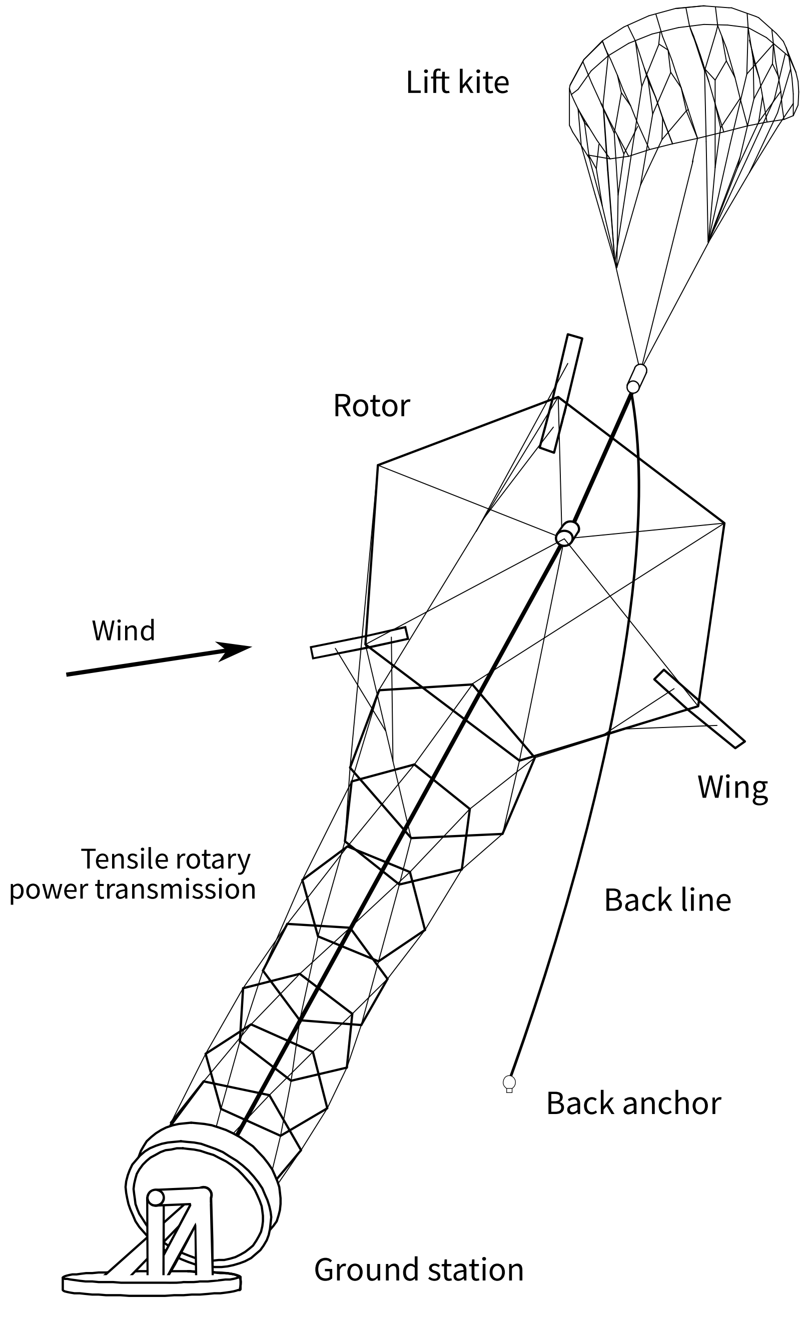
Daisy Kite AWES with labelled main components. Oliver Tulloch. Modelling and Analysis of Rotary Airborne Wind Energy Systems - a Tensile Rotary Power Transmission Design. PhD Thesis, University of Strathclyde, 2021. https://doi.org/10.48730/pm13-at49



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Design Analysis of a Rotary Airborne Wind Energy System

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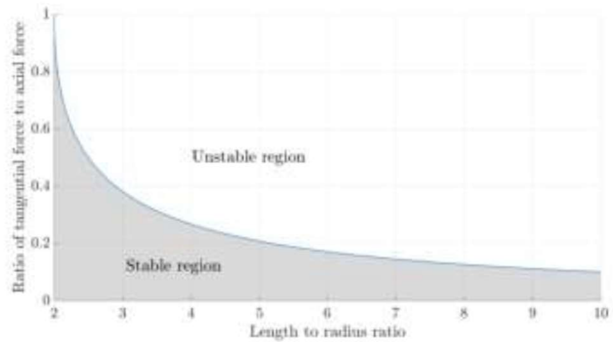
The rotary kite airborne wind energy system (AWES) under study incorporates a unique design of tensile rotary power transmission (TRPT) from the airborne components to the ground. Recent model development and experimental campaign have demonstrated promising features of this prototype such as stable lifting structure, less line drag and easier to automate for larger deployments [1,2]. The aim of this study is to investigate impacts of design parameters on system performance. Model-based steady state analysis has been undertaken considering key factors in the TRPT design, the rotor design, and the tether drag.

The amount of torsion that a single TRPT section can transmit is dependent on the TRPT's geometry, the axial force applied to it and the torsional deformation of the section. The static torque is calculated against selected design parameters individually. The critical value of the torsional deformation angle, δ_{crit}, can be identified for a given geometry. The operational limits are then analyzed to determine the maximum force ratio that can be achieved. The simulation figure shows the stable and unstable regions with a constant ring radius, the dividing line in between the two regions is formed by the values of δ_{crit} under each geometry and operating setting.

The rotor is a crucial component for any rotary AWES, which is responsible for extracting the power from the wind. The need to fly the rotor on the top end of a tether, avoiding ground strikes and reaching higher altitudes, means that the flying rotor must be tilted into the wind. The influences of the rotor elevation angle, the wing pitch angle, the blade length and the rotor solidity on the maximum power coefficient are studied, based on which an optimized rotor design is suggested.

The tether drag is assed using a simple tether drag model and an improved one. The torque loss and the TRPT efficiency are evaluated against key TRPT parameters. The full range of the tip-speed ratio is analyzed for the tether drag's impact on steady operating conditions.

The above model-based analysis provides useful insights that will help to achieve the optimized design, operation and scaling.



Force ratio against the length to radius ratio of a TRPT section.

References:

[1] Tulloch, O.: Modelling and Analysis of Rotary Airborne Wind Energy Systems – a Tensile Rotary Power Transmission Design. PhD Thesis, University of Strathclyde (2021).

[2] https://windswept-and-interesting.co.uk/