

Fast Aeroelastic Model of a Leading-Edge Inflatable Kite

Cayon, O.; Poland, J.A.W.; Schmehl, R.; Gaunaa, Mac

Publication date

2022

Document Version

Final published version

Citation (APA)

Cayon, O., Poland, J. A. W., Schmehl, R., & Gaunaa, M. (2022). *Fast Aeroelastic Model of a Leading-Edge Inflatable Kite*. 171. Poster session presented at 9th international Airborne Wind Energy Conference, Milano, Italy.

Important note

To cite this publication, please use the final published version (if applicable). Please check the document version above.

Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights. We will remove access to the work immediately and investigate your claim.

Green Open Access added to TU Delft Institutional Repository

'You share, we take care!' - Taverne project

<https://www.openaccess.nl/en/you-share-we-take-care>

Otherwise as indicated in the copyright section: the publisher is the copyright holder of this work and the author uses the Dutch legislation to make this work public.



Oriol Cayon

MSc Student
Delft University of Technology
Faculty of Aerospace Engineering
Wind Energy Group

Kluyverweg 1
2629 HS Delft
The Netherlands

oriol.cayon@gmail.com
kitepower.tudelft.nl



Fast Aeroelastic Model of a Leading-Edge Inflatable Kite

Oriol Cayon^{1,2}, Jelle Poland¹, Roland Schmehl¹, Mac Gaunaa²

¹Delft University of Technology

²Technical University of Denmark

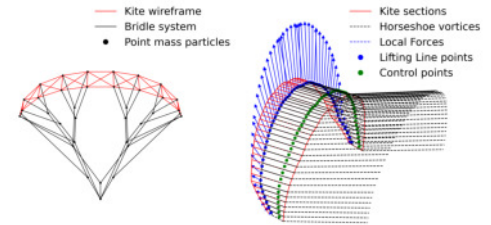
When designing an airborne wind energy system, it is necessary to be able to estimate the traction force that the kite produces as a function of its flight trajectory. Being a flexible structure, the geometry of a soft kite depends on its aerodynamic loading, and vice versa, which forms a complex Fluid-Structure Interaction (FSI) problem. Currently, kite design is usually done on an experimental basis, since no model meets the requirements of being accurate and fast at the same time.

In this project, an FSI methodology is developed to study the steady-state aerodynamic performance of leading-edge inflatable (LEI) kites by coupling two fast and simple models.

On the structural part, the deformations are calculated with a particle system model [1], based on the assumption that the shape of the kite can be modeled using a wireframe wing model represented by the bridle line attachment points, whose coordinate changes are modeled using a bridle line system model and canopy ballooning relations.

On the aerodynamic side, the load distribution is calculated with a 3D nonlinear vortex step method [2,3], coupled with 2D polars obtained with a correlation model derived from CFD data [4], to account for viscous effects and flow separation, as well as the changes in airfoil geometry. Based on 2D thin airfoil theory, the 3/4c point is used to determine the magnitude of the forces and the 1/4c point is used to determine direction of these forces. Moreover, the model developed for LEI kites is capable of taking into account ballooning and variations in kite and

airfoil geometry, while proving to be robust and inexpensive. This model has been validated with several geometries, together with a RANS analysis of the LEI kite, showing great accuracy for pre-stall angles of attack.



Particle system model representation (left), vortex step model discretization example (right).

References:

- [1] Poland, Jelle. . "Modeling aeroelastic deformation of soft wing membrane kites". MSc thesis. TU Delft, 2022.
- [2] Damiani, Rick et al. (2019). A Vortex Step Method for Non-linear Airfoil Polar Data as Implemented in KiteAeroDyn. doi: 10.2514/6.2019-0804.
- [3] Ranneberg, M. (2015). Direct wing design and inverse airfoil identification with the nonlinear Weissinger method. arXiv preprint arXiv:1501.04983.
- [4] J. Breukels. "An engineering methodology for kite design". PhD thesis. TU Delft, 2011.