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A COMPARATIVE STUDY ON THE AERODYNAMIC MODEL FIDELITY EFFECTS IN PRELIMINARY AIRCRAFT DESIGN OPTIMIZATION

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Abstract: A comparative study between the multidisciplinary design optimization results of a regional jet transport aircraft based on different fidelity aerodynamic models is presented. The optimization of the wing structure of the aircraft is based on surrogate models of performance parameters for both the objective function and constraints, for which the parameterized design configuration is used as input. The performance parameters include mission fuel consumption, structural stress under specified load cases, balanced field length for take-off and climb performance. A fluid-structure interaction procedure is used to couple the aerodynamic and structural models and generate databases with information about aerodynamic forces and moments accounting for aircraft deformation and stress. The structural model consists of an equivalent beam model representing a wingbox structure with varying thickness along span. The aerodynamic models consist of a potential flow model with viscous drag corrections for the low/medium fidelity analysis and a commercial CFD RANS code for comparison. A representative fuselage and tail configuration is use as a baseline configuration of the aircraft. Systems mass distribution is also provided for the baseline aircraft configuration. Propulsion is modeled using a provided engine database. A quasi-static calculation of several operating points along the mission profile is used for integration of fuel consumption and assessment of mission fuel consumption for configurations respecting the load cases and take-off performance constraints. Results obtained for the two aerodynamic models are compared both at the database generation phase as well as in the performance parameters, allowing for the understanding of the influence of the aerodynamic model fidelity in the final optimized design. For the database generation phase, deformation obtained from the different fidelity models will be compared in terms of both displacement and wing twist, in order to understand if the coupling of differences in aerodynamic predictions and corresponding deformations cause significant differences in the aerodynamic efficiency and structural weight, particularly in an optimization context where the structure flexibility has an increasing trend. In the mission analysis phase, the accumulated effects of the previous results are compared in order to quantify the end line effect of the different fidelity models in terms of operating costs (fuel consumption) and production costs (wing structural mass).