MAE 482 - Flight Simulation for Aircraft Safety

SYLLABUS

Fall Semester 2013

Instructor: Dr. Mario Perhinschi
521 Engineering Sciences Building
304-293-3301
Mario.Perhinschi@mail.wvu.edu

Course main topics:
- Definition of the aircraft health management concept;
- Description of upset flight conditions and their effects on aircraft dynamics and aerodynamics;
- Principles of modeling aircraft sub-system abnormal conditions;
- Design of simulator tests for abnormal condition analysis;
- Dynamic signatures and impact on performance of aircraft actuator, sensor, propulsion, and structural failures;
- Impact of upset environmental condition on aircraft performance;
- Introduction to system fault detection;
- Introduction to control schemes for accommodation of aircraft sub-system abnormal conditions.

Textbook:
No textbook is required. Handouts will be provided with relevant material.

Pre-requisites:
MAE365 Flight Dynamics or consent of instructor.

Recommended:
Prior experience with Matlab and Simulink.

Course objectives:
- Description of aircraft health management systems;
- Review of the most common abnormal flight conditions for fixed and rotary wing aircraft;
- Analysis of causes and dynamic effects of abnormal flight conditions;
• Assessment of dynamic signatures and impact on performance of abnormal flight conditions through simulation and tests using PC-based simulation and a 6-DOF motion-based flight simulator;
• Overview of general methodologies for abnormal flight conditions detection and accommodation through automated control laws.

Learning outcomes:
At the end of this course, the students should be able to:
• Explain the role, motivation, and means of aircraft health management systems;
• Describe the general conditions and effects of the most frequent abnormal flight conditions;
• Analyze the effects of abnormal flight conditions on aircraft control, handling qualities, and performance;
• Design and perform tests on PC-based and motion-based flight simulators followed by data processing and interpretation for the analysis of dynamic signatures and impact on performance of abnormal flight conditions;
• Describe the most commonly used methods for fault detection and accommodation and explain their principles.

Course structure:
1½ hour lectures and laboratory sessions - TR 2.00-3.15pm in G24 – Simulation Lab. Motion-based flight simulator tests may be scheduled at different times.
Help/problem sessions - if necessary.
Office hours: TR 3.30-5.30 pm. If necessary and possible, individual appointments at different times may be scheduled.

Web Site Access:
Use your MIX account to access http://ecampus.wvu.edu/. Lecture notes, handouts, homework, additional material, and announcements will be posted there. Check your eCampus e-mail account often. Note: E-mail within eCampus is NOT automatically forwarded to your MIX account.

Homework/ Simulation Analysis Reports:
Homework/Simulation Analysis Reports are individual assignments unless they are specifically assigned as a team/group effort. Homework/Simulation Analysis Reports are due at the beginning of the class on due date. Late
submissions are penalized 10% credit per day. Note: all simulation analyses are performed using desktop computer simulation tools and/or the WVU 6 – DOF motion-based flight simulator. There will be 6 simulation labs and 2 homework assignments for this course.

Tests/Quizzes:
There will be 3 announced tests and 2 announced quizzes, but no final exam. The tests will consist of designing simulation experiments with pre-determined objective (e.g. detect and analyze an actuator failure), perform them, and analyze the results. The quizzes will have a standard format including questions and problems that the student is expected to answer/solve.

Attendance:
You are strongly encouraged to attend lectures, although it is not mandatory. If you miss a class, you are responsible for the material covered in class, irrespective of your absence. It is strongly discouraged to miss a test, quiz, or a lab session. Unless you notify me in advance of the scheduled activity time, I may not generate a makeup. Students must attend all lab sessions and perform all simulation analyses for a passing grade.

Grading:
Tests 7% each = 21% A= 90% - 100%
Quizzes 6% each = 12%  B= 80% - 89%
Homework 6.5% each= 13%  C= 70% - 79%
Simulation analyses 9% each = 54%  D= 60% - 69%
                      F= <60%

Neatness and clarity are important for all assignments.

Academic Integrity Statement:
The integrity of the classes offered by any academic institution solidifies the foundation of its mission and cannot be sacrificed to expediency, ignorance, or blatant fraud. Therefore, I will enforce rigorous standards of academic integrity in all aspects and assignments of this course. For the detailed policy of West Virginia University regarding the definitions of acts considered to fall under academic dishonesty and possible ensuing sanctions, please see the Student Conduct Code at:
Should you have any questions about possibly improper research citations or references, or any other activity that may be interpreted as an attempt at
academic dishonesty, please see me before the assignment is due to discuss the matter.

**Inclusivity Statement:**
The West Virginia University community is committed to creating and fostering a positive learning and working environment based on open communication, mutual respect, and inclusion. If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with the Office of Disability Services (293-6700). For more information on West Virginia University's Diversity, Equity, and Inclusion initiatives, please see [http://diversity.wvu.edu](http://diversity.wvu.edu).
Tentative Course Schedule

**Week #1:**
I. Aircraft health management – definition and motivation. Selected examples of aviation accidents and their causes.
II. Introduction to WVU simulation tools. HW#01. Design of a flight simulator experiment.

**Week #2:**
I. Airplane and rotorcraft actuator failures: types, effects, and modeling.
II. Simulation Lab #01. Assess and analyze the dynamic effects of aircraft actuator failures.

**Week #3:**
I. Simulation Lab #01 (cont’d).
II. Test #01 – Design and perform a test in the WVU motion base flight simulator to detect and analyze an actuator failure.

**Week #4:**
I. Aircraft sensor failures: types, effects, and modeling. Aircraft propulsion failures and structural damages.
II. Simulation Lab #02. Assess and analyze the dynamic effects of aircraft sensor failures.

**Week 5:**
I. Simulation Lab #02 (cont’d).
II. Test #02 – Design and perform a test in the WVU motion base flight simulator to detect and analyze a sensor failure.

**Week 6:**
I. Simulation Lab #03. Assess and analyze the dynamic effects of aircraft propulsion system failure and structural damage.
II. Test #03 – Design and perform a test in the WVU motion base flight simulator to detect and analyze a propulsion failure or damage on main structural components.

**Week 7:**
I. Environmental upset conditions: atmospheric turbulence, wind and wind shear, icing.
II. Simulation Lab #04. Evaluate the impact of environmental upset conditions on pilot workload and pilot+aircraft performance.

**Week 8:**
I. Parameter identification and estimation – a conceptual overview.
II. Parameter identification and estimation – a conceptual overview (cont’d).

**Week 9:**
I. Introduction to artificial intelligence techniques. Quiz #01.
II. Introduction to artificial intelligence techniques (cont’d).

**Week 10:**
I. Introduction to system fault detection. HW #02.
II. Introduction to system fault detection (cont’d).

**Week 11:**
I. Aircraft sub-system abnormal condition detection,
II. Aircraft sub-system abnormal condition detection, identification, and evaluation (cont’d).

Week 12:  
I. Simulation Lab #05. Experimenting the use of abnormal condition detection schemes based on parameter identification and artificial intelligence techniques.
II. Simulation Lab #05 (cont’d).

Week 13:  
I. Introduction to automatic accommodation of aircraft sub-system abnormal conditions.
II. Control architectures with fault tolerant capabilities.

Week 14:  
Thanksgiving break.

Week 15:  
I. Control architectures with fault tolerant capabilities (cont’d). Quiz #02.
II. Simulation Lab #06. Experimenting the use of fault tolerant control laws at post failure conditions.

Week 16:  
I. Simulation Lab #06 (cont’d).
II. Final discussions and conclusion.