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High Lift Aerodynamic characteristics of a Three Lifting Surfaces Turboprop Aircraft

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This paper deals with the aerodynamic design and analysis of the high lift capabilities of a three lifting surfaces turboprop aircraft. The aircraft under investigation is part of IRON European Union (EU) funded research project, aimed to provide an innovative regional turboprop aircraft, with advanced performance. This work is focused on evaluating the canard wakes effects on the wing high-lift capabilities. The effects of the canard wake on the wing have been evaluated in terms of downwash and induced angles. A preliminary investigation carried out through a three-dimensional panel method has been useful to evaluate the downwash and upwash produced by the canard on the wing both in the symmetry plane and in the spanwise direction. The estimated induced angles have been useful to improve both the wing root incidence and the spanwise twist distribution. In this way, it has been possible to compensate the loss in wing lift and to mitigate the upwash effects produced by the canard tip vortex. Panel code results have been also compared to a high-fidelity numerical method such as CFD-RANS calculations. The complete aircraft in landing configuration, including the horizontal tail plane, has been analyzed by means of RANS simulations. This analysis highlighted that the canard, when its flap is deployed, introduces a strong downwash angles on the tail plane despite the large horizontal stagger between those surfaces. This latter leads to a reduction of the longitudinal stability at low angles of attack. An investigation about different canard vertical positions and reduction of the canard flap deflection has been performed to carry out the aircraft layout being the best compromise between maximum achievable lift coefficient, longitudinal stability and architectural constraints.

I. Nomenclature

A.o.A.	=	Angle of Attack
B	=	Body or fuselage
b	=	lifting surface span
C	=	Canard
CFD	=	Computational Fluid Dynamics
C_{L0}	=	lift coefficient at zero angle of attack
C_{Lmax}	=	aircraft maximum lift coefficient
DOC	=	Direct Operating Costs
$d\varepsilon/d\alpha$	=	downwash derivative with respect to the angle of attack
E	=	aircraft aerodynamic Efficiency
H	=	Horizontal tail-plane
i_H	=	tail-plane pitch angle
i_W	=	wing incidence angle
JPAD	=	Java Program toolchain for Aircraft Design
LND	=	landing
MAC	=	wing Mean Aerodynamic Chord
MDAO	=	Multidisciplinary Design Analysis and Optimization
RANS	=	Reynolds Average Navier-Stokes
S_w	=	wing area
TLAR	=	Top Level Aircraft Requirements
W	=	Wing
W	=	aircraft Weight
X_{cg}	=	aircraft center of gravity position with respect to the mean aerodynamic chord

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