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Stability, flying qualities and longitudinal parameter estimation of a twin-engine CS-23 certified light aircraft

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ABSTRACT

This paper presents some results of the flight test campaign conducted on the Tecnam P2006T aircraft, on the occasion of its certification process. This twin-engine propeller airplane is certified under the normal category CS-23 and FAR 23. A prototype of this light aircraft has been tested in flight for a post-design performance optimization and for the assessment of flight qualities. These experiences have led to the application of two winglets to the original wing. The final configuration has been extensively tested for the achievement of CS-23 certification. The longitudinal and lateral-directional response modes have been assessed and quantified. At the same time the longitudinal airplane model, through a dedicated set of flight maneuvers, has been characterized by means of parameter estimation studies. The aircraft stability derivatives have been estimated from the acquired flight data using the identification technique known as Output Error Method (OEM). Some estimated stability derivatives have been also compared with the corresponding values extracted from leveled flight tests and from wind tunnel tests performed on a scaled model of the aircraft.

1. Introduction

This paper presents the results of a flight testing research conducted on the P2006T aircraft, an innovative airplane produced by Tecnam. The purpose of this research is the determination of P2006T stability derivatives and the assessment of its flight qualities through the application of longitudinal parameter estimation techniques.

The selected airplane is a very light, twin-engine, propeller aircraft, with a maximum take-off weight of 1180 kg. The P2006T design and flight certification tests have been presented extensively in other papers [10–13]. Its main features are summarized in Section 2. A large amount of post-design work, and many flight tests have been carried out by the authors during the flight certification of this aircraft under the European category of regulations CS-23 [5] (the airplane is also certified in the FAR 23 category [6]). The authors are involved in the flight research activities of the ADAG (Aircraft Design and Aero-Flight Dynamics Group) at the University of Naples "Federico II", Department of Aerospace Engineering. The results presented in this work have been achieved after years of research in flight testing focused on flight certification and flight quality assessment of light and ultra-light airplanes. The details of past experiences are found in the cited references [2–4,11].

The flight tests analyzed in the present research took place during the CS-23/FAR 23 certification campaign of the P2006T. Although some flight maneuvers presented here are not strictly required for the certification in these categories, they are necessary for the purpose of aircraft dynamic stability characterization and parameter estimation. The reported P2006T flight qualities have been assessed analyzing the response to properly devised command histories. It is seen that the estimated stability derivatives show a good agreement with calculations made in the design phase and with wind tunnel results. Dynamic characteristics of phugoid, short period, dutch roll modes have been estimated by applying standard methods of analysis to a number of properly excited damped responses. Moreover, the flight data acquired through a dedicated set of performed maneuvers have been used to estimate the aircraft stability derivatives through the well-known 'maximum likelihood method' (MLM, see, for example, the book by Jategaonkar [7]). A Matlab code implementing this method, and based on the classical linearized equations of Flight Dynamics, has been used to construct the longitudinal aircraft aerodynamic model. In other previous papers written by the authors [2,3], the process of aircraft system identification has been shown and applied to light and ultra-light airplanes and motor-gliders. These flight test experiences have also shown the importance of aircraft system identification to implement a correct and high-fidelity model in a flight simulation environment [2].

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