POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 41st cycle

THEMATIC Research Field: FIBER-OPTIC HEALTH AND USAGE MONITORING SYSTEM: ADVANCED MATERIALS, PHOTONIC SENSING AND PREDICTIVE ALGORITHMS

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	The increasing demand for safer, more efficient, and sustainable transportation systems has made predictive diagnostics a key challenge for modern engineering. Fiber-optic sensing technologies, due to their lightness, immunity to electromagnetic interference, and high sensitivity, represent an enabling solution for the real-time monitoring of complex infrastructures and vehicles. The PhD position is funded by the FUTURO project, supported by Regione Lombardia under the Collabora e Innova 2024 call (CUP E49I25001990007), which aims to develop an innovative fiber-optic diagnostic system for predictive maintenance of railway infrastructure.The project integrates advanced sensing modules, photonic interrogation units, and data-driven diagnostic algorithms to create a fully autonomous, intelligent monitoring system. Although the primary application is in the railway sector, the methodologies, materials, and technologies developed, from the design of composite-based sensing modules to the implementation of machine-learning algorithms for data analysis, have a broad cross-sectoral relevance, including strong potential applications in the aerospace industry, where weight reduction, structural integrity, and continuous monitoring are equally crucial.The objective of the PhD research is therefore to contribute to the development of an integrated Health and Usage Monitoring System (HUMS) based on fiber-optic technology, exploring materials integration, sensing architectures, and advanced data processing for

	predictive and condition-based maintenance.
Methods and techniques that will be developed and used to carry out the research	The research will combine experimental materials engineering, photonics, and data science approaches. The main activities include: Design and manufacturing of fiber-optic sensing modules, embedding Fiber Bragg Gratings (FBGs) or interferometric fibers into composite structures, optimized for mechanical robustness and high sensitivity; Development of data processing and predictive analytics algorithms, employing signal processing, time-series modeling, and machine learning to identify anomalies and estimate the remaining useful life of monitored components; Experimental validation of the developed modules and algorithms in laboratory and field environments, with potential extensions to aerospace-relevant demonstrators.
Educational objectives	The PhD candidate will acquire a comprehensive and multidisciplinary background covering materials science, photonics, structural monitoring, and artificial intelligence. Specifically, the training objectives include: Understanding of fiber-optic sensing technologies and their integration into structural materials; Knowledge of composite materials and manufacturing processes for sensor embedding; Proficiency in signal acquisition, data fusion, and machine learning for predictive diagnostics; Competence in developing digital twin and condition-based maintenance frameworks; Experience in experimental validation and system integration with industrial partners. The candidate will be trained to conduct research that bridges the gap between materials engineering, photonics, and intelligent data analysis — a crucial combination for future smart infrastructures and aerospace systems.
Job opportunities	The PhD graduate will gain skills highly valued across several industrial and research domains, including: Aerospace and aeronautical industries, for the

	development of lightweight, self-monitoring composite structures and HUMS technologies; Railway and civil infrastructure sectors, for implementing predictive maintenance and digitalization strategies; Energy and oil &gas industries, for real-time monitoring of pipelines and critical assets; Research and innovation centers, focusing on advanced materials, photonics, and structural health monitoring; Technology start-ups and spin-offs, developing smart sensors and AI-based diagnostic solutions. The multidisciplinary nature of this PhD will prepare the candidate to play a leading role in the development of next-generation intelligent monitoring systems for a wide range of industrial applications.
Composition of the research group	2 Full Professors 2 Associated Professors 2 Assistant Professors 7 PhD Students
Name of the research directors	Prof. Paolo Bettini

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	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.