

**Ph.D. in Information Technology
Thesis Defense**

June 4th, 2026

At 2:00 p.m.

Sala Riunioni PT1 - Building 20A

Beatrice MELANI – XXXVIII Cycle

**A STRUCTURED FRAMEWORK FOR REQUIREMENT SPECIFICATION AND
VALIDATION SUPPORTING FLIGHT CONTROL SYSTEMS DESIGN**

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Abstract:

The thesis proposes a structured framework for requirement specification and validation tailored to the development of rotorcraft Flight Control Systems (FCSs). The framework is designed to comply with certification regulations and aerospace standards and to align with Systems Engineering (SE) guidelines. It is introduced to support the transition from a document-based to a Model-Based Systems Engineering (MBSE) approach where structured domain models are adopted as the primary means of information exchange and system representation. Grounded in a function-based perspective, the developed framework establishes coherent relationships among functions, requirements, and architectures, ensuring consistency and traceability across all levels of system definition.

Starting from a thorough literature review that consolidates heterogeneous standards and practices into a unified conceptual foundation, the thesis introduces a general framework that organizes SE activities into a logical sequence, while accommodating their iterative and recursive nature, and clarifies dependencies between different entities (functions, requirements, architecture). A comprehensive categorization of requirements is defined, supported by informal, semi-formal, and formal specification methods that balance compliance with standards against usability for engineers. To support requirement validation, an algorithm is introduced for assessing consistency of formalized requirements. The algorithm is integrated within a novel software tool that enables requirement authoring, automated translation into formal languages, and coverage and syntactic correctness checks. Additionally, an optimization algorithm for logical architectures is presented, reducing dependencies between subsystems and simplifying interface management, with downstream benefits for physical architectures and overall engineering efficiency.

The framework and associated tools address key challenges in aerospace engineering, including regulatory compliance, the need for readability of requirements alongside formal rigor, the early validation of requirements, the problem of lack of tool interoperability and consequent issue with traceability. By embedding requirement specification and validation within a coherent MBSE process, this work contributes to advancing both methodological rigor and practical efficiency in the engineering of rotorcraft FCSs. Interestingly, the developments in this thesis are generalizable to other complex and safety-critical domains.

PhD Committee

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