AIRBORNE WIND ENERGY CONFERENCE 2021

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Modelling aeroelastic deformation of inflatable membrane kites

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Research Goal

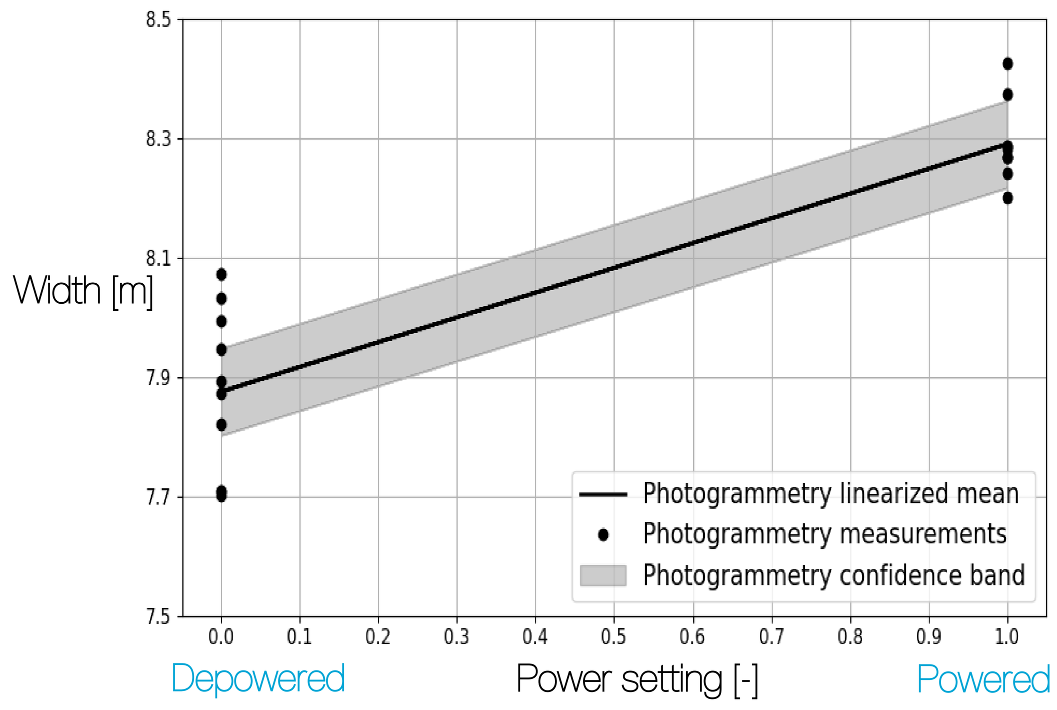
Assess the aeroelastic deformation effects of a soft wing membrane kite by developing a fast structural model.

Data acquisition

Kitepower B.V.'s in-flight footage (2017) of a 25m^2 kite was used to extract video stills of the extreme states, where only the symmetric deformation data was found of sufficient quality.

Distortions were removed using a lens distortion and assuming struts of constant length. The kite width and trailing-edge (TE) length are measured.

In between the extreme states, the 5% change in width is linearized.

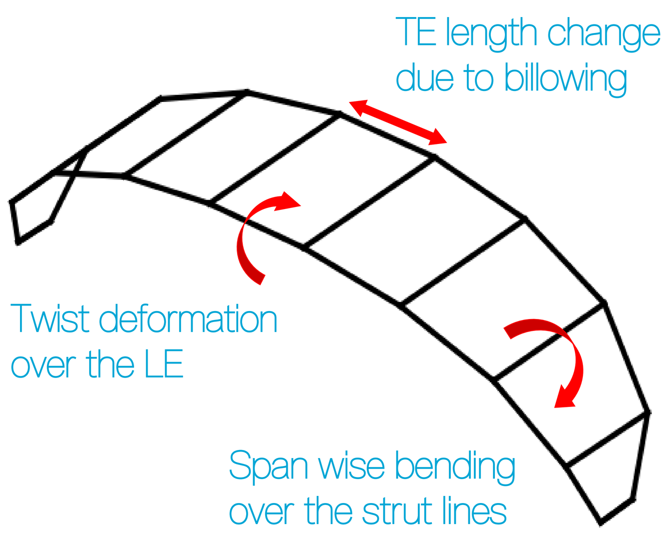


Canopy billowing causes an on average 2.5% difference in TE length.

Wing model

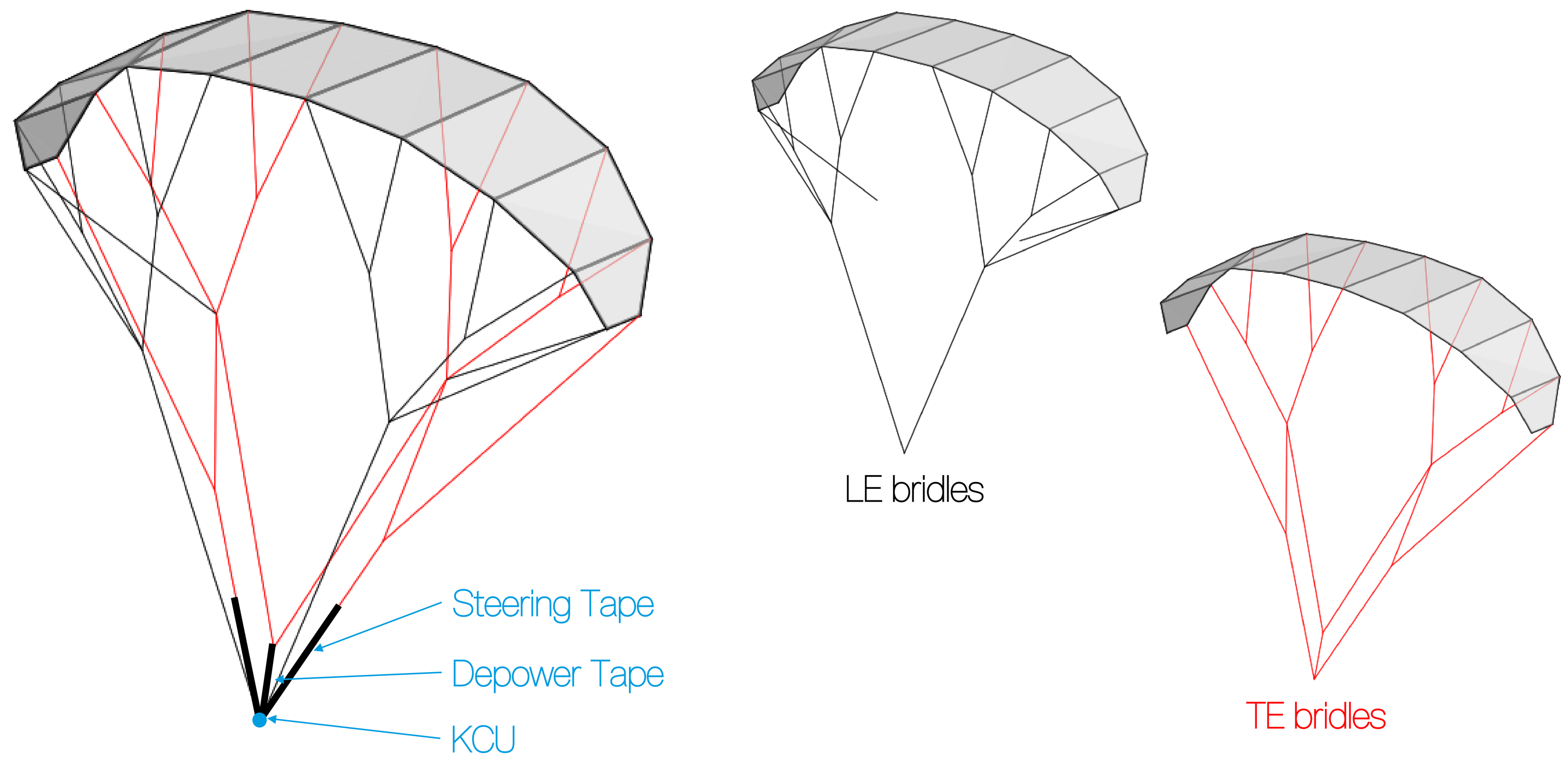
The shape of the kite is dominated by the aerodynamic force resisted by the elongation resisting properties of the membrane and bridle lines, that are attached to all struts on both the leading edge (LE) and TE.

Modelling hypothesis: One can describe the shape by the bridle line attachment points, who form the corners of a wireframe multi-plate representation.



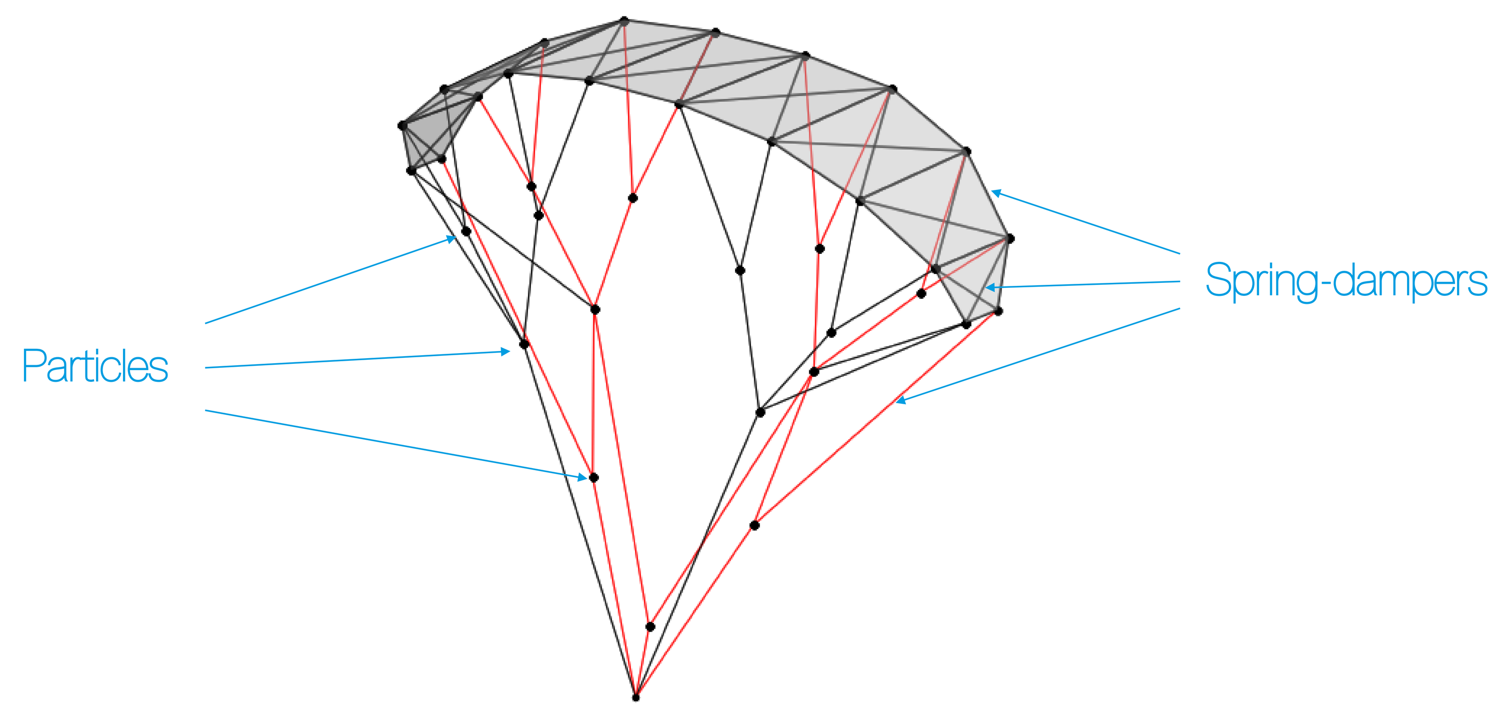
Bridle line system

Differences with the actual system are due to not modelling the bridle line forking near the kite and attaching both LE and TE lines to the KCU.

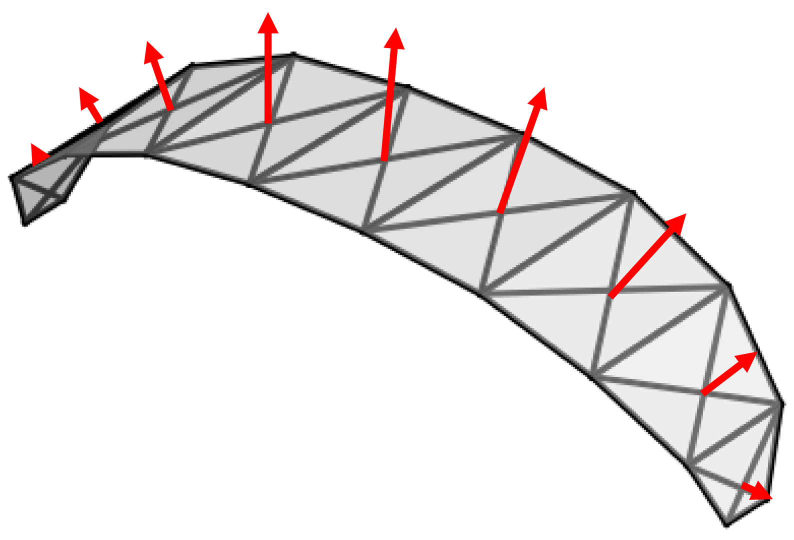


Particle system model (PSM)

The PSM consists of particles, spring-dampers and an external force and calculates the aeroelastic deformation by finding the new corner point locations.

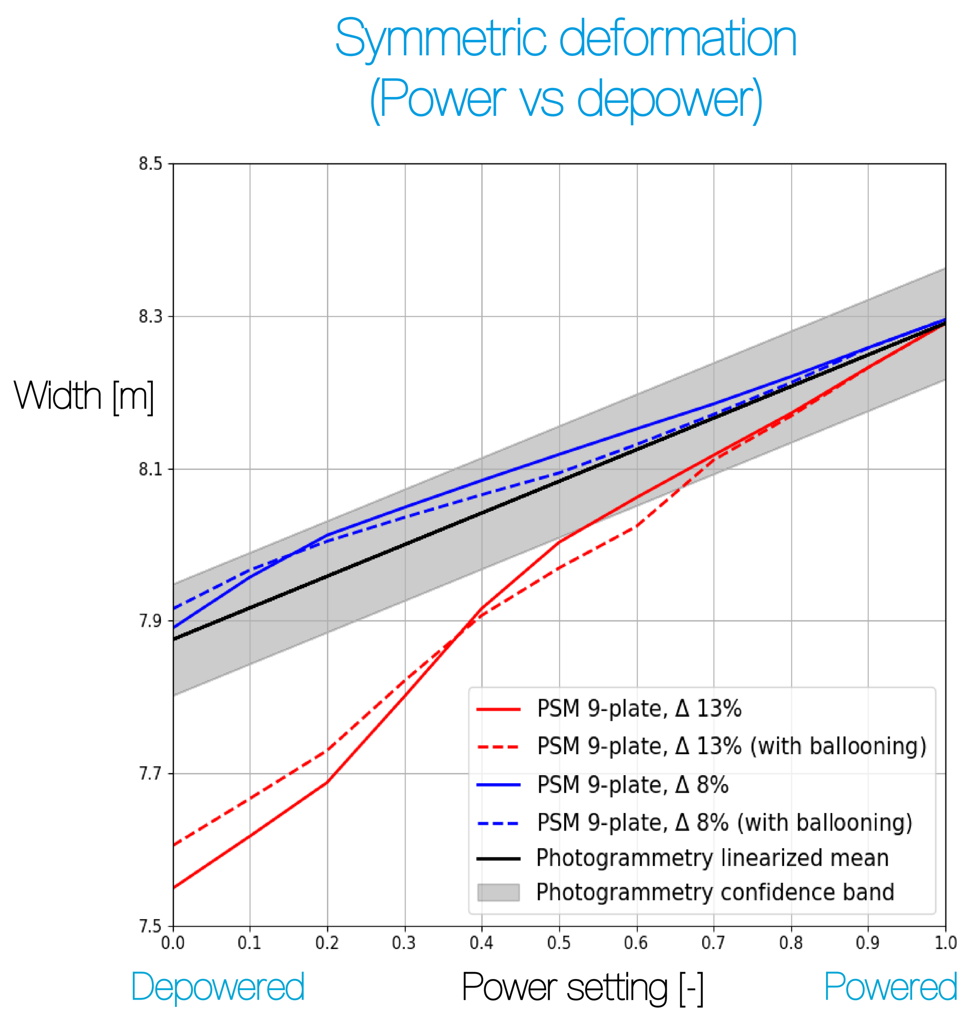


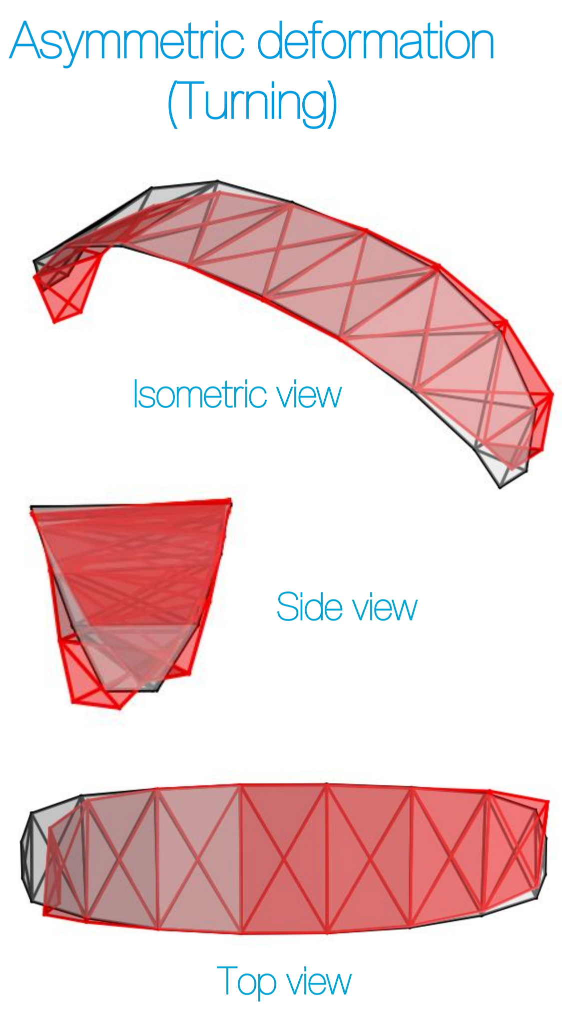
A lift force is applied normal to each panel and scaled based on the plate area and orientation. When simulating turns, this resulted in dynamic stabilization.



Results

Validation data was only found for symmetric deformation, therefore asymmetric deformation is only qualitatively assessed.





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