



PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 38th cycle

THEMATIC Research Field: HARDWARE-IN-THE-LOOP SIMULATION OF AUTONOMOUS GUIDANCE, NAVIGATION, AND CONTROL FOR DEEP-SPACE CUBESATS

Monthly net income of PhDscholarship (max 36 months)

€ 1400.0

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 miniaturization of electronics has enabled nanosatellites, or CubeSats: shoebox-sized systems able to carry out scientific investigations like conventional spacecraft. CubeSats have reduced the entry-level cost in low Earth orbit by one order of magnitude. Yet, the current paradigm prevents their usage for deep-space exploration.

The ERC-funded project EXTREMA (Engineering Extremely Rare Events in Astrodynamics for Deep-Space Missions in Autonomy), introduces the self-driving interplanetary CubeSats: probes able to drive themselves during the cruise, without requiring any contact with the ground. This concept involves self-determining the position and elaborating a guidance law on board. The project also exploits ballistic capture, a celestial mechanism to acquire an orbit about a planet.

Methods and techniques that will be developed and used to carry out the research

EXTREMA is a project articulated in three pillars, namely Pillar 1: Autonomous navigation, Pillar 2: Autonomous guidance, and Pillar 3: Autonomous ballistic capture. The three pillars are combined together to forge the EXTREMA Simulation Hub, an integrated infrastructure that reproduces dynamic simulations of the spacecraft-environment interaction, allowing high-fidelity testing, validation, and verification, through Hardware-In-the-Loop (HIL) simulations, of deep-space autonomous GNC systems for CubeSats.

The research involves the development, integration, and



	The research involves the development, integration, and validation of both software and hardware solutions and tools to support the assessment of autonomous GNC for deep-space CubeSat. To this purpose, the navigation, guidance, and control have to be interconnected to test the validity and robustness of the developed algorithms in a fully functional facility that will simulate the transfer of a spacecraft from an initial condition towards a target located in deep space.
Educational objectives	The objective of this Ph.D. is to develop skills in the design and analysis of autonomous guidance, navigation, and control as well as in the wider deep-space astrodynamics. Through this project, the candidates will develop skills in mathematical modeling, numerical analysis, and computer programming (Matlab, Python, C++, or similar). Moreover, the candidates will develop skills in both computer and processor/hardware-in-the-loop simulations. Soft skills in presenting the research, writing reports, outreach, dissemination, and preparing industrial progress meetings will be also achieved through the Ph.D. project.
Job opportunities	The job opportunities that this project opens up are in the field of spacecraft guidance, navigation, and control. The research is framed in the context of deep-space exploration, a former niche that is nowadays growing within the wider space field.
Composition of the research group	1 Full Professors 1 Associated Professors 2 Assistant Professors 10 PhD Students
Name of the research directors	Prof. 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 (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	2100.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>The Ph.D. candidate will receive a desk and a personal computer. Apart from the compulsory ones, the Ph.D. candidate will have the opportunity to follow additional courses, receive economic support to attend summer schools, and participate in conferences. There will be the possibility of paid teaching assistantship.</p> <p>The candidates 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 Ph.D. program, the candidates will have access to the facilities of the DART Lab in order to carry out experimental activities. The candidates will also have the opportunity to attend some Ph.D. classes on both soft and hard skills. Moreover, there could be the possibility to carry out activities as a teaching assistant. A personal computer will be provided, and funding is available for attending meetings, workshops, and international conferences.</p>