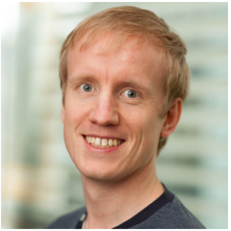

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AWESCO Airborne Wind Energy System Modelling, Control & Optimisation

Fluid-Structure Interaction Simulations on Kites

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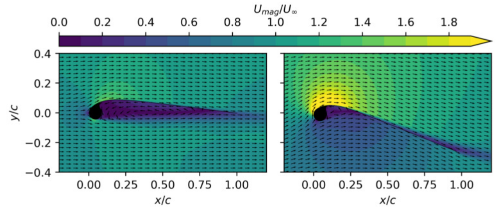
In the kite power group at TU Delft we are currently investigating leading edge inflatable (LEI) kites. The kite consists of a membrane canopy which is supported by an inflatable tubular frame. The frame transfers the wind loads from the canopy to the bridle line system which is further connected to the main tether. This tensile structure is highly flexible and exhibits large displacements as a result of the aerodynamic loads. Consequently, the loads and displacements are strongly coupled and form a complex fluid-structure interaction (FSI) problem. The flow separates both on the suction side due to the high angle of attack to maximize the lift force, and behind the tubular leading edge, where a constant separation bubble is formed. Moreover, the low aspect ratio and high anhedral angle of the kite make the flow highly three dimensional and the effect of wingtip vortices and crossflow cannot be neglected.

Currently, at TU Delft we use a simulation method which was initiated by Breukels [1]. His aerodynamic model uses two dimensional finite strip-approximation which divides the wing into two dimensional sections (airfoils) and neglects the three dimensionality of the flow. The section forces are calculated from two dimensional simulations with computational fluid dynamics (CFD). In this project, we continue the work by Breukels and use a full three dimensional CFD model. The model is coupled with a nonlinear structural finite element method (FEM).

At this stage we are focusing on two dimensional LEI kite airfoils. The two dimensional simulations are used to verify and validate the framework and also to study the effect of flow transition. The CFD simulations are carried out by using OpenFOAM which is coupled with a TU Delft inhouse structural solver by an efficient preCICE coupling environment. The results are compared to already existing experimental data from sailwing airfoils [2, 3].



The velocity field around the LEI kite airfoil with 0 (left) and 15 degrees (right) angle of attack.

References:

[1] Breukels, J.: An Engineering Methodology for Kite Design, PhD thesis (2011)

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