX experiment, different parameterization schemes have been used to estimate cloud layer fluxes. The schemes are: the simple cumulus flux scheme, the Betts–Miller adjustment scheme, an eddy diffusion scheme, and a new eddy diffusion scheme with counter–gradient term which is developed as a part of this study. For the strong active cumulus regime from case 1, the liquid water potential temperature and total water fluxes obtained from different parameterization schemes yield very similar

results. Unlike the other parameterization schemes, the new eddy diffusion scheme with a counter–gradient (non–local) term yields upward buoyancy fluxes which are in a good agreement with earlier studies. Additional tests of parameterization schemes were also applied to the weak active cumulus regime of case 1, but the weaker fluxes obtained did not agree with each other.
Dissert. Abstr.
Atmospheric Boundary Layer; Atmospheric Turbulence; Boundary Conditions; Cloud Cover; Cloud Physics; Cumulus Clouds; Parameterization; Planetary Boundary Layer; Turbulence Effects;

14 LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

No abstracts in this category.

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.

N96–22545*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
Research activities in applied mathematics, fluid mechanics, and computer science Final Report, 1 Apr. – 30 Sep. 1995
1 Nov. 1995 136 p
Contract(s)/Grant(s): (NAS1–19480; RTOP 505–90–52–01)
Report No.(s): (NASA–CR–198246; NAS 1.26:198246; NIPS–96–08344) Avail: CASI HC A07/MF A02

This report summarizes research conducted at the Institute for Computer Applications in Science and Engineering in applied mathematics, fluid mechanics, and computer science during the period April 1, 1995 through September 30, 1995.
Author
Algorithms; Computational Fluid Dynamics; Errors; Euler Equations of Motion; Hessian Matrices; Microstrip Antennas; Multidisciplinary Design Optimization; Multigrid Methods; Navier–stokes Equation; Parallel Processing (computers); Preconditioning; Research and Development; Turbulence Models; Unstructured Grids (mathematics); Very Large Scale Integration;

N96–23106* Washington Univ., Seattle, WA.
A reliable algorithm for optimal control synthesis Ph.D. Thesis
Vansteenwyk, Brett Harler; et al1 Jan. 1993 183 p
Report No.(s): (NIPS–96–07489) Avail: Univ. Microfilms Order No. DA9401482

In recent years, powerful design tools for linear time–invariant multi–variable control systems have been developed based on direct parameter optimization. In this dissertation, an algorithm for reliable optimal control synthesis using parameter optimization is presented. Specifically, a robust numerical algorithms is developed for the evaluation fo the H(sup 2)–like cost functional and its gradients with respect to the controller design parameters. The method is specifically designed to handle defective degenerate systems and is based on the well–known Pade series approximation of the matrix exponential. Numerical test problems in control synthesis for simple mechanical systems and for a flexible structure with densely packed modes illustrate positively the reliability of this method when compared to a method based on diagonalization. Several types of cost functions have been considered: a cost function for robust control consisting of a linear combination of quadratic objectives for deterministic and random disturbances, and one representing an upper bound on the quadratic objective for worst–case initial conditions. Finally, a framework for multivariable control synthesis has been developed combining the concept of closed–loop transfer recovery with numerical parameter optimization. The procedure enables designers to synthesize not only observer–based controllers but also controllers of arbitrary order and structure. Numerical design solutions rely heavily on the robust algorithm due to the high order of the synthesis models and the presence of near–overlapping modes. The design approach is successfully applied to the design of a high–bandwidth control system for rotorcraft.
Dissert. Abstr.
Algorithms; Control Systems Design; Controllers; Design Analysis; Feedback Control; Loop Transfer Recovery; Multivariable Control; Numerical Control; Optimal Control; Robustness (mathematics);

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.

N96–21520* Mississippi Univ., University, MS.
Sonic Boom Propagation Through a Realistic Turbulent Atmosphere Ph.D. Thesis
Boulanger, Patrice Marc; et al1 Jan. 1994 137 p
Report No.(s): (NIPS–96–34064) Avail: Univ. Microfilms Order No. DA9509512

The human subjective response to a sonic boom is conditioned by the value of the rise time and the shape of the

shock wave at ground level. Previous work in modeling sonic boom propagation from the craft to the ground through the planetary boundary layer has used a scattering center based model incorporating single scales of turbulence. The first model of the atmosphere presented here involves two scales each for convective and mechanical turbulence. The model was fit to the time autocorrelation of the fluctuating temperature and wind data collected during JAPE 2. Scattering calculations employing this model underpredict the number of perturbed waveforms when compared to the measured distributions during JAPE 2. The two scale model represents a significant improvement over the single scale model, however, the high occurrence of unperturbed rise times is an indication that the smaller and intermediate scales are needed to fully describe the scattering of sonic booms by turbulence. An improved model of the turbulent atmosphere using the von Karman spectrum is presented next. The JAPE 2 meteorological data are fit to a von Karman spectrum, and fit parameters are used to determine the number density of turbules needed to model the fluctuating atmosphere. The index of refraction for the turbules and the turbule numbers are varied to approximate the measured second and fourth moment of the index of refraction fluctuations. The turbule spatial and size distributions for each realization are determined by Monte Carlo methods. Another improvement to the scheme is the use of the measured height of the planetary boundary layer, and the altitude dependence of the index of refraction fluctuation. The maximum in the predicted rise time distribution shows good agreement with the measured one, but the shift of the distribution toward higher values is underpredicted. The predicted and measured distributions of peak overpressure agree reasonably well with the position of the measured maximum being slightly overpredicted.
Dissert. Abstr.
Atmospheric Models; Human Reactions; Meteorological Parameters; Planetary Boundary Layer; Sonic Booms; Temporal Distribution; Turbulence;

N96–22286*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
An efficient and robust method for predicting helicopter rotor high–speed impulsive noise
Brentner, Kenneth S.; et al1 Jan. 1996 14 p Presented at 34th Aerospace Sciences Meeting and Exhibit, Reno, NV, United States, 15–18 Jan. 1996
Report No.(s): (NASA–TM–111251; AIAA PAPER 96–0151; NAS 1.15:111251; NIPS–96–07966) Avail: CASI HC A03/MF A01

A new formulation for the Ffowcs Williams–Hawkings quadrupole source, which is valid for a far–field in–plane observer, is presented. The far–field approximation is new and unique in that no further approximation of the quadrupole source strength is made and integrands with r(exp –2) and r(exp –3) dependence are retained. This paper focuses on the development of a retarded–time formulation in which time derivatives are analytically taken inside the integrals to avoid unnecessary computational work when the observer moves with the rotor. The new quadrupole formulation is similar to Farassat's thickness and loading formulation 1A. Quadrupole noise prediction is carried out in two parts: a preprocessing stage in which the previously computed flow field is integrated in the direction normal to the rotor disk, and a noise computation stage in which quadrupole surface integrals are evaluated for a particular observer position. Preliminary predictions for hover and forward flight agree well with experimental data. The method is robust and requires computer resources comparable to thickness and loading noise prediction.
Author
Aeroacoustics; Aerodynamic Noise; Aircraft Noise; Horizontal Flight; Noise Prediction; Rotors;

N96–22325*# BBN Systems and Technologies Corp., Canoga Park, CA. Acoustic Technologies Div.
Noise–Induced Sleep Disturbance in Residences Near Two Civil Airports Final Report
Fidell, Sanford; Howe, Richard R.; Tabachnick, Barbara G.; Pearsons, Karl S.; and Sneddon, Matthew D.; et al1 Dec. 1995 138 p
Contract(s)/Grant(s): (NAS1–20101; RTOP 538–03–15–01)
Report No.(s): (NASA–CR–198252; NAS 1.26:198252; BBN–8096; NIPS–96–37153) Avail: CASI HC A07/MF A02

A large–scale field study of noise–induced sleep disturbance was conducted in the vicinities of Stapleton International Airport (DEN) and Denver International Airport (DIA) in anticipation of the closure of the former and opening of the latter. Both indoor and outdoor measurements of aircraft and other nighttime noises were made during four time periods. Measurements were made in 57 homes located as close as feasible to the runway ends of the two airports. Sleep disturbance was measured by several indices of behaviorally confirmed awakening (button pushes upon awakening) and body movement (as measured with wrist–worn actimeters). A total of 2717 subject–nights of observations were made over the course of the study. Although average noise event levels measured outdoors decreased markedly at DEN after closure of the airport and increased slightly at DIA after its opening, indoor noise event levels varied much less in homes near both airports. No large differences were observed in noise–induced sleep disturbance at either airport. Indoor sound exposure levels of noise events were, however, closely related to and good predictors of actimetrically defined motility and arousal.
Author
Airports; Biological Effects; Noise Intensity; Noise Measurement; Sleep Deprivation;

N96–22389* Georgia Inst. of Tech., Atlanta, GA.
Analytical investigations in aircraft and spacecraft trajectory optimization and optimal guidance Ph.D. Thesis
Markopoulos, Nikos; et al1 Jan. 1994 186 p
Report No.(s): (NIPS–96–33242) Avail: Univ. Microfilms Order No. DA9517134

A collection of analytical studies is presented related to unconstrained and constrained aircraft energy–state modeling and to spacecraft motion under continuous thrust. With regard to aircraft unconstrained energy–state modeling, the physical origin of the singular perturbation parameter that accounts for the observed two–time–scale behavior of aircraft during energy climbs is identified and explained. With regard to the constrained energy–state modeling, optimal control problems are studied involving active state–variable inequality constraints. Departing from the practical deficiencies of the control programs for such problems that result from the traditional formulations, a complete reformulation is proposed for these problems which, in contrast to the old formulation, will presumably lead to practically useful controllers that can track an inequality constraint boundary asymptotically, and even in the presence of two–sided perturbations about it. Finally, with regard to spacecraft motion under continuous thrust, a thrust program is proposed for which the equations of two–dimensional motion of a space vehicle in orbit, viewed as a point mass, afford an exact analytic solution. The thrust program arises under the assumption of tangential thrust from the costate system corresponding to minimum–fuel, power–limited, coplanar transfers between two arbitrary conics. The trajectory equation describing the above exact analytic solution is identical in form with the trajectory equation corresponding to Keplerian motion (motion with zero thrust). This solution can be used to satisfy boundary conditions corresponding to arbitrary coplanar transfer and escape problems. The thrust program can be used not only with power–limited propulsion systems, but also with any propulsion system capable of generating continuous thrust of controllable magnitude; in addition, for propulsion types and classes of transfers for which it is sufficiently optimal the results of this thesis suggest a method of maneuvering during planetocentric or heliocentric orbital operations, requiring a minimum amount of computation, and thus is uniquely suitable for real–time feedback guidance implementations. The results pertaining to the thrust program and to the exact analytic solution of the equations of motion are generalized to a much wider class of thrust programs, given the name the 'Keplerian class,' in an Addendum supplied at the end of the thesis.
Dissert. Abstr.
Aircraft Maneuvers; Climbing Flight; Flight Optimization; Flight Paths; Spacecraft Trajectories; Thrust Programming; Trajectory Optimization; Transfer Orbits;

N96–22392* Minnesota Univ., Duluth, MN.
The computation and analysis of helicopter impulsive noise Ph.D. Thesis
Xue, YU; et al1 Jan. 1994 166 p
Report No.(s): (NIPS–96–33261) Avail: Univ. Microfilms Order No. DA9514688

Helicopters have been proven to be economical and convenient vehicles with their ability to land, take off and maneuver in areas inaccesible to fixed–wing aircraft. However, the noise they generate can severely restrict their usage in both civilian and military operations. When it occurs, helicopter impulsive noise is the loudest and the most annoying. The noise usually can be broken down to high–speed impulsive noise and blade–vortex interaction noise. The physical phenomena of helicopter blade–vortex interaction are especially complicated and include three–dimensional unsteady transonic flow and regions of vorticity. A computational and analytical study of the helicopter impulsive noise has been conducted herein, particularly of the blade–vortex interaction noise. The fundamental theory and noise mechanisms are introduced and discussed. The computational study includes two–dimensional and three–dimensional approaches. The two–dimensional unsteady transonic small disturbance model was extended to control viscous effects and monotone switches. The noise generation mechanisms due to the blade–vortex interaction are discussed. A rotating Kirchoff method is developed to predict high–speed impulsive noise and blade–vortex interaction noise. A three–dimensional full potential CFD code was used for calculation of the nonlinear aerodynamic near–field, then a couple of extended Kirchoff formulations with a rotational control surface are used to compute the far–field acoustic signals. The computed numerical results showed a good agreement with experimental results. The results also identify the important parameters for impulsive noise control. The new rotating Kirchoff method can be used to predict the helicopter impulsive noise accurately and is believed to be better in many ways than other existing methods.
Dissert. Abstr.
Blade Slap Noise; Blade–vortex Interaction; Far Fields; Helicopters; Near Fields; Noise Generators; Sound Waves; Three Dimensional Flow; Transonic Flow; Unsteady Flow;

N96–23167*# Minnesota Univ., Minneapolis, MN. Dept. of Aerospace Engineering and Mechanics.
Aeroacoustics of Turbulent High–Speed Jets Final Report
Rao, Ram Mohan; and Lundgren, Thomas S.; et al1 Mar. 1996 37 p
Contract(s)/Grant(s): (NCC2–5017; DAAL03–89–C–0038)
Report No.(s): (NASA–CR–200282; NAS 1.26:200282; NIPS–96–39498) Avail: CASI HC A03/MF A01

Aeroacoustic noise generation in a supersonic round jet is studied to understand in particular the effect of turbulence

structure on the noise without numerically compromising the turbulence itself. This means that direct numerical simulations (DNS's) are needed. In order to use DNS at high enough Reynolds numbers to get sufficient turbulence structure we have decided to solve the temporal jet problem, using periodicity in the direction of the jet axis. Physically this means that turbulent structures in the jet are repeated in successive downstream cells instead of being gradually modified downstream into a jet plume. Therefore in order to answer some questions about the turbulence we will partially compromise the overall structure of the jet. The first section of chapter 1 describes some work on the linear stability of a supersonic round jet and the implications of this for the jet noise problem. In the second section we present preliminary work done using a TVD numerical scheme on a CM5. This work is only two–dimensional (plane) but shows very interesting results, including weak shock waves. However this is a nonviscous computation and the method resolves the shocks by adding extra numerical dissipation where the gradients are large. One wonders whether the extra dissipation would influence small turbulent structures like small intense vortices. The second chapter is an extensive discussion of preliminary numerical work using the spectral method to solve the compressible Navier–Stokes equations to study turbulent jet flows. The method uses Fourier expansions in the azimuthal and streamwise direction and a 1–D B–spline basis representation in the radial direction. The B–spline basis is locally supported and this ensures block diagonal matrix equations which are solved in O(N) steps. A very accurate highly resolved DNS of a turbulent jet flow is expected. Derived from text

Aeroacoustics; Aerodynamic Noise; Computational Fluid Dynamics; Flow Stability; Jet Aircraft Noise; Supersonic Jet Flow; Turbulence; Turbulent Jets;

N96–23266* Stanford Univ., CA.

Direct computation of aerodynamic sound Ph.D. Thesis

Colonius, Tim; et al1 Jan. 1994 220 p

Report No.(s): (NIPS–96–07931) Avail: Univ. Microfilms Order No. DA9429912

Aeroacoustic theory, which attempts to predict the acoustic far field produced by an unsteady flow, is well established for simple flows with compact vorticity fields. For turbulent shear flows which have extensive vorticity fields, a detailed agreement with experiment has been elusive, owing to a lack of knowledge of the structure of the acoustic sources. We examine the feasibility and accuracy of using the Navier–Stokes equations to directly compute (without models) a flow and its acoustic field. Given such information, aeroacoustic theory may be directly evaluated. A high–order–accurate numerical method for the Navier–Stokes equations is presented. Nonreflecting boundary conditions which allow the passage of sound waves and vortical structures through computational boundaries are developed. The efficacy of the method is firmly established by considering model problems including the scattering of sound waves by a vortex, and the sound generated by a two dimensional mixing layer. For vortex scattering, the sound waves are strongly refracted by the slowly decaying vortex flow, an effect incorrectly treated in previous theories. We develop a corrected theory which gives excellent agreement with the numerical results. For the mixing layer, the computations show that the acoustic field at the fundamental and first two subharmonic frequencies emanates from the region of the flow where the layer rolls up into vortices, and pairs twice, respectively. The acoustic waves produced by the pairings are beamed downstream, as previously observed by Laufer and Yen (1983) for the round jet. The acoustic field is also predicted by solving Lilley's equation; source terms necessary to solve the equation are determined from the Navier–Stokes computations. Predictions for the acoustic field based on our solution of Lilley's equation do not agree with the Navier–Stokes computations. Reasons for the discrepancy are examined in detail.

Dissert. Abstr.

Acoustic Scattering; Aerodynamic Noise; Shear Flow; Turbulent Flow; Unsteady Flow;

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.

N96–22756*# General Accounting Office, Washington, DC. National Security and International Affairs Div.

Report to the Ranking Minority Member, Subcommittee on Oversight of Government Management and the District of Columbia, Committee on Governmental Affairs, US Senate. Reengineering the Air Forces Logistics System Can Yield Substantial Savings

21 Feb. 1996 64 p

Report No.(s): (GAO/NSIAD–96–5; B–266259; NIPS–96–35700) Avail: CASI HC A04/MF A01

As part of GAO's continuing effort to review the Department of Defense's (DOD) inventory management practices, GAO compared the Air Force's management of its $33 billion reparable parts inventory with the operations of leading–edge private sector firms to identify opportunities where costs could be reduced and service improved. The review was done at the request of the Ranking Minority Member, Subcommittee on Oversight of Government Management and the District of Columbia, Senate Committee on Governmental Affairs. This report focuses on (1) best management practices used in the commercial airline industry to streamline logistics operations and improve customer service, (2) Air Force reengineering efforts to improve the responsive-

ness of its logistics system and reduce costs, and (3) barriers that may stop the Air Force from achieving the full benefits of its reengineeiing efforts.
Author
Civil Aviation; Commercial Aircraft; Congressional Reports; Inventory Management; Management Methods;

18 SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

N96–22296*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
Flowfield and acoustic characteristics of telescope cavity in SOFIA platform
Srinivasan, G. R.; et al 1 Jan. 1995 24 p Presented at AIAA 13th Applied Aerodynamcis Conference, San Diego, CA, United States, 19–22 Jun. 1995
Report No.(s): (NASA–TM–111252; AIAA PAPER 95–1862; NAS 1.15:111252; NIPS–96–07967) Avail: CASI HC A03/MF A01

Unsteady three–dimensional flowfields are calculated for the Stratospheric Observatory For Infrared Astronomy (SOFIA) at both free–flight cruise and wind tunnel conditions with a view to help in the design process of an acoustically quiet telescope cavity and to understand the flow physics of a three dimensional cavity. The calculation method is based on the numerical solution of thin layer Navier–Stokes equations on a Chimera overset grid system. The Boeing 747–200 aircraft is examined as one option for the SOFIA platform. The flowfield domain is composed of 45 grids consisting of over 4.1 million points. Numerical simulations are performed for both wind tunnel and free–flight cruise conditions at one freestream condition of M(infinity) = 0.85, alpha = 2.5 deg. Comparison of results from wind tunnel simulation show good agreement with experimental data for time–averaged surface pressures, drag for the empennage, and sound pressure levels and power spectra at various locations within the cavity and on the telescope. The presence of the open cavity induces an incremental drag increase, an increased acoustic radiation, and an increase in unsteady pressure loads on the telescope. Its impact on the effectiveness of aircraft control surfaces appears minimal.
Author
Cavities; Free Flow; Navier–stokes Equation; Sofia (airborne Observatory); Three Dimensional Flow; Three Dimensional Models;

19 GENERAL

N96–22603*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
Selected Examples of NACA/NASA Supersonic Flight Research
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The present Dryden Flight Research Center, a part of the National Aeronautics and Space Administration, has a flight research history that extends back to the mid–1940's. The parent organization was a part of the National Advisory Committee for Aeronautics and was formed in 1946 as the Muroc Flight Test Unit. This document describes 13 selected examples of important supersonic flight research conducted from the Mojave Desert location of the Dryden Flight Research Center over a 4 decade period beginning in 1946. The research described herein was either obtained at supersonic speeds or enabled subsequent aircraft to penetrate or traverse the supersonic region. In some instances there accrued from these research efforts benefits which are also applicable at lower or higher speed regions. A major consideration in the selection of the various research topics was the lasting impact they have had, or will have, on subsequent supersonic flight vehicle design, efficiency, safety, and performance or upon improved supersonic research techniques.
Author
Aircraft Control; Flight Tests; Ground Tests; NASA Programs; Research Aircraft; Research and Development; Supersonic Flight; Supersonic Speed;

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