*Corresponding Author: Matthias.Schulze@dlr.de

IFASD 2026 INTERNATIONAL FORUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS
16 – 19 JUNE GOETTINGEN (GER)

LOCAL OPTIMIZATION MODEL REFINEMENT FOR THE PRELIMINARY AEROELASTIC STRUCTURAL DESIGN OF A TRANSPORT AIRCRAFT WING

Matthias Schulze* and Thomas Klimmek

German Aerospace Center (DLR), Institute of Aeroelasticity
Bunsenstr. 10, 37073 Göttingen
Germany

ABSTRACT

One of the main objectives of the EU Flight Path 2050 is to significantly reduce the fuel consumption of future commercial aircraft designs. In addition to the thrust-specific fuel consumption and the ratio of lift to drag, the structural mass of the aircraft are key factors in reducing the aircraft's fuel consumption. The structural mass can be improved by using suitable materials or by optimizing the load-bearing structure´s design. Within the conceptual or preliminary design stage of a new aircraft development, fast but reliable simulation results have to be available to find an optimum design. To obtain rapidly simulation results during the early stages of design, simplified simulation models are typically employed. One disadvantage of simplified discretization during optimization can be, that local effects (control surface effectiveness) or local loads (landing gear or engine attachment) can affect a large area of the optimization model and thus lead to increased stiffness and mass increase. A more detailed discretization of the entire optimization model remains highly computationally demanding, especially when accounting for a large number of loads. This is true even with the ongoing advancements in modern computer performance and the adoption of high-performance computing technologies. A local refinement at the significant regions of the optimization model can be an adequate solution to improve the structural design, while keeping the speed of the simulation within reasonable limits.

Within this paper, the at the DLR Institute of Aeroelasticity developed software cpacs-MONA is used to evaluate the effect of the optimization model discretization on the aeroelastic assessment of a long-range transport aircraft wing using physics-based simulations at preliminary design stage. The design process can be splitted into three fundamental stages: the establishment of a parametric model for the Global Finite Element Model (GFEM), a comprehensive loads analysis of the flexible aircraft, and a structural optimization phase that incorporates aeroelastic constraints. As a design variable, the thickness of the shell elements of a design region from the load- bearing wing structure can be adjusted to fulfill the objective function – minimize the wing-box mass under consideration of aeroelastic constraints like control surface efficiency and allowable stress or strain values. The design variables are combined to design regions to reduce the size of the optimization task. The primary design areas of the wing-box include the segmented skin surfaces enclosed by spars and ribs, as well as the intersecting regions formed between the ribs and spars. Figure 1 visualizes a resulted thickness distribution utilizing the default discretization and highlights the regions of local effects. Given that cpacs-MONA is an extensive aeroelatic design process, the final paper will not only address the impact of the investigated discretization of the optimization model on the structural mass of the wing-box but will also explore its influence on elastic loads, dynamic behavior, and the resulting aeroelastic stability of the entire aircraft.

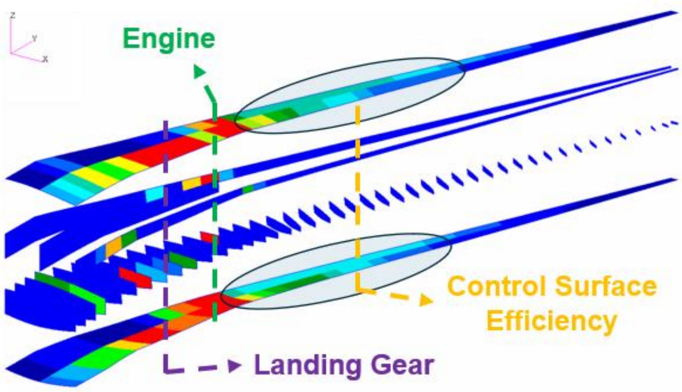

Figure 1. Local effects influencing the structural thickness of the wing design with the default optimization model discretization.

As reference, the within the DLR Project LamTA (Laminar Tailored Aircraft) long-range aircraft configuration, which is currently under development, is used.