Ph.D. in Information Technology
Thesis Defense

June 6th, 2025
At 4:30 p.m.
Room Carlo Erba – Building 7

José Joaquín MENDOZA LOPETEGUI – XXXVII Cycle

DESIGN AND DEVELOPMENT OF ADVANCED AIRCRAFT GROUND HANDLING CONTROL SYSTEMS FOR SAFE HUMAN-IN-THE-LOOP CONTROL
Supervisor: Prof. Mara Tanelli

Abstract:

During landings, aircraft reach considerable speeds during the rollout phase, which makes them susceptible to stability problems both in the longitudinal and lateral directions. Runway excursions are a key concern, where human error, aircraft system faults, and poor runway conditions are among the most common causes of such accidents. In the longitudinal direction, the pilot is typically assisted by an anti-skid system that prevents wheel locking upon brake application and maximizes braking performance. However, most of the workload associated with maintaining directional stability falls on the pilot, who must operate multiple actuators and correct any asymmetries that deviate the aircraft from its intended path. The coupling between the longitudinal and lateral dynamics, potential actuator failures, and unforgiving environmental conditions can lead to a challenging task. Moreover, the pilot's efforts to control the aircraft can couple with the aircraft's response counter-productively and give rise to the dreaded phenomenon of pilot-induced oscillations (PIOs).

In this thesis, we develop advanced aircraft ground handling control systems to improve stability, maneuverability, and safety. We propose several levels of assistance and constructively build increasingly more autonomous features. First, we analyze the ground handling dynamics and develop a high-fidelity multibody simulation model validated with experimental data. We also develop control-oriented models and uncover key subsystems and parameters contributing to directional problems. Then, we develop and experimentally validate directional stability-aware anti-skid systems that simultaneously ensure state-of-the-art braking performance and enhance directional stability. Next, we propose stability augmentation systems to reduce the likelihood of PIOs by acting on key aircraft actuators. Subsequently, we develop an active lateral assistance system robust to actuator failures and adverse environmental conditions that provides correction commands for enhanced maneuverability. We successfully validate the approach with human-in-the-loop simulations. Finally, we propose an innovative on-ground maneuvering system that can autonomously handle the rollout and taxiing phase for full pilot workload reduction.

PhD Committee

Prof. Giulio Panzani, **Politecnico di Milano**

Prof. Michel Basset, **University of Upper Alsace (UHA)**

Dr. Clement Roos, **Onera**