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Lifting-Line Aerodynamics for Airborne Wind Energy on a Prescribed Path

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Lifting-line aerodynamic models are attractive for a number of reasons. First, the computational load relative to CFD is small enough for it to be viable for a wider range of studies and engineering design application. Furthermore, the lifting-line framework is suitable for exploring the effect of different chord, twist, sweep and dihedral distributions.

A previous work [1] by the author used the unsteady thin airfoil framework to reveal the necessary implementation details for a consistent coupling between the “inner” 2D (airfoil data) representation and the “outer” 3D lifting-line representation of the method. This allows for properly capturing the correct local and total aerodynamic forces and moments for both steady and unsteady situations. This contribution is a preliminary investigation on the use of this model for Airborne Wind Energy (AWE).

As a preliminary investigation, this lifting-line model is set-up to calculate the aerodynamic forces from an Airborne Wind Energy aircraft on a prescribed path. The Ampyx AP2, 5.5m 30kW system will be the basis of this model and the prescribed path is solved using AWEBox [2]. The forces from the lifting-line model will be compared with the predicted forces from the linear aerodynamic model in AWEBBOX. Unlike, with simplified models, the present work include the full nonlinear coupling effect of the loading on the wings as well as the possibility of including the effect of full 3D unsteady flow fields (turbulence/gusts) as well as flight path and dynamics.

Most engineering models for kite aerodynamics are not capable of simulating the fully coupled effect of sweep and dihedral with these effects. This contribution will try to show how these geometric variations affect the aerodynamic forces. Additionally, the model can be enhanced with spiral vortex wake models, this work will also try to investigate these enhancements.

The lifting-line model is also the basis for two additional conference contributions. The first by Kelly [3,4] investigates the impact of upper atmospheric flows on the aerodynamic forces. The second by McWilliam [5] applies the model in to investigate the impact of these aerodynamic forces on the structural dynamics.

References:

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