MASTER OF SCIENCE
IN
AERONAUTICAL ENGINEERING

THREE-COMPONENT LDV MEASUREMENTS OF CORNER VORTICES OVER SECOND-GENERATION, CONTROLLED-DIFFUSION, COMPRESSOR BLADES IN CASCADE
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A detailed investigation of the three-dimensional flow in a cascade of second-generation controlled-diffusion compressor stator blades, at off-design inlet-flow angle, is reported. Three-component fiber-optic Laser-Doppler Velocimetry (LDV) surveys were made to fully map the flow at one plane upstream of the cascade and at three planes downstream. The measurements were performed at an inlet flow Mach number of 0.22 and a Reynolds number, based on chord length, of 640,000. The inlet surveys documented the approaching flow field in detail to establish the inlet boundary conditions for numerical simulations. At the downstream planes, total velocity distributions, total turbulence kinetic energy distributions, secondary flow velocity vector and contour plots are presented. The downstream surveys confirmed the existence of secondary flow vortices produced by the end wall. Surface vector and contour plots of non-dimensional velocity and total turbulence kinetic energy detail the complex flow field, including the size and location of the corner vortex system.

HI-FIDELITY SIMULATION AND PREDICTION OF HELICOPTER SINGLE POINT EXTERNAL LOAD STABILIZATION
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The helicopter has been used since its early development for external transport of large or bulky loads to small austere locations. Among the problems encountered as lift capability and airspeeds increased was that of divergent load oscillations due to load aerodynamics The most problematic are the single point external loads displaying unsteady aerodynamics and coupled yaw-pendulum modes accounting for the instability of cargo containers. However, a lack of simulation models for unsteady aerodynamics renders simulation and analysis incapable of predicting the critical speeds at which such loads become unstable. This thesis attempts to provide a stabilization system for controlling the yaw degree of freedom for the single point external load. Empirical models of the yaw resistance at the hook and of the yaw moments due to vortex shedding were developed and tuned using flight test data and lab measurements. Several load stabilization systems were considered, and a horizontal and vertical tail fin assembly was selected This thesis presents simulation model improvements required for a simulation to match flight results for the load yaw, along with the design, modeling and optimization of the fin stabilization system, and a simulation assessment of the envelope expansion obtained from both passive and active stabilization.

SUPERSONIC FLOW FIELD VISUALIZATION STUDIES OF THE M∞= 6 PRICE WAVERIDER PLANFORM

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Supersonic tests of the conical flow derived M∞ = 6 (design) Price waverider planform were conducted using the Naval Postgraduate School wind tunnel. These tests are part of a continuing effort to study the characteristics of waverider configured vehicles. Two sting-mounted, flat-plate stainless-steel Price waverider planform models were utilized for testing in the NPS 4-inch by 4-inch cross section supersonic blowdown wind tunnel. Tests at Mach numbers of M∞ = 1.7, 2.8 and 4 were attempted but flowfield studies were only completed at M∞ = 4. Sting mount flow blockage (choked flow) prevented test section starting at freestream test Mach numbers of M∞ = 1.7 and 2.8. Horizontal (side-view) and vertical (top-view) mounted shadowgraph pictures and pressure sensitive paint images were taken at pitch angles of α = 0˚, 2˚ and 4˚. The Mach 4 shadowgraph and pressure sensitive paint results correlate well with previous CFD results using the three-dimensional Price waverider model. The choked flow tests at M∞ = 1.7 and 2.8 are discussed in detail; suggestions are given for future work in this Mach number test spectrum.

HARDWARE INTEGRATION OF PARACHUTE GUIDANCE, NAVIGATION, AND CONTROL FOR THE AFFORDABLE GUIDED AIRDROP SYSTEM (AGAS)

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This study is a continuation of a previous work concerning the Affordable Guided Airdrop System (AGAS), a parachute structure that integrates low-cost guidance and control into fielded cargo air delivery systems. This thesis sought to integrate the previous studies and algorithms into developmental prototypes for test and evaluation (DT&E). Several objectives and tasks were completed in the course of this research and development. A RealSim® executable on an Integrated Systems, Incorporated (ISI) AC-104 real-time controller integrated actual Vertigo®, pneumatic muscle actuators (PMAs) into the MATRIX-X. The environment simulation model used in the previous work to validate, analyze and improve the simulation model. A ground station utilizing the model's control algorithms, a downlink of platform position and attitude data, and a Futaba® Pulse Code Modulated uplink demonstrated controlled guidance of a round cargo parachute (G-12). This system evolved as an RS-232 serial control RF modem uplink replaced the PCM control. After evaluating, validating, and improving the algorithms using the ground station control algorithm was written in C-code for incorporation into an autonomous system. The results from the drops were then analyzed in the MATRIX_X ® to further improve the model and qualitatively evaluate improved control strategies. Conclusions and recommendations for further study were drawn from this project.

PRELIMINARY DESIGN CODE FOR AN AXIAL STAGE COMPRESSOR

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Current two-dimensional preliminary design codes use structured programming, which is rigid and does not allow the user to vary parameters easily. This study uses object-oriented programming to allow the user to vary all selectable parameters in a familiar Windows operating environment. The programmed design is

based on the assumptions of axial and free-vortex flow between blade rows, simple radial equilibrium, and a thermally and calorically perfect gas. The program allows a fan or core stage design and uses an open architecture to facilitate upgrades and extensions.

Using the Naval Postgraduate School's (NPS) transonic compressor design as input, the preliminary design code output was compared to the detailed throughflow design of the transonic compressor. The results agreed reasonably well with detailed throughflow design. With some minor improvements this code can easily be used to develop a preliminary design that can be optimized to the user's requirements.