POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 41st cycle

THEMATIC Research Field: MODEL-BASED DESIGN, SIMULATION, AND VALIDATION OF SATELLITES SYSTEMS

Monthly net income of PhDscholarship (max 36 months)
1600.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The rapid growth of space exploration, driven by both institutional space agencies and private companies, is leading to increasingly complex missions with higher performance requirements. Space missions integrate cutting-edge technologies while meeting stringent standards of reliability, robustness, and operational efficiency. As the scale and ambition of space missions expand, so does the necessity for rigorous and repeatable system-level validation. Simulation environments play a critical role in this context, providing the foundation for early verification and validation throughout the development cycle. However, current practices often rely on disjointed setups, where transitions between Model-in-the-Loop (MiL), Software-in-the-Loop (SiL), Processor-in-the-Loop (PiL), and Hardware-in-the-Loop (HiL) stages are not smoothly integrated. This fragmentation can lead to inefficiencies, inconsistencies, and increased development risk. Moreover, the lack of a uniform and modular simulation framework limits reusability across missions and platforms.This PhD project aims to design and implement a unified simulation pipeline based on model-based design principles, with a strong focus on modularity, scalability, and repeatability. The objective is to reinforce and consolidate the transition between MiL, SiL, PiL, and HiL, so ensuring that models developed at early stages remain valid and compatible throughout the entire verification process. The final goal is to create a simulation framework that closely mirrors real-world

	operations, enabling more accurate testing, earlier fault detection, and a significant reduction in time-to-deployment for satellite systems.
Methods and techniques that will be developed and used to carry out the research	The proposed PhD project aims to 1) reinforce the integration and continuity between the MiL, SiL, PiL, and HiL simulation stages, and 2) establish a robust model-based simulation pipeline to support reliable, modular, and high-fidelity satellite development. The methodology will adopt a multi-layered and modular approach to represent the satellite system through all verification phases.The research is structured into four key methodological pillars: 1) Development of modular and parameterizable satellite models, starting from first-principles physics and control theory, that can be reused across missions; 2) Implementation of a model-driven simulation framework, enabling automatic transition from functional (MiL) to code-based (SiL and PiL) simulations via auto-code generation and embedded integration techniques; 3) Design and realization of a real-time hardware integration architecture to support HiL simulations with physical components and embedded processors, ensuring consistency in timing, data handling, and real-world behaviour; 4) Development of validation and verification (V&V) strategies, including automated testing, requirements traceability, and performance metrics monitoring, to ensure simulation fidelity and reduce human intervention in model transitions.This PhD project intends to create a reference pipeline for future space missions, where simulation models are born with a system-wide vision and are engineered to accompany the system throughout its entire lifecycle, from concept to hardware validation.
Educational objectives	The objective of this PhD is to develop skills in space system modelling, simulation, verification and validation. Through this project, the candidates will develop skills in mathematical modeling, numerical analysis, computer programming (Matlab, Python, C++, or similar), and cyber security. Moreover, the candidate will develop skills on both computer and processor/hardware-in-the-loop simulations. Soft skills in disseminating the research,

	writing reports, performing outreach, and preparing industrial progress meetings will be also achieved through the PhD project.
Job opportunities	The current research prepares the PhD candidate to both academic and industrial careers. Knowledge of model-based system engineering, modeling and simulation of space systems are fundamental skills for careers in space-related companies and universities.
Composition of the research group	1 Full Professors 1 Associated Professors 5 Assistant Professors 26 PhD Students
Name of the research directors	Francesco Topputo

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	800.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
The candidate will be hosted in the DART Lab (Deep-space Astrodynamics Research &Technology Laboratory) at the Department of Aerospace Science and Technology, Politecnico di Milano. During the PhD program, the candidate will have access to the facilities of the DART Lab to carry out experimental activities. The candidate will also have the opportunity to attend some PhD classes on both soft and hard skills. Moreover, there could be the possibility to carry out activities as teaching assistant. The PhD candidate will receive a desk, possibly through a hot-desking procedure, and a personal computer, if needed. Apart from the compulsory ones, the PhD candidate will have the opportunity to follow additional courses and receive economic support to attend summer schools and participate in conferences. There will be the possibility of paid teaching assistantship.


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