# Conception d'une aile d'aéronef en composite : intégration d'une approche de modélisation globale/locale dans la méthode d'optimisation multi-échelle

## *Design of an aircraft composite wing-box: integrating a global/local modelling approach into the multi-scale optimization method.*

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Structural solutions involving advanced composite materials are nowadays popular within the aeronautic industry. The excellent specific mechanical properties of these materials as well as the continuous manufacturing innovation of composite components allows for tailoring lightweight, efficient and reliable solutions. The design of a complex composite structure is a quite difficult problem because the components must be conceived at different scales by considering the full set of design variables, i.e. size of the parts, number, position and orientation angles of each constitutive ply, etc.
Moreover, in order to obtain a true optimized solution, different scenarii (i.e. loading conditions) must be considered. In particular, the most relevant physical responses involved at different scales should be included into the problem formulation as well as the main manufacturing constraint in order to achieve an optimized and manufacturable solution.

This work deals with the optimization of a composite wing-box. In particular, in this study a suitable global/local modelling approach based on the Finite Element (FE) method has been incorporated within the multi-scale two-level (MS2L) optimization strategy developed at the I2M laboratory [1-5]. In the framework of the MS2L optimization approach the design problem is split into two interdependent optimization problems.
At the first level each laminate composing the wing-box is modelled as an equivalent homogeneous anisotropic plate. The design variables are the geometric parameters of each part composing the wing-box at the macroscopic scale (i.e. stringers, skin, ribs, spars, etc.) as well as the mechanical parameters of each laminate constituting the structure, these last being expressed in terms of tensor invariants by means of the polar formalism [6-8]. The goal of the first-level problem is the mass minimization of the wing-box architecture by meeting, simultaneously, both global and local design requirements. Indeed, to correctly drive the design, different critical conditions must be assessed at different scales of the structure. The wing-box structure represents the global FE model and is made of low-fidelity elements (beams and shells), while the local FE model is constituted of the most critical stiffened panels composing the wing-box. The stiffened panels constituting the local model present a more detailed geometry and mesh, i.e. stringers and ribs are modelled through shell elements in order to highlight local phenomena. Such panels are automatically extracted from the global model and suitable boundary conditions (BCs) are imposed in terms of generalized displacements, as schematically shown in Figure 1.
Both global and local models allow the optimization algorithm for correctly evaluating specific physical responses under multiple loading conditions: maximum displacement, maximum strain and assembly constraints for the global FE model and buckling load factors for the local one.

The second-level problem focuses on the laminate lay-up design. The goal is the determination of a suitable stacking sequence for each laminate composing the wing-box structure by satisfying the optimum combination of both geometrical and polar parameters resulting from the first-level problem. During this phase the optimum stacks are searched within the very general space of quasi-trivial solutions [9].
At both levels of the design procedure the optimisation is performed using the ERASMUS (EvolutionaRy Algorithm for optimisation of ModUlar Systems) algorithm [10].

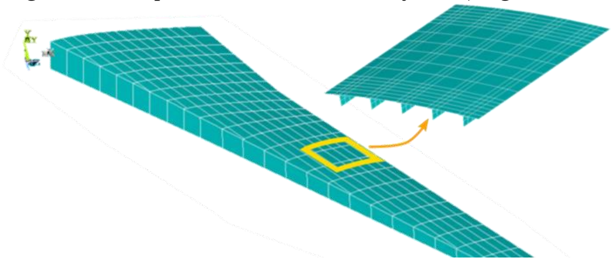

*Figure 1 – Example of a generic selection and extraction of a local model (stiffened panel) from the global one (wing).*

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