Design, determination of stability and control characteristics and airworthiness of a natural laminar flow forward-swept wing aircraft with boundary layer ingestion technologies using flight simulation

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Abstract

This masters project focuses on the design and determination of the stability and control characteristics of a natural laminar flow forward-swept wing aircraft using a custom-designed Simulink flight simulator. This report also analyses the airworthiness of the aircraft in terms of the stability and control characteristics.

Much work has been done in the research sector of the aerospace industry towards the conceptual design of the next-generation aircraft with significantly reduced energy consumption, emissions and noise, the need of which being outlined by many environmental reports and statements such as Flightpath 2050 by the European Commission [1]. However, not much of the development has been focused on studying the stability and control characteristics of such conceptual aircraft. This report, in addition to studying the flight characteristics of the conceptual aircraft, aims to also study the compliance of its flight characteristics to existing regulations, in an attempt to analyse the practicality and potential issues of similar conceptual aircraft designs and configurations.

Natural laminar flow (NLF) is a technology developed in the aerospace research sector for reducing fuel consumption in future aircraft designs. Indeed, by combining NLF with a forward-swept wing, Seitz et al [2] have predicted a 9% reduction in fuel consumption while not incurring excessive wave drag and weight penalties to the design of a short/medium range transport aircraft similar in payload and range to the Airbus 320-200. Boundary Layer Ingestion (BLI) is another common method quoted in the aerospace research sector for similar purposes. A conventional tube-and-wing aircraft that uses BLI as its sole source of propulsion is suggested to have fuel savings of 36% by Uranga [3]. The aircraft designed for this report would therefore explore the potential in fuel savings brought about by the combination of NLF, a forward-swept wing and BLI.

To ensure that the stability and control characteristics as well as the handling qualities of the aircraft complies with existing regulations, flight simulations of the aircraft will be performed. To achieve this, a physical model of the aircraft is created, and the aerodynamic data of the aircraft generated via Athena Vortex Lattice (AVL), an open-source computation aerodynamics tool that generates data based on its implementation of the

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vortex lattice method. The data is then inputted into a custom-designed Simulink flight simulator to predict the aircraft's stability and control characteristics as well as its handling qualities. The flight characteristics are then analysed against the relevant regulations in FAR Part 25 [4], Military Standard MIL-F-8785C [5] and MIL-STD-1797 [6] to analyse for potential issues and areas of incompliance in its flight characteristics, and to draft methods for the mitigation of such issues.

References

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