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Eijkelhof, D.; Schmehl, R.

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Dylan Eijkelhof

PhD Researcher
Delft University of Technology
Faculty of Aerospace Engineering
Wind Energy Group

Kluyverweg 1
2629 HS Delft
The Netherlands

d.eijkelhof@tudelft.nl
www.tudelft.nl/en/ae

Performance vs. Mass of Box Wing Designs Using Parametrised Finite Element Modelling

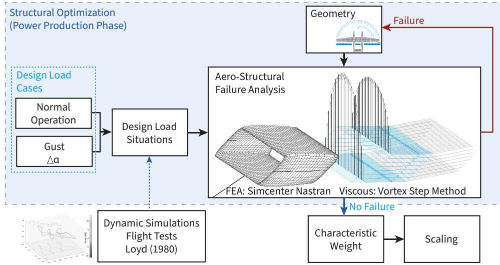
Dylan Eijkelhof, Roland Schmehl
Delft University of Technology

A big challenge for scaling up airborne wind energy fixed-wing kites is their mass. As we scale towards Megawatts, the need for larger kites becomes clear, inevitably leading to increased mass. Gravity is consistently highlighted as a critical concern, especially in relation to power production scalability [1, 2]. Consequently, it becomes imperative, during the preliminary design phase, to gain a comprehensive understanding of the scaling properties and potential limitations that may be encountered in the design process.

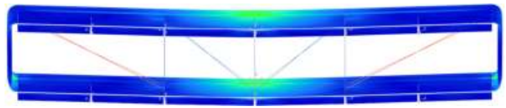
To gain a thorough understanding of the scaling process, it is crucial to use a reliable structural analysis tool for assessing the design's performance. This tool is also tailored to support the objectives of Work Package 4 (WP4) within the HAWK project, funded by the Sustainable Energy Authority of Ireland involving both industry and academia. WP4 is dedicated to evaluate the performance of the wing structure, leveraging material properties obtained through experimental testing.

The framework comprises of an open-source parameterised fixed-wing kite design and a finite element (FE) meshing tool, both developed within a Matlab environment. These tools are seamlessly integrated with an automated failure analysis interface specifically designed for use in Siemens Simcenter Nastran. Validation is performed using the Kitekraft 2.5m wingspan box wing kite.

Subsequently, an optimiser is employed to determine the material thicknesses needed for each scale while adhering to a defined objective function that encompasses both minimising weight and ensuring the quality of power output.



Flowchart of the framework developed to obtain the characteristic weight at each design scale.



Stress results of a box wing made from aluminium plate material. Highest stresses occur at the root and the cant region.

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[1] R. H. Luchsinger: Pumping cycle kite power. In Airborne wind energy (pp. 47-64). Berlin, Heidelberg: Springer Berlin Heidelberg (2013).

[2] L. Fagiano, S. Schnez: On the take-off of airborne wind energy systems based on rigid wings. Renewable Energy 107:473–88, (2017).