POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 40th cycle

INTERDISCIPLINARY Research Field: POWER-EFFICIENT COMPUTING UNITS FOR ON-BOARD AUTONOMOUS GUIDANCE

Monthly net income of PhDscholarship (max 36 months)
€ 1500.0 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	Interdisciplinary PhD Grant The PhD research will be carried out in collaboration with research groups of the PhD programme in "**INFORMATION TECHNOLOGY**". See https://www.dottorato.polimi.it/?id=422&L=1 for further information. Interdisciplinary PhD Grant The PhD research will be carried out in collaboration with research groups of the PhD programme in "INFORMATION TECHNOLOGY", more specifically in the area of Computer Science and Engineering. For further details: https://www.dottorato.polimi.it/en/phd-programmes/engineering/information-technology. The advent of CubeSats technology has recently opened the near-Earth space to small institutions and companies with its competitive costs and is now impacting the lunar and Solar System exploration. This continuous increase of deep-space missions launched per year calls for the decoupling from ground-based activities for an economic and logistically sustainable approach. The spacecraft Guidance, Navigation, and Control (GNC) procedure historically relies on mission control centers, where teams of engineers compute and then upload commands on board the spacecraft during communication windows. The overall procedure can take up to five days for interplanetary missions, and results in non-scalable operations costs which make up to 10% of the total cost of

	a space mission. Therefore, onboard autonomous systems are mandatory to achieve the next level in space exploration. However, designing a complete system for autonomous guidance in the deep space requires an interdisciplinary approach where algorithmic and domain knowledge, software-based optimizations and abstractions, and computer architecture efficiency in time and power consumption are all tightly bound. Autonomous guidance applications in the deep space must achieve their primary goal of route planning, detect environmental change in a proper time frame (from ms to minutes, depending on the task), and adapt to unseen conditions and possible hardware failures. Neglecting one of these goals will result in unavoidable failures. The main objective of this interdisciplinary PhD is to develop an autonomous guidance and control spacecraft avionics system design methodology. Heterogeneous architectures with varying processor capabilities are emerging in autonomous systems, optimizing spacecraft and mission performance and will be the focus of this research project. This will allow to introduce state-of-the-art computing solutions and methodologies in the field of computational guidance.
Methods and techniques that will be developed and used to carry out the research	Autonomous systems, by definition, require cross-domain capabilities, as they shall take input from, and provide commands to other subsystems (e.g., sensors and actuators). In addition, the project has the ambition of 1) elevating guidance algorithms to be applicable on-board hardware thanks to algorithmic specialization of the deep space domain, and 2) introducing accelerator design methodologies of advanced heterogenous platforms to pair the constrained time and power limitations while adopting a sustainable development process. Techniques like system integration testing and hardware-in-the-loop simulation will be employed to verify the performance and reliability of the developed board in simulated deep-space scenarios, leveraging on the facilities and tools available at the DART and NECST laboratories. Model-based

	design will be used to model satellite components and space environment. The proposed PhD project combines renown expertise in the field of space sensor processing, navigation filtering, and their combined integration. These two branches are both at the edge of research in their fields, and they are merged here to forge a novel research line.
Educational objectives	The objective of this PhD is to develop skills in spacecraft guidance and control, deployment of software on constrained boards with algorithmic tailoring, and system design. It is worth noting that these competences are relevant not only to the space sector but to any field and industry where edge computing is utilized. The candidate will also gain expertise in computer programming (Matlab, Python, C++, or similar), and will develop skills in hardware-software co-design, hardware design, and reliable system design. Soft skills in disseminating the research, writing reports, performing outreach, and preparing industrial meetings will be also achieved.
Job opportunities	The current research prepares the PhD candidate to both academic and industrial careers. Knowledge of embedded systems, hardware-software co-design, spacecraft avionics, and space system simulation are fundamental skills for careers in space-related companies and universities.
Composition of the research group	1 Full Professors 1 Associated Professors 2 Assistant Professors 22 PhD Students
Name of the research directors	Prof. Alessandro Morselli

Contacts
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site: www.aero.polimi.it or https://dart.polimi.it

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	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
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.