Thesis Topics for 2009

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In 2009, I am offering thesis topics in the following projects;

A: Variable Stability Flight Simulator
B: Jabiru Flight Laboratory (JabLab)
C: Vision Systems for Flight Guidance
D: Predictive Control for Terminal Guidance (landing)
E: Flight stability experiment – free flying wing in wind tunnel

My approach to selection of candidates for these topics is to accept nominations for each topic, and then to choose the most suitable person for the job. Expressions of interest can be made by emailing me. Expressions from multiple students are acceptable as students working on each project will work as a team. I will arrange a meeting later in 2nd semester with all interested parties and will assign individual responsibilities.

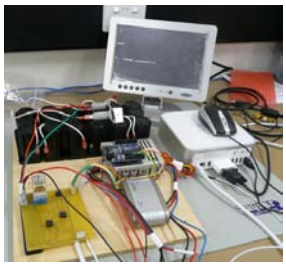
Project Descriptions:

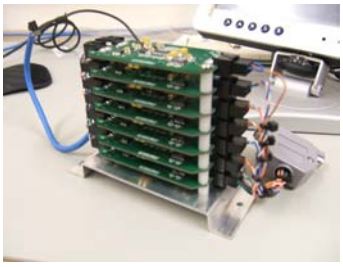
A: Variable Stability Flight Simulator

The Variable Stability Flight Simulator is a facility aimed at providing enhanced learning opportunities in courses and topics related to Flight Mechanics. It allows students and researchers to study the effects of variations in an aircraft's aerodynamic characteristics on flight stability, controllability and handling qualities. The simulator is set up to allow the simulation of any type of aircraft, and to allow implementation and testing of control system designs in real time. It has been equipped with the necessary avionics hardware to facilitate these activities, and the compatible software is being developed via thesis projects. Much progress has been made in recent towards these goals. Further developments are intended in 2009. Detailed goals are outlined in the table below. These involve development of individual hardware and software components of the simulation system, and modelling of a range of aircraft with interesting and varied dynamic behaviours.

More detailed information the facility and recent thesis work can be found at the project web page http://www.aeromech.usyd.edu.au/vsfs/ and the Flight Mechanics Thesis web page http://www.aeromech.usyd.edu.au/flightm/aero4950/aero4950.html where resources and previous theses are available.

B: Jabiru Flight Laboratory





The Jabiru Flight Laboratory is based on the School's J400 four seat Jabiru. This has being fitted out with a glass cockpit avionics system, a suite of flight sensors and a data acquisition system to measure all flight characteristics. The complete system will provide a flight test capability that will facilitate teaching and learning in flight test techniques, as well as research into flight stability, avionics systems and flight control system development.

This project is nearing maturity. The sensor and data acquisition systems are due to be installed before the end of 2009. Subsequent work will involve calibration of sensors, data fusion and integration with research projects in visual guidance and predictive control.

More detailed information the facility and recent thesis work can (soon) be found at the project web page http://www.aeromech.usyd.edu.au/JabLab and the Flight Mechanics Thesis web page http://www.aeromech.usyd.edu.au/flightm/aero4950/aero4950.html where resources and previous theses are available.

C: Vision Systems for Flight Guidance and Control

This is a new research initiative involving the use of vision systems (cameras) and image processing techniques to detect important visual features like horizons and runways characteristics in the interests providing feedback information for the control of an aircraft. Initially the concepts will be investigated by simulation via Matlab/Simulink and the VSFS. These activities will be aided in 2009 by acquisition and analysis of real flight imagery using the Jabiru Flight laboratory.

D: Predictive Control for Terminal Guidance

This project aims to develop new flight control methodologies for critical flight phases such as landing. In these flight phases the control lags associated with conventional feedback control methods become unwieldy. Predictive control methods promise to overcome these problems by taking pre-emptive action in order to bring the aircraft to an acceptable landing. This is particularly important in crosswinds and turbulence. A new method of predictive control is to be implemented and evaluated with the aid of simulation.

E: Wind Tunnel Dynamic Flight Stability Experiment

This project involves the development of wind tunnel models to demonstrate the dynamic characteristics of aircraft stability and response. The experiments demonstrate the effects of tail volume coefficient on Neutral Point and investigate static margin effects of stability. Experiments will generate virtual data for implementation as a virtual online experiment to be integrated in the AERO3560 Flight Mechanics 1 course. The web site is partially complete and development will continue in 2009. The experiments are being extended to demonstrate stability augmentation using feedback control.

Detailed duties in each of these projects are outlined in the following table …..

Detailed Duties

Topic	Title	Priority	Description of Duty
A1	Autopilot Control System Development	**High**	Aim: To complement the Mode Control Panel and Flight Management System developments with control system design and evaluation. Hardware and software development using Simulink. Development of control laws for various aircraft. Demonstration of their effects and variations. One of the goals here is to develop the software systems to a point where control designs in Assignment 4 of AERO4560 Flight Mechanics 2 can be integrated and trialled to reinforce learning. Preparation for implementation of the laboratory exercise in 2009 is involved. I would like also to investigate the application of predictive control techniques to general flight control applications for various aircraft.
A2	Flight Simulator Aircraft Models	**Medium**	Aim: To Implement various aircraft models in the Flight Simulator. Research aerodynamic derivative characterisation for various aircraft. Implementation of database and polynomial representation of aerodynamic data. Simulation of aircraft dynamics. Some of this may involve completion of current aircraft modelling initiatives.
A3	Flight Simulation Software Systems	**High**	Aim: To develop plugins to control third-party software systems like X-plane or MS Flight Simulator to provide landscape imagery and instrument displays. This project furthers significant developments that have lead to the large scale integration of X-Plane graphics upgrades into the simulator. More work is required to streamline plugin operation and integration so that the simulation operation is seamless. Extension can be considered to the integration with MS Flight Simulator as this has new higher integrity graphics. Integration of other avionics software systems is also desirable. **May require C/C++**
A4	Variable Stability Simulation Development	**High**	Aim: Continue development of the Variable Stability Module and implement it in F.M teaching programme. Involves development of software interfaces, organisation of data structures and storage methods, transmission between PC's and real-time implementation in the Real-Time simulation. Development of interfaces through which the operator of the Simulator modifies flight stability, controls flight modes and options, weather conditions, instrument and system failures etc. This

			interface also will give flight path plots of the scenarios flown, and will store trajectory data for later analysis. Navigation aids and communication to simulation core. This project involves research associated with organising and assessing the effectiveness of the simulation in teaching flight stability and control. **May requires C/C++**
A5	Flight Simulator Propulsion Models and Landing system dynamics	**High**	Aim: Develop generic dynamic models for four basic engine types and undercarriage dynamics. Currently only turbofan models are implemented. It is desired to generate generic models for the other three engine types and to make them selectable in the flight simulator. A good generic dynamics model of aircraft undercarriage systems is required to improve the landing dynamics. Implementation in Simulink in real-time.
A6	F111 Flight simulation and control (** Subject to completion in 2008)	**Medium**	Aim: To implement F111C flight dynamics model in the Flight Simulator. Develop database system, polynomial derivative representations and interfacing routines for Simulink. Model control systems and implement dynamics model. Develop control laws and routines, interface with MCP.
A7	** Aircraft spinning simulation	**Medium**	Aim: To develop a simulation of aircraft spinning for the Flight Simulator. Develop Simulink spinning model, implement databases in Simulink. Test results in simulation.
A8	** Sidestick development and integration	**Medium**	Aim: To develop sidesticks for alternative method of controlling the simulation. This may involve some mechanical and electronic work, including simulink software development, I/O and control.
B1	Jabiru Flight test and control lab	**High**	Aim: Complete the installation of flight test equipment and perform full aircraft flight test programme. Sensor and computer system design and integration. Sensor calibration. Software preparation, data acquisition, test and analysis procedures. Flight test programme, data acquisition and analysis. This involves some flight in the aircraft for flight test manoeuvre evaluation and data collection for analysis. An end goal is to develop a complete characterisation of the aircraft's dynamics for simulation if the VSFS.
B2	Jabiru Avionics System Assessment	**Medium**	Aim: Integrate and assessment of the EFIS/One avionics system. This will involve electronic interfacing associated with installation and integration with the Flight Test equipment (B1). The primary goals are the assessment of the operation of the system in flight, and of its use and utility in teaching future avionics course units.

C	Vision Systems for Flight Guidance	**High**	Aim: To develop vision processing techniques to analyse flight response data from camera images. This will involve acquisition of camera images of typical flight scenery like horizons and runways. The focus is on detecting important features in the scene that can be identified and tracked in order to determine the aircraft state for subsequent use in control. Initially the techniques can be developed and analysed using matlab. Simulation of the image processing, data analysis and feedback control integration can be simulated together with a flight simulation in order to evaluate closed loop performance. Involves implementation of algorithms in real-time for integration into data acquisition systems. The intention is to develop navigation filters to accurately track the aircraft state. - Tight coupling of the image processing algorithms with inertial data. - Robustification of feature detection algorithms - Extension to detection of general features for automated visual navigation.
D	Predictive Control for Terminal Guidance	**High**	Aim: To develop predictive control strategies and to evaluate them for terminal guidance. This project involves the development of algorithms to evaluate a new technique for predictive control. The aim is to implement this technique in terminal flight phases in order to evaluate control performance improvement offered by the predictive feature. This can be done by comparison with conventional control designs via flight simulation. The study will evaluate control of landing approach and flare in calm, crosswind and turbulent conditions. A global aim is to integrate this approach with visual navigation to provide guidance indicators to the pilot via a flight director and to research the effectiveness as a flight control aid. - Another element will aim to develop the basic principles of a new predictive control technique. This is new research that will require a very good student with good mathematical skills. Very challenging.
E1	Static Stability experiment and Web development	**Medium**	Aim: Wind-tunnel test to demonstrate static stability of a wing and wing/tail combinations. Complete experimental equipment set-up. Perform wind tunnel experiments and develop web page. Develop Labview software to acquire data and run flight control loops. This may require conversion to Visual C for an interested student with suitable skills.