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DEVELOPMENT OF A THRUSTER-BASED PAYLOAD STABILIZATION METHOD FOR A SINGLE-AIRPLANE TETHERED LIFTING SYSTEM

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ABSTRACT

Vertical lifting operations with aircraft are essential during emergencies, to access remote regions and for various construction operations, even though they are costly. Helicopters are typically used for these operations, but these aircraft are known for their high operating cost partly due to their mechanical complexity and fuel consumption. An alternative method for vertical load lifting includes airships. However, they lack the manoeuvrability required for most aerial operations, they require oversized hangars for storage, and use helium, a limited resource gas.

An alternative approach to efficiently lift a payload consists on using high-efficiency airplanes flying along a circular path while being tethered to a centralized payload. The system aims to replace the highly loaded rotor disk of a rotorcraft by high-efficiency airplane wings. The payload has to remain at the centre of the trajectory for such a lifting method to work. The payload can maintain a steady position using either (1) a multi-airplane configuration to balance the lateral loads or using (2) a long tether and accept some payload motion, as demonstrated as early as 1942 for cargo delivery. In addition to a 5-fold reduction in power requirements for the same payload, this concept enables to reuse commercial airplanes with minimal mechanical modifications.

In order to minimize the system complexity while providing a precise payload position, the current work focus on the development of a thruster-based Payload Control System (PCS) for a single circling airplane. Installed at the tip of the tether, the PCS first allows for a precise positioning of the payload to compensate the airplane trajectory deviation and the aerodynamic forces on the tether. Second, the PCS allows for a shorter tether, which diminishes the influence of aerodynamic forces on the system. Third, the PCS creates a rotating force around the payload to compensate the lateral force imbalance in the case of a single tether concept. As a result, the PCS is the missing key to enable efficient single-tethered airplane payload delivery and aerial work in remote regions.

This presentation aims to present the latest developments in the PCS design, numerical simulations, and experimental results. The prototype is designed to control the lateral position and yaw of a 2 kg payload (including the PCS) under a UAV simulating the circular trajectory of an airplane. This PCS is equipped with a Pixhawk flight controller, real-time kinematics GPS and five thrusters.