

Development of an Aeroelastic Simulation Framework for Leading Edge Inflatable Kites

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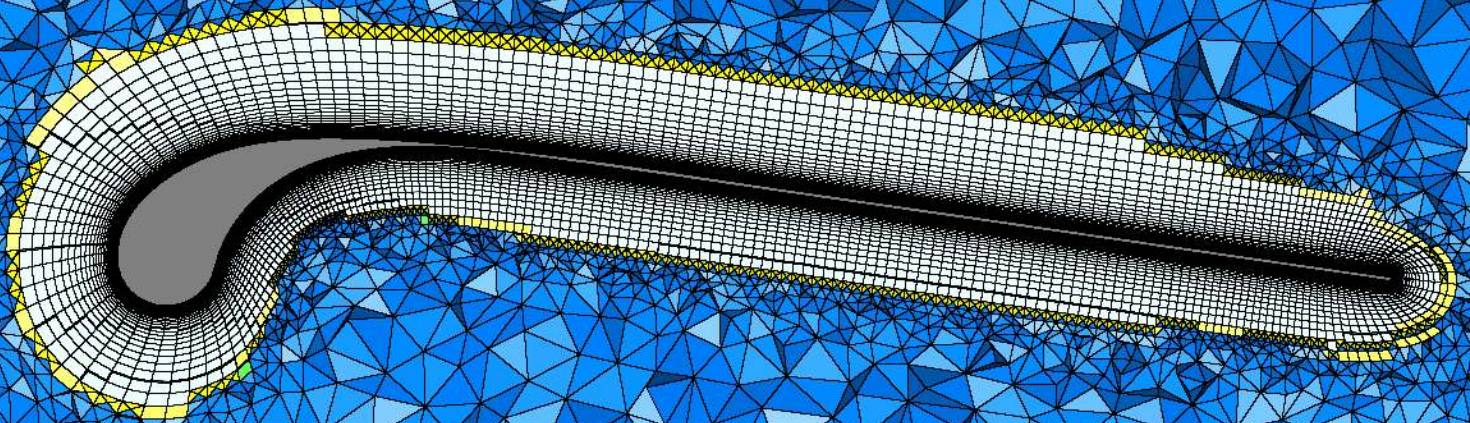
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CFD simulation of the flow around the TU Delft V3 kite: volume mesh slice near the symmetry plane. Geert Lebesque. Steady-state RANS simulation of a leading edge inflatable wing with chordwise struts. MSc Thesis, TU Delft, 2020.
<http://resolver.tudelft.nl/uuid:f0bc8a1e-088d-49c5-9b77-ebf9e31cf58b>.





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Development of an Aeroelastic Simulation Framework for Leading Edge Inflatable Kites

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Leading edge inflatable (LEI) kites pose a strongly coupled fluid-structure interaction problem due to the formidable flexibility of the wing's structure. Whilst pure aerodynamic analyses (in which the membrane wing is assumed to be a rigid body) do provide insight into the flow field around the kite [1,2], the omission of structural deformations is an approximation that neglects substantial aeroelastic effects.

As such, a more accurate representation of the flow field would account for load and design shape changes due to fluid-structure interactions. Building upon an aeroelastic model developed for ram-air kites [3], the purpose of this project is to establish a computational simulation framework that accurately reproduces the aeroelastic deformation phenomena endured by LEI wing profiles in airborne wind energy (AWE) operations.

The aeroelastic simulation framework follows a partitioned coupling approach that conducts parallel communications between dedicated aerodynamic and structural solvers. The Reynolds-averaged Navier-Stokes (RANS) equations, closed by the $k-\omega$ shear stress transport (SST) turbulence model, simulate the flow field around the wing using the open-source computational fluid dynamics (CFD) software OpenFOAM. The in-house finite element solver mem4py, developed solely for flexible mem-

brane wings [3], models the structural deformations. The two-way coupling between the aerodynamic and structural solvers is handled by preCICE, a software library for fluid-structure interaction coupling [3].

The modelling framework has been developed according to this method in the interest of building upon the existing body of knowledge regarding flexible membrane wing aeroelasticity. The feasibility of this strategy ultimately depends on the trade-off between computational cost and accuracy.

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CFD simulation of the flow around the TU Delft V3 kite: streamlines colored by the downstream velocity component U_z and pressure coefficient C_p on the wing surface, at $\alpha = 12^\circ$, $\beta = 0$ and $Re = 3 \times 10^6$. Geert Lebesque. Steady-state RANS simulation of a leading edge inflatable wing with chordwise struts. MSc Thesis, TU Delft, 2020. Postprocessing result by John Watchorn. <http://resolver.tudelft.nl/uuid:f0bc8a1e-088d-49c5-9b77-ebf9e31cf58b>.

