# MASTER OF SCIENCE
# IN
# AERONAUTICAL ENGINEERING

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**EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF THE ENDWALL FLOW IN A CASCADE OF COMPRESSOR BLADES**

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An investigation of the three-dimensional flow in a cascade of second-generation controlled-diffusion blades, which was as a result of the interaction of the endwall boundary layers with the blade profiles, is reported. Five-hole probe wake surveys were performed at various spanwise locations to determine the total pressure loss distribution. Downstream velocity vector information was also obtained from the five-hole probe surveys. Two-component laser-Doppler velocimetry (LDV) was used to characterize the flow in the inlet and wake regions. A numerical investigation of the flowfield was conducted using SWIFT, a computational fluid dynamics code developed by Dr. Roderick Chima of NASA Glenn Research Center. Experimental blade-surface pressure coefficients were compared with values predicted using SWIFT. Overall, good correlation between the five-hole probe and LDV measurement techniques was obtained; however, the CFD predictions did not match well with the experimental results, particularly at the midspan location of the blade where separation of the suction surface boundary layer occurred.

**DoD KEY TECHNOLOGY AREA:** Aerospace Propulsion and Power

**KEYWORDS:** Laser Doppler Velocimetry, Controlled-Diffusion Compressor Blading

**INCORPORATION OF ENHANCED GROUND PROXIMITY WARNING SYSTEM (EGPWS) IN THE NASA AMES RESEARCH CENTER CAE BOEING 747-400 FLIGHT SIMULATOR**

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The NASA Ames Research Center CAE Boeing 747-400 flight simulator is used primarily for the study of human factors in aviation safety. The simulator is constantly upgraded to maintain a configuration match to a specific United Airlines aircraft and maintains the highest level of FAA certification to ensure credibility to the results of research programs. United's 747-400 fleet and hence the simulator are transitioning from the older Ground Proximity Warning System (GPWS) to the state-of-the-art Enhanced Ground Proximity Warning System (EGPWS). GPWS was an early attempt to reduce or eliminate Controlled Flight Into Terrain (CFIT). Basic GPWS alerting modes include: excessive descent rate, excessive terrain closure rate, altitude loss after takeoff, unsafe terrain clearance, excessive deviation below glideslope, advisory callouts and windshear alerting. However, since GPWS uses the radar altimeter which looks straight down, ample warning is not always provided. EGPWS retains all of the basic functions of GPWS but adds the ability to "look ahead" by comparing the aircraft position to an internal database and provide additional alerting and display capabilities. This thesis evaluates three methods of incorporating EGPWS in the simulator and describes the implementation and architecture of the preferred option.

**DoD KEY TECHNOLOGY AREA:** Air Vehicles

**KEYWORDS:** Enhanced Ground Proximity Warning System, Ground Proximity Warning System, Controlled Flight Into Terrain, Terrain Alerting and Display, Terrain Clearance Floor, Flight Simulator, NASA

**VISION-BASED NAVIGATION FOR AUTONOMOUS LANDING OF UNMANNED AERIAL VEHICLES**

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The role of Unmanned Aerial Vehicles (UAVs) for modern military operations is expected to expand in the 21st Century, including increased deployment of UAVs from Navy ships at sea. Autonomous operation of UAVs from ships at sea requires the UAV to land on a moving ship using only passive sensors installed in the UAV. This thesis investigates the feasibility of using passive vision sensors installed in the UAV to estimate the UAV position relative to the moving platform. A navigation algorithm based on photogrammetry and perspective estimation is presented for numerically determining the relative position and orientation of an aircraft with respect to a ship that possesses three visibly significant points with known separation distances. Original image processing algorithms that reliably locate visually significant features in monochrome images are developed. Monochrome video imagery collected during flight test with an infrared video camera mounted in the nose of a UAV during actual landing approaches is presented. The navigation and image processing algorithms are combined to reduce the flight test images into vehicle position estimates. These position estimates are compared to truth data to demonstrate the feasibility of passive, vision-based sensors for aircraft navigation. Conclusions are drawn, and recommendations for further study are presented.

**DoD KEY TECHNOLOGY AREAS:** Air Vehicles, Computing and Software, Sensors

**KEYWORDS:** Unmanned Aerial Vehicle, Navigation, Infrared Imaging, Image Processing, MATLAB®, Simulation

**EXPLORATION OF FIBRE CHANNEL AS AN AVIONICS INTERCONNECT FOR THE 21ST CENTURY MILITARY AIRCRAFT**

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Avionics architectures are evolving from "Federated" systems consisting of highly specialized black boxes connected together via MIL-STD-1553 and ARINC 429 data buses to "Integrated" and "Distributed" architectures. These new architectures contain high data-rate sensors, parallel processors, and shared memory with high levels of integration. These systems require a new interconnection system that overcomes the limitations of older standards. One such interconnection system is Fibre Channel. This thesis evaluates Fibre Channel as avionics interconnection standard. It begins by defining the requirements and measures of performance for an interconnection system suitable for the new avionics architectures. The requirements address technical performance, affordability, reliability, sustainability, and maintainability considerations. The Fibre Channel standards are then compared to the requirements for the avionics interconnection system. In order to perform a technical performance evaluation of a switched fabric avionics interconnection system, a computer simulation model was developed. The OPNET

Modeler® tool from OPNET, Inc. was used to model the components of an advanced avionics system. The results of this simulation demonstrated that Fibre Channel meets all the performance requirements of an avionics interconnect.

**DoD KEY TECHNOLOGY AREAS:** Air Vehicles, Computing and Software, Electronics, Modeling and Simulation

**KEYWORDS:** Fibre Channel, Interconnect, Avionics, Bandwidth, Modeling, Simulation