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CFD based Multidisciplinary Maneuver Simulation of Transport Aircraft

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In this paper we present activities of work package 3 (WP3), "Virtual Flight Test", of the German Aerospace Center (DLR) Project *VicToria*. The mission of WP3 is the multidisciplinary numerical simulation of jet transport aircraft including flight mechanics, aerodynamics, and structural dynamics. Aerodynamic modeling focuses on a CFD method solving the URANS equations, for the activities presented the DLR TAU code is used together with a HPC framework to enable massively parallel simulations. In contrast to existing flight dynamic frameworks based on e.g. the widely used Doublet-Lattice Method, a physically meaningful calculation of aerodynamic forces especially in the nonlinear regime (transonic flow, high angles of attack) requires the solution of the Navier-Stokes equations. Similar research activities in the past have shown promising results, where the superiority of the CFD-based approach compared to Low-Fidelity methods was demonstrated [1].

The aircraft configuration of VicToria WP3 is the *Advanced Technology Research Aircraft* (ATRA), an Airbus A320-200 used as a platform for aeronautical research by DLR. For the numerical simulations, a hybrid, unstructured CFD grid is used with control surfaces modeled by a mesh deformation approach. The structural model consists of a statically condensed, 3D FEM represented by a set of eigenvectors and eigenvalues. While the structural deformations are small and calculated in a linear way, the rigid body motions of the aircraft are treated in a full nonlinear fashion. The coupled flight dynamic and structural dynamic governing equations are formulated as a system of first order ODEs in generalized coordinates and solved in the time domain. For the fluid-structure coupling, a semi-implicit predictor-corrector scheme is implemented. Both steady (trimmed horizontal flight) and unsteady simulations are presented. The results of the steady trim simulations are used as initial conditions for the unsteady time marching calculations where the aircraft is excited either by control surfaces inputs or by *1-cos* type gusts. Results are presented in terms of rigid-body and elastic degrees of freedom (structural deformations). In addition to the validation of the simulations with results from Nastran solution sequences SOL144 (steady trim) and SOL146 (unsteady aeroelastic), the comparison to experimental data from flight tests (longitudinal maneuver with input of the horizontal tail plane) of the ATRA is presented and discussed.

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