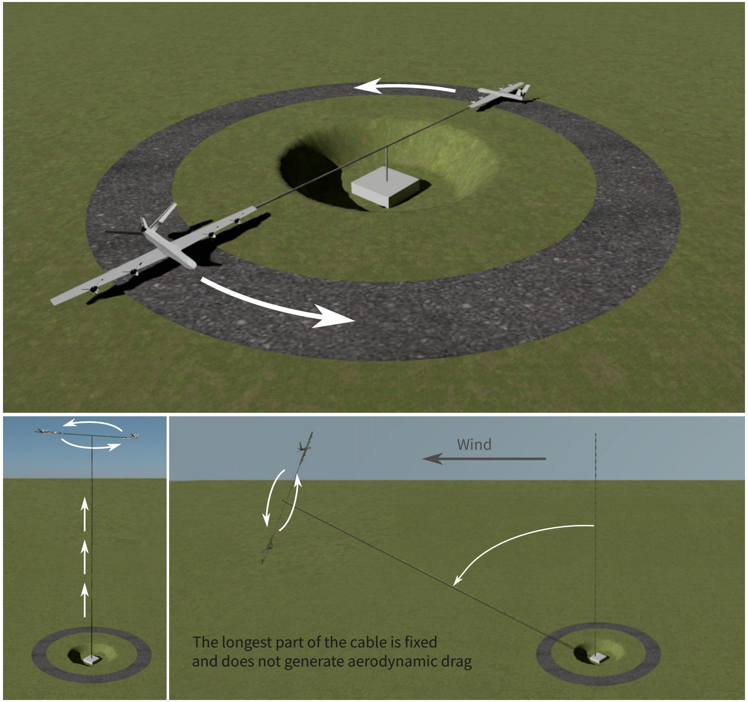

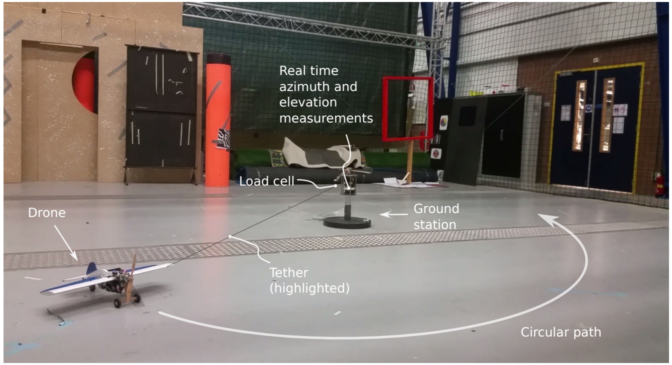

Experimental take-off system (top): Experimental rotational start of a half dual-drone system in fully automated take-off and landing sequence. The axi-symmetric round-the-pole flight of a single wind drone has been investigated by means of a dynamic model and an experimental test setup in order to investigate the dual drone concept.

Dual drone concept (left): Two wind drones are linked by a cable at their starboard wing-tip. They accelerate along a circular landing strip using the power from the motors until take-off (top-left). After take-off, the two drones lift the main cable to the desired altitude (bottom-left). i. e. the main cable is kept fixed and the drones continue to rotate thanks to wind power while using their motors as generators.

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Preliminary Test on Automatic Take-Off and Landing of a Multi-Drone Low-Drag Airborne Wind Energy System

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Crosswind Airborne Wind Energy Systems are currently able to reach altitudes of several hundred meters above ground level. Although this is higher than conventional wind turbines, the optimal altitude is limited by the increasing aerodynamic drag of the tether. Simple models for steady-state crosswind flight suggest that for typical wind shear profiles the power loss due to sweeping a longer tether through the air outweighs the power gained by accessing more powerful winds at higher altitude.

A possible solution to this problem is represented by the so called "dancing kite" concept, where a single long cable is attached to two shorter cables, each connected to a kite. The kites are flown in such a way that the long cable is kept in a fixed position with respect to the ground, thus not dissipating power by drag forces, and only the two short cables follow the crosswind motion of the kites. This concept might be the first that is able to reach altitudes of several thousand meters, thus reaching the extreme power densities of the jet streams, allowing to build low cost and powerful wind turbines.

Envisioning a take-off system for such a concept is particularly challenging, and having repeatable and robust take-off and landing capabilities is crucial for the success of the dancing kite principle.

Extending the dancing kite principle to a rigid wing setup can have several advantages, above all, it allows for simple take-off and landing sequences. For example, attaching the tethers to the wing tip of several drones results in a multi-drone system that can take-off and land on an axisymmetric circular runway. For this purpose, the axisymmetric round-the-pole flight of a single wind drone has been investigated by means of a dynamic model and an experimental test setup. In this work, a simple 3-degree-of-freedom model represents the flight of the wind drone in spherical coordinates. The drone is modelled as a point mass with aerodynamic properties, throttle and pitch control. The model also takes into account the stabilizing effect from the lift of the horizontal stabilizer, from the pitch angular velocity, and from the restoring pitch moment due to the centre of gravity being below the aerodynamic centre.

The experimental campaign demonstrated full autonomous take-off and landing capabilities of a small scale wind drone flying round the pole in an axisymmetric configuration. The passive stability of the flight suggests that autonomous take-off and landing can easily be achieved in a dual drone system.

References:

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