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Supervisor Expression of Interest

MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2025

Supervisor name: Antonio Raimondo

Email address: antonio1.raimondo@polimi.it
Link "Pagina docente": Antonio Raimondo
Department Name: Department of Aerospace Science and Technology (DAER)

Research topic: Composite Structures

MSCA-PF Research Area Panels:

- ☐ ECO_Economic Sciences
- X ENG_Information Science and Engineering
- ☐ ENV_Environmental and Geosciences
- ☐ LIF_Life Sciences
- ☐ MAT_Mathematics
- ☐ PHY_Physics
- ☐ SOC_Social Sciences and Humanities
- ☐ CHE_Chemistry

Brief description of the Department and Research Group:
The **Department of Aerospace Science and Technology (DAER)** conducts research and education in a wide range of aerospace disciplines, with a focus on cutting-edge and challenging engineering fields. Its activities impact multiple areas of society, including the safety and efficiency of air and space vehicles,

sustainable aviation, wind energy utilization, space exploration, and the training of highly skilled engineers.

(*https://www.aero.polimi.it/en/the-department*)

The **NABUCCO** research group focuses on enhancing the efficiency of future aircraft and space structures through the use of composite materials and innovative structural concepts. By combining numerical and analytical approaches with experimental testing, the group develops advanced methodologies for the design, analysis, and validation of composite structures. The aim is to improve structural integrity, optimize performance, and minimize weight, supporting the development of next-generation aerospace vehicles.

(*https://www.aero.polimi.it/en/research-labs/nabucco-design-analysis-and-testing-of-aerospace-composite-structures-under-buckling-and-post-buckling-requirements*)

TITLE of the project: Development of Virtual Manufacturing Models for Defect Prediction in Composite Structures

Brief project description: The aviation industry is facing growing pressure as the increasing demand for mobility poses significant challenges in addressing environmental issues. To meet these demands, research on innovative materials and novel lightweight structural architectures has become a crucial focus in the aeronautical sector, offering potential solutions for improved efficiency, sustainability, and performance. In this context, composite materials, with their exceptional strength-to-weight ratio and design flexibility, are essential in achieving the enhanced performance needed for the next generation of aircraft technologies.

Currently, the manufacturing of composite structures presents significant challenges due to the complexity of the materials and the sensitivity of the production processes. Defects such as voids, fiber misalignment, delaminations, resin-rich areas, and porosity can arise during fabrication, leading to reduced mechanical performance, structural inefficiencies, and increased production costs. This research project aims to develop advanced virtual manufacturing models that can accurately predict and mitigate these defects, enhancing the reliability and quality of composite components.

The project will integrate Finite Element (FE) simulations, process modeling, and experimental validation to establish a comprehensive framework for defect prediction. A key focus will be the development of high-fidelity numerical models capable of simulating critical composite manufacturing processes, such as autoclave curing, resin infusion, and automated fiber placement (AFP). These models will incorporate material behavior, thermal and pressure effects, resin flow dynamics, and consolidation mechanisms to accurately represent real-world manufacturing conditions. To enhance the accuracy and robustness of defect prediction, data-driven approaches, such as machine learning, will be incorporated.

Experimental validation will be a crucial component of the study, ensuring the reliability of the virtual models. Composite specimens will be manufactured under controlled conditions, and non-destructive evaluation (NDE) techniques, such as ultrasonic testing and digital image correlation (DIC), will be used to detect and characterize defects. The experimental data will be compared with simulation results, enabling iterative model improvements and the refinement of defect prediction methodologies.

Additionally, the project will focus on process optimization, identifying the most effective manufacturing parameters, such as curing cycles, pressure distribution, and fiber placement strategies, to minimize defect formation. This optimization will contribute to improved design-for-manufacturing strategies, ensuring that composite components are engineered with manufacturability in mind from the early stages of design.

The expected outcomes of this research include a significant reduction in manufacturing defects, leading to higher-quality and more reliable composite structures, enabling engineers to fully exploit the weight-saving potential and design flexibility of composite materials. Additionally, the project aims to improve manufacturing rates by minimizing waste, contributing to the reduction of cost and time for the development of the next generation of commercial aircraft with more efficient and sustainable manufacturing practices.