Development of Safe and Efficient Control for Airborne Wind Energy (AWE) Systems – a Rotary Ring Kite Design

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Introduction

- A PhD investigating a novel rotary kite airborne wind energy (AWE) system. The aim is to achieve safe and efficient operation through control.
- The Daisy Kite system has been developed by Windswept and Interesting Ltd. Through the production and testing of various prototypes the design has been refined.
- The PhD will initially focus on the development of a computer model of the Daisy Kite system.

The most recent prototype undergoing testing. Photo taken by Rod Read, founder of Windswept and Interesting Ltd [1].

- The motivation behind AWE is to produce lightweight energy harvesting devices capable of reaching higher altitudes than conventional horizontal axis wind turbines at a lower cost of energy.
- At present the only commercially available device is the SkySails [2] towing kite. The product pulls sea going vessels and is capable of replacing 2MW of engine power.
- In recent years AWE has received an increasing amount of attention from industry and academia. Kite Power Solutions [3] (KPS) has recently received permission of test their 600kW device in Southern Scotland.

Daisy Kite System

- The Daisy Kite design is very different to most other AWE systems. It uses the effect of autorotation to create lift and usable shaft power.
- A lifter kite is used to pull the entire system into the air where the driver kites cause the entire system to rotate.
- The device uses a cylinder of tensioned tethers held apart by a number of rigid rings. This system transmits the rotational motion created by the driver kites down to the ground station to drive the generator.
- The current prototype has produced a maximum output of just over 300W.

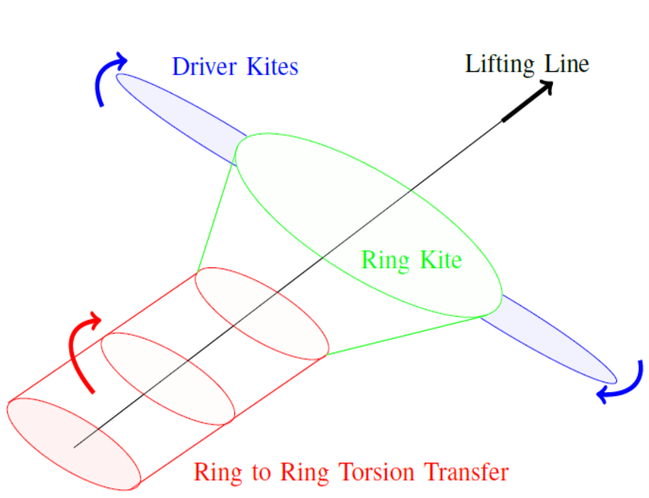
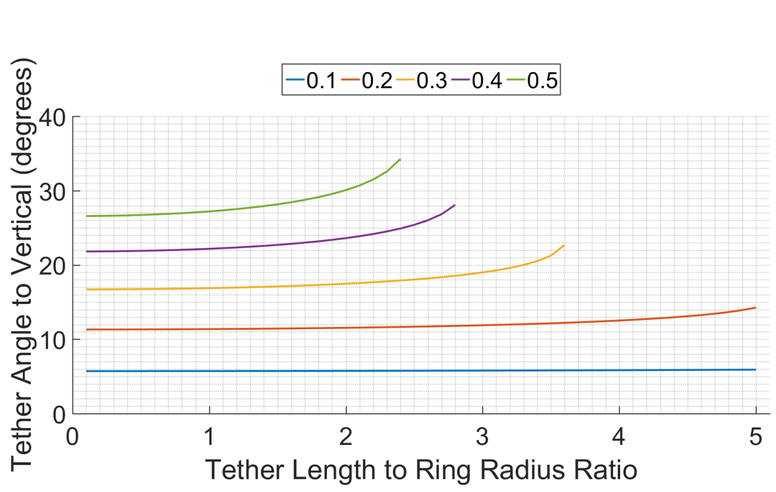
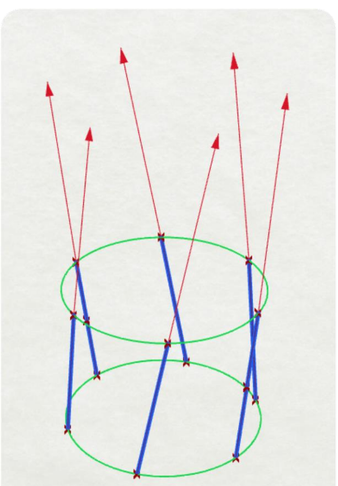


Diagram showing the main components of the Daisy Kite system.

Torsion Transfer Analysis

- The torsion transfer system has been analysed by creating the model shown below. The force vectors (red) show the lift and rotational force produced by the driver kites. The tethers (blue) are modelled as springs.
- The two rings (green) are rigid with the lower ring held stationary and the upper ring free to move.
- To investigate the system the ring radius and lift force were held constant while the tether length and rotational force were varied.
- The angle between the tethers and the vertical is used to compare different simulations. The greater the angle the closer the system is to failure, the point at which tethers cross and become tangled.
- The graph below shows the results. The 5 different coloured lines show the ratios of rotational to lift force that were investigated, ratios of 0.1 to 0.5.
- The graph shows that a lower rotational force and smaller tether lengths result in smaller angles and therefore a more robust system.





Right – Image of the torsion transfer model
Left – Graph of the obtained results

Conclusions and Future Work

- A basic analysis of the torsion transfer system has been achieved.
- The torsion transfer model will be expanded to include multiple rings and a model of the driver and ring kites will be produced.
- The two models will be linked to create a model of all the airborne components of the Daisy kite system.
- A new prototype is to be produced that is equipped with a number of sensors and data loggers. Experimental data will be collected and compared to the results from the computer model.
- The computer model will be used to asses the systems performance and refine the device's design.
- The model will be used to develop efficiency and safe operation of the Daisy kite system.

References

[1] – R. Read. Windswept and Interesting LTD. [Online]. Available: http://windswept-and-interesting.co.uk/

[2] - SkySails. [Online]. Available: http://www.skysails.info

[3] - Kite Power Solutions. [Online]. Available: http://www.kitepowersolutions.com/

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