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Development of a Tilt-Rotor Aircraft Model Using System Identification Technique

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Abstract : The introduction of tilt-rotor aircraft into the existing civilian air transportation system will provide beneficial effects due to tilt-rotor capability to combine the characteristics of a helicopter and a fixed-wing aircraft into one vehicle. The disposability of reliable tilt-rotor simulation models supports the development of such vehicle. Indeed, simulation models are required to design automatic control systems that increase safety, reduce pilot's workload and stress, and ensure the optimal aircraft configuration with respect to flight envelope limits, especially during the most critical flight phases such as conversion from helicopter to aircraft mode and vice versa. This article presents a process to build a simplified tilt-rotor simulation model, derived from the analysis of flight data. The model aims to reproduce the complex dynamics of tilt-rotor during the in-flight conversion phase. It uses a set of scheduled linear transfer functions to relate the autopilot reference inputs to the most relevant rigid body state variables. The model also computes information about the rotor flapping dynamics, which are useful to evaluate the aircraft control margin in terms of rotor collective and cyclic commands. The rotor flapping model is derived through a mixed theoretical-empirical approach, which includes physical analytical equations (applicable to helicopter configuration) and parametric corrective functions. The latter are introduced to best fit the actual rotor behavior and balance the differences existing between helicopter and tilt-rotor during flight. Time-domain system identification from flight data is exploited to optimize the model structure and to estimate the model parameters. The presented model-building process was applied to simulated flight data of the ERICA Tilt-Rotor, generated by using a high fidelity simulation model implemented in FlightLab environment. The validation of the obtained model was very satisfying, confirming the validity of the proposed approach.

Keywords : flapping dynamics, flight dynamics, system identification, tilt-rotor modeling and simulation
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