Aerodynamic design guidelines of an aircraft dorsal fin through numerical and experimental analyses

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The present paper aims to provide aerodynamic design guidelines for an aircraft dorsal fin, obtained using CFD RANS technique. A parametric aerodynamic investigation about dorsal fin length, height, sweep angle, and planform area has been performed in order to evaluate the effects of geometric variations on the dorsal fin and vertical tail aerodynamic behavior in sideslip conditions. More than 30 dorsal fin geometries have been investigated, mounted on a typical large turbopropeller fuselage with a vertical tail. Main results show that there is no effect of the dorsal fin up to 20° of sideslip angle. At higher angles, the vertical tail stalls and the flow field around the empennage is strongly influenced by two vortices generated by the dorsal fin intersection with the fuselage (primary vortex) and with the vertical tail (secondary vortex). The stall phenomenon appears around 35° of sideslip angle. Moreover, dorsal fin slightly reduced fuselage instability. Finally, some wind tunnel tests have been performed on two dorsal fin geometries to validate the numerical analyses. Experimental tests have shown a good agreement with CFD simulations and have given useful qualitative indications on the aerodynamic behavior of the vertical tail at high angles of sideslip, with and without dorsal fin.

Nomenclature

B	=	body or fuselage
D, F	=	dorsal fin
V	=	vertical tail
S	=	surface
df	=	dorsal fin
h	=	height
l	=	length
C_N	=	yawing moment coefficient
c_r	=	root chord
Λ	=	sweep angle

I. Introduction

THIS work provides guidelines about preliminary sizing of a dorsal fin of a generic regional turbopropeller aircraft, through the computational fluid dynamics (CFD) technique, and aims to extend the work about the vertical stability and control aerodynamic preliminary design developed by the authors[1-4]. In these works a new method for the evaluation of airplane directional stability and control has been proposed, applying the CFD on a modular model of a generic regional turboprop aircraft. The result of these studies is a methodology which effectiveness is not enclosed only for the turboprop air transport category, but it has also been exploited for the preliminary design of a new general aviation commuter aircraft[5,6]. The aerodynamic calculations performed by the

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