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Mission Performance Analysis of a Conceptual Coaxial Rotorcraft for Air Taxi Applications

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Abstract

The rotorcraft industry has recently shown a new interest in compound rotorcraft as a feasible alternative to tackle the rapid growth of civil aviation activities and associated environmental impact. Indeed, aircraft contribution to the global emissions of CO_2, NO_x, and noise are driving the development of innovative technologies and vehicles. At present, compound rotorcraft architectures are regarded by the industry as promising platforms that can potentially increase productivity at a reduced environmental cost. In order to quantify the benefits of compound rotorcraft, this paper details the performance analysis of a coaxial counter-rotating rotor configuration with a pusher propeller. A comprehensive approach targeting the assessment of the aforementioned rotorcraft design for civil applications is presented herein. The methodology developed encompasses a rotorcraft flight dynamics simulation module and an engine performance module, coupled with a gaseous emissions prediction tool for environmental impact studies. They have been integrated together to constitute a standalone performance simulation framework and verified with the performance calculations of Harrington's "rotor 1" and the Sikorsky X2TD. The method is then applied to evaluate the performance of a conceptual coaxial rotorcraft, during a notional inter-city air taxi mission, in terms of cruise altitude, speed, and range, overall mission time and environmental impact. The several trade-offs between these parameters highlight the need for an integrated optimisation process. Besides, the concept demonstrates the benefits of the compound rotorcraft architecture with a best range speed reaching 90 m/s leading to reduced response times and increase of round trips in a given time. As a consequence, operators will need fewer vehicles and heliports to cover the same areas. This outcome is highly attractive in the current growing market.

Keywords: rotorcraft, coaxial rotor, simulation, performance, mission analysis, gaseous emissions

1. General Context

The continuous rise in global energy demand, resulting inevitably in the depletion of fossil fuel, motivates the exploration for more efficient and sustainable transport alternatives. Although the aviation activity is a relatively small contributor to the global carbon dioxide (CO_2) footprint, with an estimated 2% share of the worldwide emissions [1], it is subject to increasing concerns from government authorities and international regulatory bodies. This is explained by the fast growth of the global aviation traffic with an average annual growth of 4% [2]. The 2035 global traffic is forecasted to be twofold the one in 2016 making the aviation industry the most rapidly growing source of CO_2 emissions. Moreover, aircraft contribute to climate change in more than CO_2 emissions: Nitrogen-oxides (NO_x), water vapour, particulate matter (soot) are also emitted by aircraft engines. All emissions from aviation were estimated to represent approximately 5% of the global temperature rise in 2005 [3]. NO_x also severely impairs people's health when present in high concentration. A third critic directed to the aviation industry is its noise emissions. Indeed aircraft noise is

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