Title: *Next Possible FG&C developments Using Up-front Function Integration to Achieve Improved Operational Safety, Performance Consistency Between Modes, Architectural Design Simplification, Reusability and Cost Reductions*

Course Abstract:

Competition drives airframe companies to focus on cost and flight safety. This course examines the drivers of cost and flight safety related to Flight Guidance & Control system design. Design complexities have an adverse impact on both. The course examines the reasons behind extraordinary systems complexities and their impact on flight safety as documented in the accident and incident records. It is concluded that to a large extend the increase in FG&C system complexities with each airplane generation can be explained by two factors: new functionality and the difficulty of integrating new functionality with legacy design concepts. Examples: 1) adding full flight envelope protection to legacy automatic control designs; 2) integrating automatic and FBW manual control. Next, the course shows how many FG&C system complexities can be eliminated and most automation safety issues can be addressed by from-the-ground-up redesign, using strategies for up-front functional integration of modes, mode logic and system interfaces with the cockpit. It involves 1) generalization and normalization of control mode functions to eliminate sub-modes and function overlap and achieve mode compatibility and adaptation to airplane type and flight condition; 2) use of MIMO-based Core Controllers for longitudinal and lateral-directional control that serve all control modes (including FBW manual mode); 3) full flight regime design with inherent envelope protection; 4) building block modular design, directly reusable on different airplane types. The guiding design principles for these concepts, including insights in basic airplane control dynamics relationships will be discussed. It will also be shown how the generalized control strategy can be implemented in the Primary Flight Display to visualize control cues to allow the pilot to efficiently use the control effectors during manual control to guide the airplane to preselected control reference targets and to aid the flight crew to effectively monitor automatic control mode operations.

The final section of the course will examine the evolution of FG&C Redundant Hardware Architectures, starting from the earlier analog designs and progressing to today's digital architectures and RM concepts. It will be shown that up-front integration of FG&C functions opens up opportunities co-hosting of functions to simplify the Architecture of Hardware Redundancy needed to maintain flight safety under failure conditions. Some new ideas will be offered to eliminate the need for back-up control modes and simplify control surface actuation design.