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Publication date
2019

Document Version
Final published version

Citation (APA)
Thedens, P., Bungart, M., & Schmehl, R. (2019). *Steady-State Solver for a Ram-Air Kite Aeroelastic Model Based on Dynamic Relaxation*. 131-131. Abstract from 8th international Airborne Wind Energy Conference (AWEC 2019), Glasgow, United Kingdom.

Computer rendering of the Skysails Power 200 kW AWE system

Skysails Power 200 kW AWE system in operation as rendering (left) and in the workshop (11 September 2019)

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Steady-State Solver for a Ram-Air Kite Aeroelastic Model Based on Dynamic Relaxation

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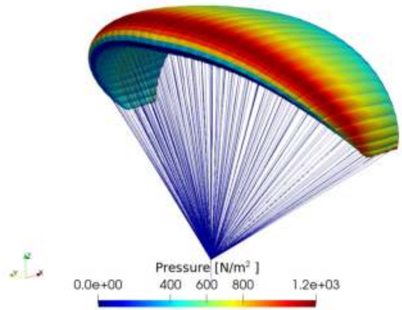
We present a computationally efficient steady-state solution method to model the aeroelastic deformation of a ram-air kite for airborne wind energy applications. The kite's weight in comparison to the aerodynamic forces is small which justifies a quasi-steady analysis, neglecting gravitational and inertial force effects [1]. The approach is suitable to efficiently determine the deformed configuration of a ram-air kite for design and optimization purposes as found in [2]. Because of the expected large deformations and changes in the flow field, fluid-structure interaction has to be taken into account in the analysis.

Ram-air kites have been modeled in the past using explicit time integration, such as in [3], to study transient flight behavior and maneuvers. At SkySails Power we aim to model the steady-state for specific angles of attack using dynamic relaxation (DR) by finding the equilibrium state between flow and structure. The steady-state solver ignores transient effects and therefore dramatically reduces computation time.

The kite's deformations are computed with the finite element method. Membrane elements with a non-compression and orthotropic material model are used for the canopy, and the bridle system is modeled using cable elements. The aerodynamic forces are computed with a 3D inviscid panel method which allows a fast pressure field computation.

The solver is used to determine the deformed shape and forces acting on the kite's structure during flight and can be used for geometric parameter optimization.



Deformed ram-air kite under pressure load determined by fluid-structure interaction.

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