Intégration d'une approche globale-locale de modélisation aux éléments finis dans la stratégie d'optimisation *multi-scale two-level* : application à l'optimisation d'un tronçon de fuselage en matériau composite.

Integration of a global-local finite element modelling approach in the multi-scale two-level optimisation strategy: application to the optimisation of a composite fuselage barrel.

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In this work the integration of a suitable global-local (GL) finite element (FE) modelling approach in the framework of the multi-scale two-level (MS2L) optimisation strategy is proposed in order to deal with the problem of the preliminary optimisation of composite thin-walled structures typical of the aeronautical field.
This kind of structure usually presents three different working scales: the "global" macroscopic scale of the whole structure (e.g. a fuselage or a wing); the "local" macroscopic scale of the stiffened panels composing the structure and the mesoscopic scale of the laminae constituting the laminates. To properly design these structures, a rigorous multi-scale optimisation approach reveals necessary. However, design strategies available in the literature (e.g. [1] [2]) are able to retrieve only sub-optimal solutions. This is due, on the one hand, to the use of heavily simplified mechanical models with weak links between the different design scales and, on the other hand, to the systematic use of simplifying rules for the definition of the design variables involved at each pertinent scale that extremely shrinks the design space.

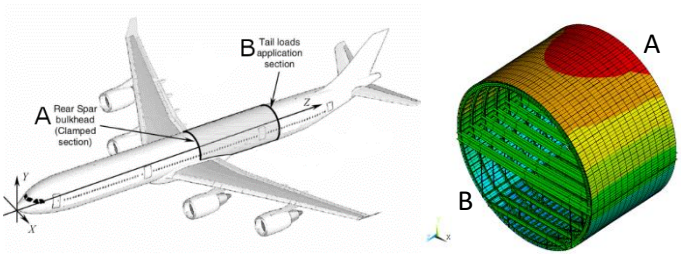

Fig. 1. Portion of the fuselage object of the optimization problem

In the context of the MS2L optimisation strategy [3] the whole set of geometric and mechanical design variables needed for the description of the composite structure at each relevant scale is considered without making use of simplifying rules. Moreover, the integration of a suitable GL FE modelling approach allows for correctly evaluating the different phenomena that take place

at the different scales. Global and local FE models of the fuselage architecture are linked together in a coherent way without increasing too much the computational cost.
The optimisation problem presented is the least-weight design of a composite fuselage barrel belonging to the aft part of a wide-body aircraft (Fig. 1) that undergoes multiple loading conditions and subject to constraints on the stiffness of the structure, of "no-buckling" and of "no-failure" conditions whose reference solution is taken from [2].
According to the MS2L framework, the design problem is split into two different and interdependent optimisation problems. The first-level problem involves "global" and the "local" macroscopic scales of the structure. At this stage the laminates constituting the structure are modelled as equivalent homogeneous anisotropic plates: the mechanical response of each laminate is described using the polar formalism [4] [5]. The variables of this step are of both geometrical and mechanical nature. The goal of this phase is the weight minimisation of the fuselage architecture by considering different physical responses evaluated at both global and local levels. The second-level problem focuses on the search for a suitable stack (for each laminate composing the fuselage) meeting the optimum variables provided by the first-level problem. At both levels of the design procedure the optimisation is performed using the ERASMUS (EvolutionaRy Algorithm for optimisation of ModUlar Systems) algorithm [6].

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