Testing the TU Delft 20 kW kite power system at Valkenburg airfield, Leiden, The Netherlands (12 April 2012).

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Preparing the Road for 24 Hours Flight Operation of a Pumping Kite Power System

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Based on the unique 20 kW technology demonstrator of the Delft University of Technology, a private-public partnership targets for further improvement of the system. Therefore, the team of enevate b.v. systematically improves the KPS's reliability and robustness with the aim of demonstrating 24 hours of continuous automatic operation. To achieve this goal, system components are being redesigned, control algorithms are made fault-tolerant and capable of adapting to changing wind conditions.

The kite is steered and de-powered by a Kite Control Unit (KCU), suspended about 10m below the kite and connected to the main tether from the bottom and to power and steering lines from the top. As this main tether does not conduct electricity an airborne power supply is required. It consists of a wind turbine, which is directly mounted on the KCU. Both, maximum power point tracking and power management are implemented within the KCU using a single printed circuit board. The latter manages all power related tasks comprising a highly available power supply, which is guaranteed by a battery back-up.

The central on-board control system of the KCU is composed of a three-processor logic, working on three separate layers. To achieve high reliability, these layers can be bypassed regarding the level of criticality, enabling controllability of the system in case of a subsystem failure.

The top-layer runs a Linux operating system, handling the communication and the sensor data collection. In the future all flight path computations will run on this layer. The second layer, an ARM micro-controller, manages the positioning of the two drive trains, providing the possibility to feed-in manual steering override commands. The third layer is transforming the position control commands of layer two into motor currents. All layers are designed such that they cannot block each other in the top-down direction, which implies that faulty data can not affect the operation of the layer underneath.

Although this architecture achieves a high level of reliability it cannot ensure that the system does not experience faults or failures during automatic operation. Therefore, the flight control system has to be able to recognise undesired states and to react adequately without human interaction. This ability is realized by employing a Health Supervisor that acts as a guarding loop. It regularly checks the system for certain health symptoms such as irregularities in the KCU, inconsistency in the predicted flight path or other hazardous flight dynamic states. Based on those symptoms the Health Supervisor assigns a certain health status to the system. The supervisor consequently has the authority to overrule the autopilot in order to initiate automatic counteractions. The counteractions thus cover a range of minor changes in the system behaviour and updates in the desired flight path as well as immediate landings or emergency touchdown manoeuvres.