Assessing the Impact of Actuator and Rotor Dynamics on Energy-Optimal Electric Rotorcraft Missions

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Abstract. This paper investigates how actuator rate limits and rotor dynamic response influence the execution of missions optimized for energy consumption in electric unmanned helicopters. While prior studies commonly assume idealized control authority, practical propulsion systems exhibit finite response rates and dynamic lag that may affect achievable energy savings. Using a MATLAB/Simulink and FLIGHTLAB simulation framework, we compare optimized mission profiles under ideal and constrained actuation models. The results demonstrate that actuator and rotor dynamics primarily influence transient behavior during phase transitions, introducing smoothing and short duration power deviations. However, their impact on cumulative mission energy is minimal, with total energy differences below 1%. These findings indicate that simplified actuator models can be sufficient for preliminary energy assessment at mission level, while higher fidelity dynamics remain essential for realistic trajectory tracking and control feasibility.