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A NEW APPROACH IN AIRCRAFT VERTICAL TAILPLANE DESIGN

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ABSTRACT

The paper presents a new procedure to evaluate the sideforce (and hence the directional stability and control contribution) generated by the vertical tailplane of a typical regional turboprop aircraft in sideslip and with rudder deflection. The evaluation of stability and control derivatives has a deep influence on tailplane design. To develop a new procedure that correctly estimates the effect of aircraft's components aerodynamic interference (wing-body sidewash and wake, horizontal tailplane end-plate effect, rudder deflection), a regional turboprop aircraft geometry has been chosen, with some constraint such as fuselage slenderness, wing and tails positions, and aspect ratios. CFD analyses have been executed on hundreds of configurations. The University's computing grid SCoPE has been useful to solve the Reynolds-averaged Navier-Stokes equations in a short amount of time. Numerical results are presented in a few charts to define the aerodynamic interference coefficients and then a new procedure to design a vertical tailplane is proposed. This new approach provides a simple relationship among the aerodynamic interference factors and accurate results for turboprop aircraft configurations.

Keywords: aircraft, aerodynamics, CFD, vertical tail

1 INTRODUCTION

A reliable tailplane design needs an accurate determination of the stability derivatives. Extreme flight conditions often set severe design requirements for tail surfaces, like minimum control speed with one engine inoperative or maximum cross-wind aircraft capability: stability and control must be ensured even in very large angles of sideslip [1,2], up to 25°. Federal Aviation Authorities (FAA) and European Aviation Safety Agency (EASA) state such requirements. Vertical tail design criteria also depend on the type of airplane (and so the flow regime), engines number and position, wing-fuselage, and horizontal tail position [3].

Most known methods to evaluate directional and control stability derivatives of an airplane are reported in United States Air Force Data Compendium [4] and in Engineering Science Data Unit [5]. Both share results of tests performed by the National Advisory Committee for Aeronautics (NACA), which, by many hours of wind tunnel, provided a huge amount of data about tailplane planforms, partial, and complete aircraft configurations. The investigations focused on the segregation of aerodynamic interference effects of fuselage, wing, and horizontal tail, from the isolated vertical tail. The geometries involved were quite