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Control Co-Design for Takeoff and Landing of Tailsitter VTOL AWES

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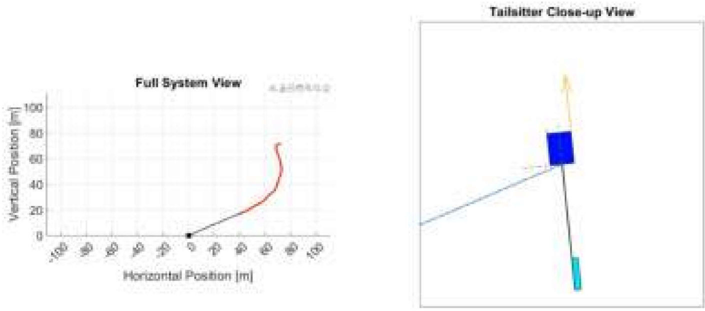
This research proposes a Control Co-Design (CCD) framework for the optimization of wind-planes (Fly-Gen Airborne Wind Energy systems) based on a tailsitter configuration, focusing on resolving the critical design conflict between the power generation and hover phases. While aerodynamic principles suggest that positioning generation turbines at the wingtips maximizes power harvesting efficiency [1], the requirement for Vertical Take-Off and Landing (VTOL) authority necessitates placing additional propulsion units closer to the fuselage to allow precise pitch control during this critical phase. The proposed framework optimizes the distribution of this installed power—specifically the positioning of motors along the wing, the propeller dimensions, and the wing dihedral angle—to mediate this trade-off between optimal energy extraction and takeoff feasibility.

The co-design problem is formulated using a simulation-based optimization approach that couples the plant geometry with a Linear Quadratic Regulator (LQR) control system, regulating motor speeds to generate the necessary thrust and moments. The modeling framework focuses the analysis to the longitudinal plane (pitch, surge, and heave), leaving lateral dynamics, roll/yaw coupling and downwash on control surfaces as accessory effects.

The cost function in this study is constructed from direct simulation measures and control stability quantities. This approach allows for a rigorous examination of the dynamic stability margins and power efficiency penalties incurred by the forced relocation of motors from the ideal wingtip location to the fuselage. The result is a specialized tailsitter design that sacrifices a quantified degree of harvesting efficiency to guarantee robust VTOL capabilities within a strict longitudinal control envelope.



Ground station approach path and Tailsitter attitude visualization

References:

[1] Trevisi, F., Cassoni, G., Gaunaa, M., and Fagiano, L. M.: Concurrent aerodynamic design of the wing and the turbines of airborne wind energy systems, Wind Energ. Sci., 11, 195–216, https://doi.org/10.5194/wes-11-195-2026, 2026

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