Rapid Calculation of Unsteady Aircraft Loads

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At the early stages of aircraft design process, a large parameter space is explored, where the designers are typically relying on empirical and linear correlations. Several lower-fidelity methods with linear aerodynamic assumptions exists for rapid estimation of aerodynamic loads. The main advantage of these techniques is their extremely high computational speed. Their main drawback is that they heavily rely on the existence and availability of previous data, and this hinders their applicability to the design of radically new configurations. On the contrary, higher-fidelity methods based on the three-dimensional Reynolds-averaged Navier-Stokes (RANS) solvers provide a good alternative to existing practice, however, they are still too expensive for routine use from the industrial viewpoint. It is important to limit the risk in setting the target design loads already at early design phase. In case the target loads are underestimated, the expensive re-design is typically required. Equally, if the target loads are overestimated, the aircraft will be heavier than needed with degraded performances.

The present work aims at making progress in rapid load calculations, with the development, implementation, and demonstration of a steady and unsteady hybrid aerodynamic solver, which combines solvers of different fidelity levels. The hybrid aerodynamic solver builds on the latest advances in algorithmic solutions, which are significantly faster than current state-of-the-art solvers. The work presents a part of a larger project carried out at the University of Southampton to develop a rapid computationally efficient aerodynamic method suitable for preliminary sizing aircraft studies. The innovative approach couples recently developed in-house built unsteady vortex lattice method solver, based on Katz and Plotkin method [1], and RANS solver for the infinite-swept wing problem, implemented in DLR-Tau code [2]. The innovative aspects of the proposed work include the hybrid unsteady approach which may capture strongly non-linear finite-wing effects, encountered near stall flow conditions around swept wings, at a computational cost of a 2D RANS computation. The unified analysis tool may be used for both low- and high-speed aerodynamic analyses. Furthermore, the hybrid unsteady approach is highly suitable for high-fidelity dynamic aeroelasticity analysis in the time-domain at manageable costs. In the final paper we will present the validation of the unsteady coupling algorithm around swept–wing configurations and demonstrate the rapid aerodynamic loads capability on test cases of increasing complexity. A simple wing will be run and compared with the 3D URANS simulation using forced sinusoidal motion.

REFERENCES

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