Advanced Flight Control Systems (AFCS) Theory & Practice Short Course:

This short course includes 5 days of background academics and laboratory exercises covering pertinent aspects of flight control systems and theory. Additionally, this course prepares attendees for Advanced Flight Control Systems Part I and II flying courses, however, it is not a prerequisite.

DAY 1 - Monday

1. Review coordinate systems and transformations (Body, Wind, NED)
2. Review of six degree of freedom equations of motion
3. Develop a physical feel for the six degree of freedom equations of motion
4. Review linear and non-linear stability and control derivatives used in analysis, wind tunnel formulations, and experimental flight test
5. **Hands on laboratory** - Mass-Spring-Damper theory and SIMULINK model
6. HOMEWORK - Take home quiz – aircraft stability and control derivatives (NO MATLAB NEEDED)

DAY 2 - Tuesday

1. Simplify 6 degree of freedom equations of motion to longitudinal 3 degrees of freedom
2. **Hands on laboratory** - Create a longitudinal 3 degrees of freedom equations of motion SIMULINK model (Piloted Simulation). This includes flight visuals (Flight Gear) and a joystick
3. Develop a physical feel for linear and non-linear longitudinal stability and control derivatives

DAY 3 - Wednesday

Hands on laboratories:

1. Discuss pitch capture task. Show relevance to flight test practices
2. Develop a physical feel for longitudinal linear and non-linear stability and control derivatives using 3-DOF model and pitch capture tasks (Flight Gear and Joystick provided)
3. Discuss typical flying qualities maneuvers. Leverage maneuverer catalog and flying qualities maneuvers
4. Develop a physical feel for longitudinal/lateral/directional linear and non-linear stability and control derivatives using 6-DOF variable stability graphical user interface (Flight Gear and Joystick provided)
5. Introduce transfer functions, explain the meaning of various longitudinal and lateral directional transfer functions for classical first order, second order, fourth order, etc. Relate transfer functions to aircraft motion
6. HOMEWORK – Take home quiz – practical transfer functions (NO MATLAB NEEDED)

DAY 4 - Thursday

1. Explain feedback stability augmentation
2. Describe inner loop and outer loop design concepts and significance
3. Specify outer loop modes and functional attributes
4. Determine mode performance as it applies to stability, damping, bandwidth, and frequency response
5. Use command response, disturbance rejection, command tracking, and gain scheduling
6. Match sensors and computational error sources with error compensation methods
7. Give control mode examples for altitude, airspeed, and landing flare modes
8. Discuss angle of attack, pitch rate, and N_z flight controls responses from a pilot and engineer perspective
9. Describe flight control system hardware architectures and components
10. HOMEWORK – Take home quiz on various flight control concepts (NO MATLAB NEEDED)

Hands of laboratories:

1. Overview of feedback, forward, feed forward, and command paths
2. Discuss various elements in each path i.e. actuators, sensors, notch filters, etc.
3. Using transfer functions discussed – run bode plot script (provided)
4. Using transfer functions discussed – run root locus script (provided)
5. Using transfer functions discussed – run Nyquist and Nichols script (provided)
6. Introduce higher order system with actuators, sensors, notch filters, etc.
7. Using higher order system and root locus stabilized an unstable aircraft (provided)
    a. To simplify the example we will only use pitch rate feedback (i.e. analog version of F-16 emergency mode)

Note: all examples will be provided. We will run, discuss, and modify examples to enhance learning.

DAY 5 - Friday

1. **Hands on laboratory** - Fly short period augmentation SIMULINK model (Flight Gear and Joystick)
2. **Hands on laboratory** – Fly pitch rate SIMULINK model (Flight Gear and Joystick)
3. **Hands on laboratory** – Fly N_z SIMULINK model (Flight Gear and Joystick)
4. Review Pitch Rate Command/Hold Algorithm theory
5. **Hands on laboratory** - Tune and fly 3 degree of freedom Pitch Rate Command/Pitch Attitude Hold SIMULINK model (Flight Gear and Joystick)
6. Discuss N_zU (flight path rate with speed stability). Develop an overall understanding of important blocks.
    a. Show derivation – N_z versus gamma dot for constant airspeed. Discuss sensor choices including advantages and disadvantages

COST IS $ 2,995.00 PER ATTENDEE