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High fidelity fluid-structure interaction simulation of a multi-megawatt airborne wind energy reference system in cross-wind flight

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Airborne wind energy (AWE) is an emerging technology for the conversion of wind energy into electricity by flying crosswind patterns with a tethered aircraft connected to a generator either on board or on the ground. Having a proper understanding of the unsteady interaction of the air with the flexible and dynamic system during operation is key to developing viable AWE systems [1]. High fidelity simulation tools are needed to correctly predict these interactions, which will provide insights for the design and operation of advanced and efficient AWE systems. The research goal of this contribution is to simulate the time-varying fluid-structure interaction (FSI) of an AWE system in a cross-wind flight manoeuvre.

This research examines the multi-MW AWE reference system presented in [2]. The high fidelity FSI of the wing of this system is determined by means of a partitioned and explicit approach, using the open-source coupling tool CoCoNuT. This method couples an existing finite element method (FEM) model of the wing structure with a newly developed computational fluid dynamics (CFD) model of the wing aerodynamics. Moreover, a prescribed flight path of the AWE system is enforced and realized by overlaying the moving body-fitted mesh attached to the AWE aircraft's wing over a background mesh. By means of the chimera technique both meshes are connected, interpolating the solution at the overset boundary.

The FSI model predicts a lift coefficient that is between 30-40% lower than predicted in [2] for the complete flight range. This can be explained by the inability of the lower fidelity model used in [2] to predict flow separation. Furthermore, the FSI model predicts 3.2% less lift compared to the undeformed structure for the highest loading. This can be explained by the negative wing twist predicted by the FSI model. These discrepancies emphasize the need for both FSI and high-fidelity tools. Ongoing research is directed towards coupling our high fidelity FSI model with the body dynamics model presented in [2] in pursuit of physically feasible flight prediction and the accurate simulation of power production.

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