



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 37th cycle

Research Area n. 1 - Advanced Materials and Smart Structures

**THEMATIC Research Field: STRUCTURAL HEALTH AND BALLISTIC IMPACT MONITORING
AND PROGNOSIS ON A MILITARY HELICOPTER**

Monthly net income of PhDscholarship (max 36 months)

€ 1325.0

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 aim of the research is to develop a Structural Health Monitoring and Prognosis (SHMP) tool for corrosion degradation, bullet impact damages, that can be even possibly exploited for airframe load monitoring and generic damage development. These have been identified as critical factors for the structural integrity of the helicopter, since they can compromise the whole structural assessment and be a safety concern for the crew. The project includes two main streams of activities: 1) Development of a corrosion monitoring system, 2) Development of a ballistic impact and damage monitoring system, with three goals:

1. impact detection,
2. damage detection and quantification
3. load monitoring and damage progression estimate

One shared goal is the development of a Digital-Twin and a Structural Health Monitoring and Prognosis (SHMP) system able to extract relevant damage features from sensors' signal and to provide both the actual healthy condition of the structure and the prognosis of damage progression.

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

The PhD candidate will first develop models (in the form of a Digital-Twin) of the systems under analysis. The Digital-Twin will be based either on Finite Element models



	or on analytical/empirical models, where the presence of the damage is considered in the model to simulate the behaviour of the structure in more realistic operative conditions. For CORROSION MONITORING the digital-twin implies the definition of: • An experimental database of corrosion data under different environments • A corrosion rate prediction model • An experimental database of sensor signals in presence of corrosion For IMPACT AND DAMAGE MONITORING the digital-twin implies the definition of: • A model to predict structural behaviour due to impact damage • A model to predict sensor signals in presence of damage • A readily available numerical database for fast sensor signal classification • A model for damage progression under fatigue loads The Digital-Twin will then be used for the optimization of SHMP algorithms, specifically leveraging on machine learning techniques, such as, but not limited to: • Physics informed neural networks • Transfer learning
Educational objectives	We provide doctoral candidates with high-level scientific training, fostering and refining research and problem-solving abilities. At the end of the PhD cycle the candidate will be able to plan and carry out original research by working in a team or leading a research group active in the field of structural health monitoring and prognosis. The candidate will strongly enhance both theoretical and experimental skills acquired during master studies. Opportunities will be offered for spending visiting periods hosted by project partners for scientific cooperation. Specifically concerning the HUMS field of application, the candidate will get command in the disciplines of: • HUMS system optimisation • Performance assessment



	• Sensor installation, acquisition and data processing • Machine learning algorithms • Bayesian model identification and updating • Methods for diagnosis and prognosis of systems under degradation • System model development (digital twin)
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared with Master of Science holders in the same field. Specifically, the skills and know-how developed during the PhD will allow to cover positions for design, monitoring and integrity assessment of advanced systems and components in aerospace, automotive and mechanical companies.
Composition of the research group	1 Full Professors 3 Associated Professors 0 Assistant Professors 9 PhD Students
Name of the research directors	Proff. Claudio Sbarufatti, Marco Giglio

Contacts
<i>Prof. Claudio Sbarufatti</i> Phone ++39 022399 8213 Email claudio.sbarufatti@polimi.it ; <i>Prof. Marco Giglio</i> Phone ++39 022399 8234 Email marco.giglio@polimi.it ; phd-dmec@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	564.01 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Funding for educational activities (purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences); funding per PhD student per year: 2nd



year: per student euros 1.534 3rd year: per student euros 1.534. Teaching assistantship: availability of funding in recognition of support to teaching activities by the PhD student; there are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations. **Computer availability:** 1st year: individual use 2nd year: individual use 3rd year: individual use **Desk availability:** 1st year: individual use 2nd year: individual use 3rd year: individual use.