Aircraft Loft Optimization With Respect To Aeroelastic Lift And Induced Drag Loads

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A multidisciplinary shape optimization framework for aircraft design is being developed at Cassidian, particularly during the conceptual design phase where it is necessary to evaluate and rank several different design concepts for a given mission. Since the design driving disciplines can strongly influence each other, they must be considered concurrently. For example, it is advantageous to regard aeroelasticity from the start to avoid subsequent rework. The framework uses a central parametric geometry description, combined with multidisciplinary design optimization (MDO). This allows the designer to compare performance optimized feasible concepts, based on an extensive criteria model, and select the best one.

The framework consists of the in-house MDO program *LAGRANGE*, a geometric parametrization tool, *DescartesNDB*, based on OpenCascade, and an aerodynamic solver. The optimisation model includes an extensive design criteria model (e.g. strength, stability, aeroelastic effectiveness, flutter, trimming etc.) comprising all relevant constraints. Gradient based optimization algorithms are used with analytical determination of gradients wherever possible. The geometric shape parametrization is based on the CPACS data format. CPACS is developed by the German Aerospace Center (DLR) allowing a parametric description of a complete aircraft. These parameters range from global shape changes such as wing sweep to local details like the airfoil profile of a wing section. The parametric aircraft model constitutes the centre of the framework, from which all analysis models (e.g. structural,

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aerodynamic, etc.) are derived. This way, the analysis models follow the shape change of the parametric geometry model in case a shape parameter is altered. One advantage of this relation to the parametric model is that extensive shape changes are possible before the mesh quality of the analysis models deteriorates to the point where re-meshing is necessary. The vortex lattice based aerodynamic solver has been expanded to provide an induced drag AIC matrix, calculated according to the Trefftz plane method. This component of drag is of special interest in conceptual design, since it represents a major fraction of the overall drag and is mainly influenced by parameters determined at this stage. Utilizing an AIC matrix for induced drag permits capturing the influence of elastic deflection on induced drag during optimization. Thus, the described framework can perform aeroelastic shape optimization of aircraft configurations taking induced drag into account while respecting structural design criteria up to several million constraints, automatically updating the aeroelastic loads.

The capabilities of the framework are demonstrated using the optimisation of a high aspect ratio wing. The wing planform is optimised to minimise induced drag both with and without constraints on the structural strength; showing the different optimum shapes resulting from a purely aerodynamic optimisation to a multidisciplinary one.