Politecnico di Torino

AEROSPACE ENGINEERING

DIMEAS - High-Fidelity Multi-Physics Structural Modeling for Electrified Aircraft and Spacecraft

Funded By	Dipartimento DIMEAS
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Context of the research activity	Development of high-fidelity multi-physics structural models for thin-walled aerospace structures, integrating thermal, electrical, magnetic, and chemical fields. The work relies on advanced finite element formulations and unified structural theories. The activity is carried out within the AMPERE project, funded under the MUR FIS 2 programme.
Objectives	This PhD project aims at developing advanced multi-physics structural models for thin-walled components of electrified aircraft and spacecraft. The rapid evolution of hybrid-electric aviation and modern space systems demands structural models that can capture complex interactions between thermal loads, electric currents, electromagnetic fields, chemical processes, and mechanical behavior. Traditional structural formulations, largely developed for isotropic metallic components, are inadequate for modern composite laminates, multifunctional materials, and heterogeneous thin-walled systems. The research will employ unified structural theories and high-order finite elements, such as those of the Carrera Unified Formulation (CUF), to create a new generation of multi-physics structural models. These models will accurately describe: thermo-electro-mechanical coupling in thin-walled aircraft components subjected to electric propulsion and thermal management systems; chemo-thermal degradation in multifunctional materials and battery-integrated structures; magnetic–thermal–elastic interactions relevant for space instruments and satellite subsystems; local instability phenomena in shells exposed to thermal gradients; thermoelastic disturbances affecting pointing stability and structural precision in satellites. The multi-physics environment will be linked to the multi-scale thermal models developed within AMPERE, thereby enabling the construction of high-fidelity digital twins for representative aerospace structures. Numerical simulations will be validated through benchmark experiments and reference test cases.

	Outcome of the project includes improved predictive capabilities for structural integrity, thermo-mechanical stability, and performance of thin-walled components in advanced aerospace applications.

Skills and competencies for the development of the activity	Background in structural mechanics, continuum mechanics, and finite element analysis. Familiarity with thin-walled structures, composites, or multi-physics modelling is appreciated. Good programming skills and motivation for theoretical and numerical research are expected.