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Roll performance assessment of a light aircraft: Flight simulations and flight tests

Fabrizio Nicolosi [a,1], Agostino De Marco [a,2], Vito Sabetta [b], Pierluigi Della Vecchia [a,*,2]

[a] *University of Naples Federico II, Italy*
[b] *Tecnam Costruzioni Aeronautiche, Capua, Italy*

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ABSTRACT

A methodology is presented for the roll performance assessment of a light aircraft. The study is based both on flight simulations and flight tests, focusing on the accurate determination of the lateral control power. The chosen test airplane was a Tecnam P92, a two-seat ultralight aircraft which was specifically equipped with a lightweight and accurate instrumentation for the planned set of flight data measurements. A matrix of flight experiments for the test campaign was established with the support of 6-degree-of-freedom simulations, implementing a carefully constructed baseline dynamic model of the aircraft. The article discusses first the general problem of a reliable evaluation of aircraft roll performance indicators, i.e. the estimation of the aerodynamic derivatives that mainly influence the airplane ability to roll. Next, the results of extensive flight test activities are presented. The analysis of several roll maneuvers performed at different flight speeds and with different aileron maximum deflections showed interesting rolling characteristics for this non-aerobatic aircraft. One notable finding was a clear nonlinear dependency of the aileron efficiency index on aileron deflection amplitude. A control power derivative extracted from flight data in the form of lookup table was used to correct the baseline flight dynamics model. Flight simulations outputs based on the updated model showed a satisfactory agreement with experimental time histories. According to this, the present effort proposes a new method to estimate the aileron control derivative in whole the flight envelope for light aircraft.

1. Introduction

A set of controllability requirements must be met by all aircraft to be certified for commercial use or adopted by the military. Many military airplanes also have additional maneuverability requirements. A poor design of aerosurfaces or their actuation systems often results in a limited amount of control authority available, and hence in the inability to meet the requirements. Thus, a reliable design of flight control surfaces is crucial, and it must be based on the adoption of appropriate methodologies.

Due to the iterative nature of design, it is important for designers to evaluate with good confidence the control authority of candidate concepts as early as possible in the design process. Normally numerous possible configurations are considered before the stability and control specialists start their analysis for the detailed control system design [1,2].

The analysis of control power required to meet controllability specifications at critical flight conditions has always been an important issue in aircraft design. It is well known that aircraft flight qualities are strongly dependent on the set of aerodynamic derivatives that make up the aircraft aerodynamic database. The correct estimation of these quantities, especially the control derivatives, at various flight conditions is often difficult when nonlinear dependencies of aerodynamic coefficients on state variables are involved. The size and placement of control surfaces determines the aircraft control authority. Excessive control authority can translate into increased weight and drag, while inadequate control power can result in a failed design. Thus, the designer's goal when sizing and placing control surfaces is to provide sufficient, yet not excessive, control power to meet the requirements of prescribed maneuvers, military specifications, or certification guidelines [3, Part VII].

This article addresses the traditional, aileron actuated, roll control of light aircraft, which is regulated by the FAR 23 [4] or CS-23 [5] specifications and MIL-STD-1797 guidelines [6]. Since roll controllability requirements must be met also with flaps deployed, the assessment of aircraft roll control derivative is considered a very important issue by designers because a good balance between

* Corresponding author.
E-mail address: pierluigi.dellavecchia@unina.it (P. Della Vecchia).
[1] Associate Professor, Dept. Industrial Engineering, Naples, 80125, Italy.
[2] Assistant Professor, Dept. Industrial Engineering, Naples, 80125, Italy.

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