AEROSTRUCTURAL OPTIMIZATION OF A BUSINESS JET WING

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ABSTRACT

During the early stages of a business jet aircraft design, the wing planform and architecture are still under development and continues to evolve in order to find the best trade-off between aerodynamic performances, structural mass and other design drivers.

For each planform and architecture evaluated, an aerostructural optimization process is used to determine the optimal wing structure, balancing shape constraints, mass, and loads criteria [1]. This method relies upon the same computational tools used for aircraft certification, is fully integrated in the industrial design process and well automated for a given planform, which involves creating specific meshes for that geometry (structural FEM, aerodynamic meshes …). However, during the initial design phase as the wing planform geometry changes continuously (and consequently the internal architecture associated with it), generating meshes for each planform considered would be too much time consuming and prevents design office from quickly evaluating wing sensitivities to each geometrical parameter and finding the most efficient design.

Improving our optimization process during early design stages is therefore essential to avoid costly iterations which ultimately prevent aerostructural derivatives from being used in the process of selecting the best planform and wing architecture very early in the development process.

More specifically, automatic mesh generation has been implemented to the process for CAD geometries, aerodynamic and structural meshes; based on a geometric set of wing planform parameters (Table 1). At the same time, a parametric mass model has been developed as a supplement to automatically ensure a realistic wing mass distribution for each geometry and associated architecture. This mass is adjusted for each structural part (Wing Box, Aileron, spars and stringers, …) to take into account sampling and assembly elements and also takes into account other mass part as the electric cable or the painting. It aims to be as close as possible of a real business jet wing mass distribution as assessed by the design office. Using these parametric tools, an aerostructural optimization is performed for each planform to minimize the mass while respecting sizing criteria, drawing, manufacturing and aeroelastic constraints (flutter, aileron efficiency …). The different wing sensitivities computed are used to create a mass response surface that could be compared to a drag response surface in order to select the best geometry according to the expected performances. This parametric process has been implemented in the past for a winglet [2] but the complexity was lower than for a wing.

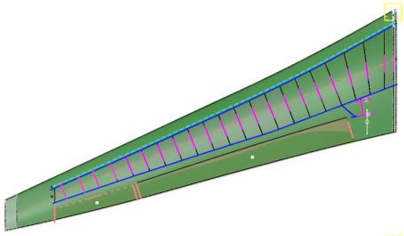
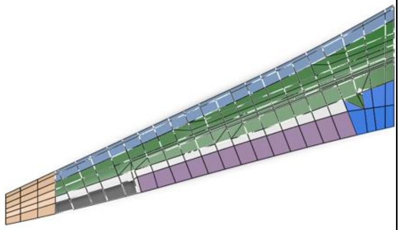
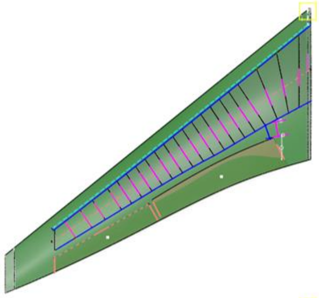
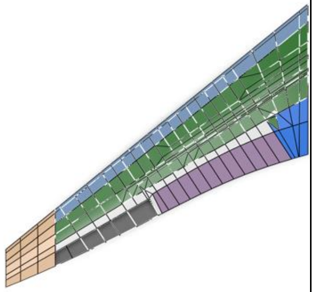
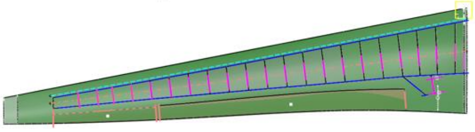
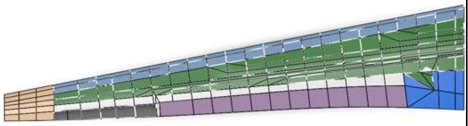
	CAD	Structural FEM Mesh
Baseline		
Lowest Aspect Ratio, Highest Sweep Angle		
Highest Aspect Ratio, Lowest Sweep Angle		

Table 1: Examples of derived configurations of parametric CAD and mesh

This paper describes the industrial process developed at Dassault Aviation to automatically generate parametric meshes including mass modeling, which aims to quickly compute an optimized mass response surface in the preliminary design phase in order to help the designers find the optimal wing planform.

First, the global optimization process will be briefly presented. Then the method used to create parametric meshes will be described. Finally, optimization results for several wing planform including a mass response surface will be detailed and illustrated.

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References

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