POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

PNRR 118 PNRR Research Field: BIOMIMETIC MULTIFUNCTIONAL MEMBRANE FOR DEPLOYABLE AND INFLATABLE ULTRA-LIGHTWEIGHT SPACE SYSTEMS

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	Future space missions will require multifunctional materials. The traditional concept of components with a single specific purpose will be replaced by solutions in which several different properties (e.g.: excellent shielding, shape change and mechanical characteristics) are embedded in a single material. Multifunctionality will thus offer the possibility to design more efficient space structures, able to enhance reliability and safety under different space mission scenarios. The goal of the PhD research is the development and characterization of a multifunctional membrane inspired by biological systems for space applications. This membrane can be used in deployable or inflatable space systems, applied as a coating on a structure or as an internal element in a multilayer composite. The biomimetic capabilities studied could include sensing, morphing and self-healing. The possibility of making a single multifunctional element of this type brings benefits in terms of additional capabilities. The different functions will be obtained through the complete integration in the membrane of almost zero invasive sub-systems, which also guarantees compactness and lightness of the space systems, both satellite and dedicated to planetary exploration, greater reliability, and safety, leading to a longer life of missions.
Methods and techniques that will be developed and used to carry out the research	The optimization of the materials, the development of biomimetic functions and the definition of the techniques to integrate them in an ultra-lightweight space system will

	to integrate them in an ultra-lightweight space system will be the work addressed in the PhD project. Considered functionalities will be: •sensing, based on photonic technology, will exploit extremely fine new generation optical fibres (50-25 μm) and possibly optoelectronics integrated on-chip to minimize the complexity and invasiveness of the monitoring system. The sensing system will allow continuous monitoring of the membrane by evaluating its correct functioning (for example, ensuring the correct deployment/configuration of the membrane or of the structure to which it belongs) and the state of health (identifying the triggering of damage such as micro-perforations that manifest with a change in the state of tension); •self-healing, ensured by using appropriate self-healing polymers to produce the membrane with which to impregnate the reinforcing component, for which the most appropriate material and weight will be selected according to the operating scenario. The purpose is to prevent the spread of damage and to repair it, automatically and definitively, without requiring maintenance intervention by an operator; •morphing, conferred with shape memory alloy actuators to obtain the deployed configuration without kinematic mechanisms and possibly exploiting the power available on site (irradiation and/or convection of fluids). this property can be exploited in the unfolding or control phase, or it can be used to facilitate the self-repair process (through the reduction of internal tensions in the damaged area or by facilitating the closure of cracks). for better integration into the membrane, the actuators will preferably be wires and/or foils. A key phase will be the study in a simulated space environment of all the materials considered, to optimize their performance and validate their reliability. Operational scenarios and system requirements will be defined with the support of a partner with experience in space research, e.g., Argotec (https://www.argotecgroup.com/),

	including a research period in their R&D department.
Educational objectives	During the 3-year education, the candidate will become familiar with all the aspects related to the development, production, and characterization of innovative space structures. The research will provide the opportunity to achieve high-level skills in the areas of experimental techniques, numerical modelling and structural design of space systems. In particular, the researcher will acquire deep knowledge in the field of manufacturing and testing of flexible structures, including state-of-the-art procedures for the production, actuation, and sensing of smart composite materials.
Job opportunities	The PhD graduate will have high-quality theoretical and technological expertise in the field of innovative space systems. The competencies acquired during the research will be appealing to manufacturers of satellites and space research agencies, which require highly skilled engineers having the capability to understand and manage the design and manufacturing process of ultra-lightweight space structures as well as the knowledge of their thermal and mechanical performances in space.
Composition of the research group	2 Full Professors 1 Associated Professors 1 Assistant Professors 0 PhD Students
Name of the research directors	Prof. Antonio Mattia Grande

Contacts
Dipartimento di Scienze e Tecnologie Aerospaziali - Politecnico di Milano - via La Masa 34, 20156 Milano - Italy - tel. +390223998323 - fax +390223998334 - email: antoniomattia.grande@polimi.it - web site: www.aero.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	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Argotec (https://www.argotecgroup.com/)
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	TU Delft (NL)
By number of months abroad	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.