Aerodynamic Analysis Of Aircraft Wing

An Applied Approach from Design to Concept Demonstration
Computational Mechanics Approach for Multidisciplinary Nonlinear Sensitivity Analysis
Analysis of Linked Aircraft Aerodynamics and Flight Dynamics
Aerodynamic Analysis for Aircraft with Nacelles, Pylons, and Winglets at Transonic Speeds
Classical Aerodynamic Theory
Aerodynamic Design and Analysis System for Supersonic Aircraft. Part 1: General Description and Theoretical Development
Nonlinear Aeroelastic Analysis of Aircraft Wing-with-store Configurations
Knowledge-Based Integrated Aircraft Design
On the Aerodynamic Analysis of a Modern All Electric Powered Blended Wing Body Aircraft with Bird Strike Resistance Device
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Rival Theories in Aerodynamics, 1909-1930
Aircraft Design Projects
Aircraft Aerodynamic Design with Computational Software
Fixed and Flapping Wing Aerodynamics for Micro Air Vehicle Applications
The Enigma of the Aerofoil
Initial Aerodynamic Analysis and Design of a Blended-wing-body Aircraft
Aerodynamic Analysis of an Over-the-wing Engine-mount Aircraft
Effects of Wing Modification on an Aircraft's Aerodynamic Parameters as Determined from Flight Data
Aerodynamic-structural Study of Canard Wing, Dual Wing, and Conventional Wing Systems for General Aviation Applications

SANTANA NICHOLSON

An Applied Approach from Design to Concept Demonstration Courier Corporation
This research continued work that began under the support of NASA Grant NAG1-2119. The focus of this effort was to continue investigations of Genetic Algorithm (GA) approaches that could be used to solve an actuator placement problem by treating this as a discrete optimization problem. In these efforts, the actuators are assumed to be "smart" devices that change the aerodynamic shape of an aircraft wing to alter the flow past the wing, and, as a result, provide aerodynamic moments that could provide flight control. The earlier work investigated issued for the problem statement, developed the appropriate actuator modeling, recognized the importance of symmetry for this problem, modified the aerodynamic analysis routine for more efficient use with the genetic algorithm, and began a problem size study to measure the impact of increasing problem complexity. The research discussed in this final summary further investigated the problem statement to provide a "combined moment" problem statement to simultaneously address roll, pitch and yaw. Investigations of problem size using this new problem statement provided insight into performance of the GA as the number of possible actuator locations increased. Where previous investigations utilized a simple wing model to develop the GA approach for actuator placement, this research culminated with application of the GA approach to a high-altitude unmanned aerial vehicle concept to demonstrate that the approach is valid for an aircraft configuration. Crossley, William A. and Cook, Andrea M. Langley Research Center
Computational Mechanics Approach for Multidisciplinary Nonlinear Sensitivity Analysis Cambridge University Press
Small Unmanned Fixed-wing Aircraft Design is the essential guide to designing, building and testing fixed wing UAVs (or drones). It deals with aircraft from two to 150 kg in weight and is based on the first-hand experiences of the world renowned UAV team at the UK’s University of Southampton. The book covers both the practical aspects of designing, manufacturing and flight testing and outlines and

the essential calculations needed to underpin successful designs. It describes the entire process of UAV design from requirements definition to configuration layout and sizing, through preliminary design and analysis using simple panel codes and spreadsheets to full CFD and FEA models and on to detailed design with parametric CAD tools. Its focus is on modest cost approaches that draw heavily on the latest digital design and manufacturing methods, including a strong emphasis on utilizing off-the-shelf components, low cost analysis, automated geometry modelling and 3D printing. It deliberately avoids a deep theoretical coverage of aerodynamics or structural mechanics; rather it provides a design team with sufficient insights and guidance to get the essentials undertaken more pragmatically. The book contains many all-colour illustrations of the dozens of aircraft built by the authors and their students over the last ten years giving much detailed information on what works best. It is predominantly aimed at under-graduate and MSc level student design and build projects, but will be of interest to anyone engaged in the practical problems of getting quite complex unmanned aircraft flying. It should also appeal to the more sophisticated aero-modeller and those engaged on research based around fixed wing UAVs.

Analysis of Linked Aircraft Aerodynamics and Flight Dynamics University of Chicago Press

Aerodynamic design of aircraft presented with realistic applications, using CFD software. Tutorials, exercises, and mini-projects provided involve design of real aircraft. Using online resources and supplements, this text prepares last-year undergraduates and first-year graduate students for industrial aerospace design and analysis tasks.

Aerodynamic Analysis for Aircraft with Nacelles, Pylons, and Winglets at Transonic Speeds John Wiley & Sons

This modern text presents aerodynamic design of aircraft with realistic applications, using CFD software and guidance on its use. Tutorials, exercises, and mini-projects provided involve design of real aircraft, ranging from straight to swept to slender wings, from low speed to supersonic. Supported by online resources and supplements, this toolkit covers topics such as shape optimization to minimize drag and collaborative designing. Prepares seniors and first-year graduate students for design and analysis tasks in aerospace companies. In addition, it is a valuable resource for practicing engineers, aircraft designers, and entrepreneurial consultants.

Classical Aerodynamic Theory DARcorporation

Morphing Wings Technologies: Large Commercial Aircraft and Civil Helicopters offers a fresh look at current research on morphing aircraft, including industry design, real manufactured prototypes and certification. This is an invaluable reference for students in the aeronautics and aerospace fields who need an introduction to the morphing discipline, as well as senior professionals seeking exposure to morphing potentialities. Practical applications of morphing devices are presented—from the challenge of conceptual design incorporating both structural and aerodynamic studies, to the most promising and potentially flyable solutions aimed at improving the performance of commercial aircraft and UAVs. Morphing aircraft are multi-role aircraft that change their external shape substantially to adapt to a changing mission environment during flight. The book consists of eight sections as well as an appendix which contains both updates on main systems evolution (skin, structure, actuator, sensor, and control systems) and a survey on the most significant achievements of integrated systems for large commercial aircraft. Provides current worldwide status of morphing technologies, the industrial development expectations, and what is already available in terms of flying systems Offers new perspectives on wing structure design and a new approach to general structural design Discusses hot topics such as multifunctional materials and auxetic materials Presents practical applications of morphing devices

Aerodynamic Design and Analysis System for Supersonic Aircraft. Part 1: General Description and Theoretical Development

Createspace Independent Publishing Platform

Written with students of aerospace or aeronautical engineering firmly in mind, this is a practical and wide-ranging book that draws together the various theoretical elements of aircraft design - structures, aerodynamics, propulsion, control and others - and guides the reader in applying them in practice. Based on a range of detailed real-life aircraft design projects, including military training, commercial and concept aircraft, the experienced UK and US based authors present engineering students with an essential toolkit and reference to support their own project work. All aircraft projects are unique and it is impossible to provide a template for the work involved in the design process. However, with the knowledge of the steps in the initial design process and of previous experience from similar projects, students will be freer to concentrate on the innovative and analytical aspects of their course project. The authors bring a unique combination of perspectives and experience to this text. It reflects both British and American academic practices in teaching aircraft design. Lloyd Jenkinson has taught aircraft design at both Loughborough and Southampton universities in the UK and Jim Marchman has taught both aircraft and spacecraft design at Virginia Tech in the US. * Demonstrates how basic aircraft design processes can be successfully applied in reality * Case studies allow both student and instructor to examine particular design challenges * Covers commercial and successful student design projects, and includes over 200 high quality illustrations

Nonlinear Aeroelastic Analysis of Aircraft Wing-with-store Configurations

Butterworth-Heinemann

Just when classic subject areas seem understood, the author, a Caltech, M.I.T. and Boeing trained aerodynamicist, raises profound questions over traditional formulations. Can shear flows be rigorously modeled using simpler “potential-like” methods versus Euler

equation approaches? Why not solve aerodynamic inverse problems using rapid, direct or forward methods similar to those used to calculate pressures over specified airfoils? Can transonic supercritical flows be solved rigorously without type-differencing methods? How do oscillations affect transonic mean flows, which in turn influence oscillatory effects? Or how do hydrodynamic disturbances stabilize or destabilize mean shear flows? Is there an exact approach to calculating wave drag for modern supersonic aircraft? This new book, by a prolific fluid-dynamicist and mathematician who has published more than twenty research monographs, represents not just another contribution to aerodynamics, but a book that raises serious questions about traditionally accepted approaches and formulations – and provides new methods that solve longstanding problems of importance to the industry. While both conventional and newer ideas are discussed, the presentations are readable and geared to advanced undergraduates with exposure to elementary differential equations and introductory aerodynamics principles. Readers are introduced to fundamental algorithms (with Fortran source code) for basic applications, such as subsonic lifting airfoils, transonic supercritical flows utilizing mixed differencing, models for inviscid shear flow aerodynamics, and so on – models they can extend to include newer effects developed in the second half of the book. Many of the newer methods have appeared over the years in various journals and are now presented with deeper perspective and integration. This book helps readers approach the literature more critically. Rather than simply understanding an approach, for instance, the powerful “type differencing” behind transonic analysis, or the rationale behind “conservative” formulations, or the use of Euler equation methods for shear flow analysis when they are unnecessary, the author guides and motivates the user to ask why and why not and what if. And often, more powerful methods can be developed using no more than simple mathematical manipulations. For example, Cauchy-Riemann conditions, which are powerful tools in subsonic airfoil theory, can be readily extended to handle compressible flows with shocks, rotational flows, and even three-dimensional wing flowfields, in a variety of applications, to produce powerful formulations that address very difficult problems. This breakthrough volume is certainly a “must have” on every engineer’s bookshelf.
Elsevier
Aerodynamic analysis of an over-the-wing engine-mount aircraft.
Knowledge-Based Integrated Aircraft Design Linköping University Electronic Press
In this work, the Ce-Liner aircraft developed by Bauhaus Luftfahrt is selected as our research target, and the aircraft has a C-wing design. This C-wing assembly is based on a non-planar three-surface configuration: the main wing, side wing and top wing. This work implement ANSYS FLUENT to simulate whether this aircraft can reduce the generation and strength of wingtip vortices during cruise, and whether it can

improve the efficiency of the aircraft with better economic benefits. The DLF-F6 model need to be validate first, and current numerical results compared with experimental values seems ensure the correctness of our approach. Consequently, the same numerical method and grid generation technique will be implemented for the overall Ce-Liner, and it can be found that this C-wing design has a very significant aerodynamic benefit due to the reduction of wingtip vortices. Our Ce-Liner configuration can increase the lift-to-drag efficiency by about 20 percent during cruise. Because this Ce-Liner is an all-electric aircraft, it can greatly reduce the weights of the turbofan engine and fuel, thus the high-lift devices can be eliminated, which could further reduce the mechanical complexity of the wing and the production or maintenance cost. Furthermore, this Ce-Liner will not need to stock fuel in the main wing, hence the thickness and weight of the wing could be further reduced. In addition, it is found that this aircraft configuration has a stronger crosswind resistance capability due to our gust crosswind simulation. Thus our research indeed justifies the requirements of the European Union project Flightpath 2050, and confirm that this Ce-Liner configuration can contribute to the cleaner sky for future environment.
On the Aerodynamic Analysis of a Modern All Electric Powered Blended Wing Body Aircraft with Bird Strike Resistance Device Elsevier Aerodynamic Analysis for Aircraft with Nacelles, Pylons, and Winglets at Transonic SpeedsAerodynamic Analysis of a Fighter Aircraft with a Higher Order Paneling Method Aerodynamic Analysis of a Fighter Aircraft with a Higher Order Paneling Method Aerodynamic Analysis for Aircraft with Nacelles, Pylons, and Winglets at Transonic SpeedsAerodynamic Analysis of a Fighter Aircraft with a Higher Order Paneling MethodThis report presents results from analyses of steady and unsteady flows about several configurations involving the wing of the F-5 fighter airplane. The analyses were performed using higher order panel methods and the configurations analyzed included the following: the clean wing (both in an unbounded and in a wind tunnel wall bounded atmosphere), the wing with an external missile store mounted at the wing tip, and the wing with an external missile store mounted on a pylon at the lower surface of the wing. The flow mach number ranged from 0.6 to 1.35 in steady flow and from 0.6 to 0.95 in unsteady flow. Each steady flow case is analyzed at three angles of attack (0.5 deg, 0.0 deg, 0.5 deg) while each unsteady flow case consisted of unsteady pitch oscillation about zero angle of attack. The reduced frequency of the oscillation was in the range from 0.2498 to 0.3955. The computed results include chordwise pressure distributions along wing sections at eight spanwise locations from 18.1 to 97.7 per cent semispan. The results also include the coefficients of lift and pitching moment for each complete configuration as well as the coefficients of aerodynamic force and couple arising from the pressure on only the surface of the missile store. (Author).Utilization

of the Wing-body Aerodynamic Analysis ProgramAerodynamic Analysis of an Over-the-wing Engine-mount AircraftAerodynamic analysis of an over-the-wing engine-mount aircraft.Aerodynamic Analysis of the Joined-wing Configuration of a HALE AircraftEffects of Wing Modification on an Aircraft's Aerodynamic Parameters as Determined from Flight DataAerodynamic Analysis of Slipstream/wing/nacelle Interference for Preliminary Design of Aircraft ConfigurationsInitial Aerodynamic Analysis and Design of a Blended-wing-body AircraftAerodynamic Analysis of the Joiined-wing Configuration of a High-altitude, Long-endurance (hale) AircraftThe three-dimensional, unsteady, flow is simulated over the joined-wing section of a HALE (High-Altitude Long Endurance) aircraft based on the Sensorcraft configuration. This is the first step in the high-fidelity, nonlinear aeroelastic analysis of the HALE aircraft. These vehicles operate in a high-altitude, low-density, low-Reynolds number (Re) environment. Also, the sensor Equipment housed within the wings requires the sections to be thick. In order to produce the necessary lift, the wings of these aircraft are made extremely long compared to the average chord of the wing section, leading to aspect ratios typically around 25. The fluid loads experienced by the structure result in these high-aspect ratio wings undergoing large deflections. These can cause appreciable change in the geometry, and hence, in the corresponding flow, and necessitate an aeroelastic analysis. The flow solution is obtained by solving the Reynolds-Averaged Navier-Stokes (RANS) governing equations, using the Spalart-Allmaras turbulence model, or by using Detached Eddy Simulation (DES). The flow solver, COBALT60 is a finite-volume, cell-centered, second-order accurate in space and time, unstructured-grid flow solver. With successful completion of the validation cases, simulations were performed at the lower and upper limits (M = 0.4-0.6, [alpha] = 0-12‘) of the operating regime of the Sensorcraft. Inviscid simulations were also considered as a computationally efficient alternative to viscous simulations for the computation of the surface pressure loads to be applied on the structure, particularly at low angle of attack ([alpha] = 0‘). This is verified by performing inviscid simulations, and comparing the resulting pressure with the corresponding viscous results at the Mach number of 0.6. The surface pressure comparison is satisfactory for this low angle of attack (? = 0‘), whereas at? = 12‘, the presence of flow separation in the joint region, and a mild oblique shock at the trailing edge of the aft wing in the joint region results in significant viscous effects. A procedure has been set up for the preliminary process of load transfer to the joined-wing structure. The study serves as the foundation to provide an integrated aerodynamic and structural analyses software using a Multi-Disciplinary Computing Environment (MDICE) to predict the aeroelastic behavior of lifting bodies.Static Aeroelastic Analysis for Generic Configuration AircraftRotary-wing Aerodynamics

The three-dimensional, unsteady, flow is simulated over the joined-wing section of a HALE (High-Altitude Long Endurance) aircraft based on the Sensorcraft configuration. This is the first step in the high-fidelity, nonlinear aeroelastic analysis of the HALE aircraft. These vehicles operate in a high-altitude, low-density, low-Reynolds number (Re) environment. Also, the sensor Equipment housed within the wings requires the sections to be thick. In order to produce the necessary lift, the wings of these aircraft are made extremely long compared to the average chord of the wing section, leading to aspect ratios typically around 25. The fluid loads experienced by the structure result in these high-aspect ratio wings undergoing large deflections. These can cause appreciable change in the geometry, and hence, in the corresponding flow, and necessitate an aeroelastic analysis. The flow solution is obtained by solving the Reynolds-Averaged Navier-Stokes (RANS) governing equations, using the Spalart-Allmaras turbulence model, or by using Detached Eddy Simulation (DES). The flow solver, COBALT60 is a finite-volume, cell-centered, second-order accurate in space and time, unstructured-grid flow solver. With successful completion of the validation cases, simulations were performed at the lower and upper limits (M = 0.4-0.6, [alpha] = 0-12‘) of the operating regime of the Sensorcraft. Inviscid simulations were also considered as a computationally efficient alternative to viscous simulations for the computation of the surface pressure loads to be applied on the structure, particularly at low angle of attack ([alpha] = 0‘). This is verified by performing inviscid simulations, and comparing the resulting pressure with the corresponding viscous results at the Mach number of 0.6. The surface pressure comparison is satisfactory for this low angle of attack (? = 0‘), whereas at? = 12‘, the presence of flow separation in the joint region, and a mild oblique shock at the trailing edge of the aft wing in the joint region results in significant viscous effects. A procedure has been set up for the preliminary process of load transfer to the joined-wing structure. The study serves as the foundation to provide an integrated aerodynamic and structural analyses software using a Multi-Disciplinary Computing Environment (MDICE) to predict the aeroelastic behavior of lifting bodies.

Study for the Optimization of a Transport Aircraft Wing for Maximum Fuel Efficiency. Volume 1: Methodology, Criteria, Aeroelastic Model Definition and Results
Cambridge University Press
This title reports on the latest research in the area of aerodynamic efficency of various fixed-wing, flapping wing, and rotary wing concepts. It presents the progress made by over fifty active researchers in the field.

Vehicle thermal Management Systems Conference and Exhibition (VTMS10)
AIAA
Why do aircraft fly? How do their wings support them? In the early years of aviation, there was an intense dispute between British and German experts over the question of why and how an aircraft wing provides lift. The British, under the leadership of the great Cambridge mathematical

physicist Lord Rayleigh, produced highly elaborate investigations of the nature of discontinuous flow, while the Germans, following Ludwig Prandtl in Göttingen, relied on the tradition called “technical mechanics” to explain the flow of air around a wing. Much of the basis of modern aerodynamics emerged from this remarkable episode, yet it has never been subject to a detailed historical and sociological analysis. In The Enigma of the Aerofoil, David Bloor probes a neglected aspect of this important period in the history of aviation. Bloor draws upon papers by the participants—their restricted technical reports, meeting minutes, and personal correspondence, much of which has never before been published—and reveals the impact that the divergent mathematical traditions of Cambridge and Göttingen had on this great debate. Bloor also addresses why the British, even after discovering the failings of their own theory, remained resistant to the German circulation theory for more than a decade. The result is essential reading for anyone studying the history, philosophy, or sociology of science or technology—and for all those intrigued by flight.

Proceedings of a Workshop on V/STOL Aircraft Aerodynamics

John Wiley & Sons

Blended-wind-body (BWB) is one of the most economical aircraft configuration, and all-electric aircraft will be the future mainstream by reducing pollutions. Bird strikes have always been a major aviation safety problem, so a cone-shaped bird-strike prevention net in front of electric fan inlet is invented. Objectives of this study are the aerodynamic analyses of all-electric powered BWB and bird strike resistance net. After validation of DLR F6 model, same numerical simulation tools then applied to our designated configurations. Major research findings are (1) invention of an all-electric ducted-fan with enough thrust produced for take-off and cruise, (2) detailed investigation of BWB's aerodynamic characteristics during cruise (0.7 Mach and FL280) with power on situation, and (3) estimation of its take-off and landing field lengths. It is found that our bird strike resistance net account for about 19% of total drag, and our findings will be helpful for next generation aircraft design, while future optimization of current electric ducted-fan engine and BWB configuration might still be needed, thus represent more potential growth in its aerodynamic performance.

Small Unmanned Fixed-wing Aircraft Design

This book contains the papers presented at the IMechE and SAE International, Vehicle Thermal Management Systems Conference (VTMS10), held at the Heritage Motor Centre, Gaydon, Warwickshire, 15-19th May 2011. VTMS10 is an international conference organised by the Automobile Division and the Combustion Engines and Fuels Group of the IMechE and SAE International. The event is aimed at anyone involved with vehicle heat transfer, members of the OEM, tier one suppliers, component and software suppliers, consultants, and academics interested in all areas of thermal energy management in vehicles. This vibrant conference, the tenth VTMS, addresses the latest analytical and development tools and techniques, with sessions on: alternative powertrain, emissions, engines, heat exchange/manufacture, heating, A/C, comfort, underhood, and external/internal component flows. It covers the latest in research and technological advances in the field of heat transfer, energy management, comfort and the efficient management of all thermal systems within the vehicle. Aimed at anyone working in or involved with vehicle heat transfer Covers research and technological advances in heat transfer, energy management, comfort and efficient management of thermal systems within the vehicle

For Engineering Students

In this research, I have analyzed different aircrafts with nonconventional wings. The analyses have included aerodynamic modeling, flight dynamics and trajectory optimization. Two different nonconventional aircrafts are analyzed, a V-shape morphing wings and a Linked UAV system. A modern adaptation of Prandtl's liftingline method is utilized to analyze the aerodynamics of both systems. This method can compute the aerodynamic forces for a system of lifting surfaces with arbitrary camber, sweep, dihedral, position and orientation. The V-shape morphing wings consist of a wing configuration that has two panels, an out-of-plane dihedral section and a horizontal section. An analysis of the aircraft turning dynamics shows that by manipulating the dihedral angles, of the V-shape wings, either by symmetric or asymmetric wing shape changes, can affect the turning capabilities of an aircraft to perform a variety of different missions depending on the importance of each of the turning performance measurements. A linked UAV concept, where individual UAVs link at high altitude, creates an aerodynamically efficient system of aircraft which has long endurance capabilities and can cruise for extended periods with significantly reduced power loads. This dissertation presents an analysis of close proximity aerodynamics and aircraft dynamics of two Linked UAVs. As the UAVs approach each other for wingtip docking there are strong aerodynamic coupling between their wings tips. An aerodynamic disturbance intensity field has been generated, utilizing both simulation and wind tunnel data, to determine a trajectory for the two UAVs to approach each other for midair docking. Finally, two optimal trajectories, a 2-D and 3-D docking trajectories are generated and compared. Dynamic wind tunnel test are performed to compare different midair wingtip docking trajectories. The results of the optimization concludes that a trajectory with a span-wise approach is more desirable since it goes through the least aerodynamic disturbances and requires less control effort to perform the midair docking maneuver.

Structural Analysis of an Equivalent Box-wing Representation of Sensorcraft Joined-wing Configuration for High-Altitude, Long-Endurance (HALE) Aircraft

The current research focuses on studying the modal response of a joined wing aircraft based on the Sensorcraft configuration. Sensorcraft, a class of High-Altitude, Long-Endurance (HALE) aircraft, is an Unmanned Air Vehicle (UAV), and is being studied by the AFRL for applications involving telecommunication relay, environmental sensing and military reconnaissance. The Sensorcraft is designed to operate at high altitudes (60,000 ft) with low speed and for long durations of time (60 to 80 hours). At these operating conditions, the density, and hence, the Reynolds number, is low. These conditions require the Sensorcraft to operate with high lift and low drag with high-aspect ratio wings. Moreover, the vehicle must be lightweight and strong, and offer high aerodynamic performance and efficiency. The AFRL has identified a diamond shape joined wing configuration for Sensorcraft due to the primary structural advantage of strength as each wing braces the other against lift loads. The University of Cincinnati (UC), along with its partners, AFRL and Ohio State University are working together to study the complete nonlinear aeroelastic behavior of the joined-wing model. At UC, four different structural modeling approaches were adopted for analysis. The current research focuses on the analysis of an in-house Sensorcraft joined wing model developed by the AFRL. This model is an equivalent representation of the actual 3-D joined wing model. The wing is idealized as a box structure consisting of shells, rods, beams, shear panels and concentrated masses. This box wing structure has the advantage of being computationally inexpensive over the full 3-D model, and has been optimized to minimize the deflections of the antennae equipment in the control surface of the wing. The fluid loads applied on the box-wing structure are obtained from a concurrent aerodynamic analysis for different mach numbers and angles of attack performed at UC. A modal representation is obtained for different operating boundary conditions as the first step in the overall aeroelastic analysis of the joined wing. AFRL has obtained the modal representation for the Sensorcraft model using NASTRAN, and as part of the DAGSI project requirement, the structural analyses at UC are performed using ANSYS. The results are compared with those from NASTRAN and the correctness of the methodology is verified. Prior to the NASTRAN box-wing model translation into ANSYS, a number of validation tests are performed to test the consistency between the functionalities of the ANSYS elements and NASTRAN elements. Once the results of the validation test cases are found to be satisfactory, the actual analysis of the joined wing is performed for clamped, rigid and symmetry boundary conditions at the wing roots. The frequencies were found to be different between the two codes for each of these boundary conditions. In order to trace the issue causing the differences in the results, a number of simpler joined wing models are analyzed. Finally, the problem is traced down to differences in the formulation between the constraint equations in ANSYS and RBE1 elements in NASTRAN. Due to the assumption of small deflections, linear static analysis is performed and considered sufficient for predicting the displacement response. However, a nonlinear analysis is also performed to validate the assumptions of linearity that have been used in the modeling of the wing.

The tip deflection from linear is estimated to be 5.3 % of the span of the wing. For higher angles of attack, the pressure difference between the upper and lower surfaces of the wing is higher, and consequently the lift forces are greater in magnitude. This could cause larger deformation in the main wing that could potentially lead to buckling of the aft wing. Hence, an eigenvalue buckling analysis is performed which show that the wing is stable and not prone to buckling for the loads employed for the linear static analysis. A procedure is also established to determine the structural response under time varying aerodynamic loads from the CFD analysis. This analysis serves as a starting point for future complete aeroelastic analysis of the joined wing.

Modern Aerodynamic Methods for Direct and Inverse Applications

In this thesis a methodology for designing wings for transport aircraft operating at high subsonic speed is investigated. Several methods are studied, including more accurate methods such as the computational methods. These are used as an addition to the semi-empirical methods. Several attempts have been made to build a computerised aircraft design in the past. Mos *t of the conceptual aircraft design programs that are available are based on the semi-empirical method only. As faster computers become available, a method for designing a high subsonic aircraft wing is studied by including computational aerodynamic and computational structural analysis in the integration process. SPARV is used as the computational aerodynamic program and NASTRAN is used as the computational structural analysis program. The objectives of this thesis are to study a method of performing, the conceptual design of win_qs for transport aircraft operatin_q at high subsonic speed and to demonstrate that aerodynamics analysis using, Computational Fluid Dynamics (CFD) and structures analysis using the Finite Element Method (FEM), can be coupled with the aircraft synthesis program in a seamless distributed computing environment. The achievement of these objectives is demonstrated by, applying the methodology to specific wing design. This method has been validated and tested for transport aircraft operating at high subsonic speed, but application on military transports may also be valid. An example case study is presented in this thesis. Improvement of the method for future development is also considered in the thesis. These include the use of a more powerful computational aerodynamics package.

A System for Aerodynamic Design and Analysis of Supersonic Aircraft: General description and theoretical development

This report presents results from analyses of steady and unsteady flows about several configurations involving the wing of the F-5 fighter airplane. The analyses were performed using higher order panel methods and the configurations analyzed included the following: the clean wing (both in an unbounded and in a wind tunnel wall bounded atmosphere), the wing with an external missile store mounted at the wing tip, and the wing with an external missile store mounted on a pylon at the lower surface of the wing.

The flow mach number ranged from 0.6 to 1.35 in steady flow and from 0.6 to 0.95 in unsteady flow. Each steady flow case is analyzed at three angles of attack (0.5 deg, 0.0 deg, 0.5 deg) while each unsteady flow case consisted of unsteady pitch oscillation about zero angle of attack. The reduced frequency of the oscillation was in the range from 0.2498 to 0.3955. The computed results include chordwise pressure distributions along wing sections at eight spanwise locations from 18.1 to 97.7 per cent semispan. The results also include the coefficients of lift and pitching moment for each complete configuration as well as the coefficients of aerodynamic force and couple arising from the pressure on only the surface of the missile store. (Author).

Large Commercial Aircraft and Civil Helicopters

The author examines nonlinear aeroelastic responses of air vehicle systems. Herein, the governing equations for a cantilevered configuration are developed and the methods of analysis are explored. Based on the developed nonlinear bending-bending-torsion equations, internal resonance, which is possible in future air vehicles, and the possible cause of limit cycle oscillations of aircraft wings with stores are investigated. The nonlinear equations have three types of nonlinearities caused by wing flexibility, store geometry and aerodynamic stall, and retain up to third-order nonlinear terms. The internal resonance conditions are examined by the Method of Multiple Scales and demonstrated by time simulations. The effect of velocity change for various physical parameters and stiffness ratio is investigated through bifurcation diagrams derived from Poinar þe maps. The dominant factor causing limit cycle oscillations is the stiffness ratio between in-plane and out-of-plane motion.