PhD in Mechanical Engineering

Research Title: Multi-scale models of AM variable stiffness composite laminates for defect quantification and propagation

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Context of the research activity	Additive manufacturing brought to the emergence of a new class of fibre-reinforced materials; namely, the Variable Angle Tow (VAT) composites. AFP and FDM machines allow the fibres to be relaxed along curvilinear paths within the lamina. In theory, the designer can conceive VAT structures with unexplored capabilities and tailor materials with optimized stiffness-to-weight ratios. In practise, steering brittle fibres, generally made of glass or carbon, is not trivial. Printing must be performed at the right combination of temperature, velocity, curvature radii and pressure to preserve the integrity of fibres. The lack of information on how the effect of these parameters propagates through the scales, from fibres to the final structure, represents the missing piece in the puzzle of VAT composites, which today are either costly or difficult to design because affected by unpredictable failure mechanisms and unwanted defects (gaps, overlaps, and fibre kinking).

Objectives	This PhD research is part of **PRE-ECO**, an ERC-StG project for the exploratory study into a radical new approach to the problem of design, manufacturing and analysis of printed composite materials. The research will deal with the development of advanced

	simulation tools for the mechanical characterization of variable stiffness composites at the micro- and meso-scale. The tools will be based on the Carrera Unified Formulation (CUF), which provide a unique framework for the development of refined structural theories with scalable accuracy. In detail, the models developed will make use component-wise kinematics for an accurate prediction of internal stress states, from fibre-matrix to laminate scales. In the second part of the research, we will explore the use of these multiscale methods for the sensitivity analysis as well as for the defect quantification and propagation. The main objective is to provide models able to incorporate the AM printer signature for accurate prediction of the VAT mechanical characteristics and to design for manufacturing. Secondments in other Institutions will be possible depending on the research interests and the performance of the PhD candidate.

Skills and competencies for the development of the activity	Ideal candidate will have the following competences: • Excellent academic background in Mechanical/Aerospace Engineering. • Excellent mathematical skills and engineering attitude. • Appropriate competencies in English speaking and writing. • Appropriate experience with structural analysis and design of composite laminates. • Programming skills.