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UNCERTAINTY QUANTIFICATION OF AEROELASTIC PARAMETERS FOR THE DESIGN OF COMPOSITE WINGS.

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The growing interest of composite materials in aeronautics pushes for a change in the design practices in order to exploit their full potential. The design of composite structures calls for multiscale simulations in order to integrate their hierarchical structure. Moreover, testing of aeroelastic phenomena is an important part of aircraft qualification today and these phenomena are highly dependent on structural and operating parameters and thus very sensitive to uncertainties [1]. Due to the inherent scattering of material data and the geometrical tolerance, aleatory uncertainties have to be taken into account and aeroelastic simulations must be integrated with statistical uncertainty quantification (UQ) and propagation (UP) methods. Scrath et al. [2] use a non-intrusive Polynomial Chaos method to quantify the response of a composite flat plate and analyze the aeroelastic stability taking a variability in ply orientation.

In this work, a non-intrusive approach is proposed for multiscale UQ and UP. The key points of the approach are underlined by investigating the influence of structural uncertainties on the aeroelastic flutter of a graphite/epoxy plate [3]. Monte Carlo (MC) hierarchical sensitivity analysis is performed to identify which parameters, at the micro-mechanical, layer, or laminate level, has the greatest influence on any given aeroelastic quantity. Attention is paid to probabilistic modelling, including dependence of the uncertain parameters of interest, at the different scales of the material (material properties, fibre orientation and thickness of each ply). Dynamic aeroelastic computations are accomplished with a finite element method coupled with the Doublet-Lattice Method on Nastran. Furthermore, UP is completed with suitable surrogate models and a tentative ranking of different surrogate models is proposed. Since the computation process starts at the microscopic scale, the stochastic modeling capabilities, through efficient numerical surrogates, are augmented.

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