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Longitudinal stability issues including propulsive effects on an innovative commercial propeller-driven aircraft

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This paper deals with the assessment of aerodynamic characteristics, including the propulsive effects, of the innovative regional turboprop aircraft configuration for the IRON EU project. This work focuses on the three-lifting surfaces configuration with rear engines of Design Loop 2. High-fidelity numerical analyses have been performed in order to build an aerodynamic database. Longitudinal stability and control characteristics, maximum lift capability, and propulsive effects have been investigated. An experimental campaign through wind-tunnel tests has been carried out to validate numerical simulations. In this paper, the experimental investigation concerning the propulsive effects includes only the setup of the scaled propulsion system. Powered wind tunnel tests are scheduled by the end of 2019.

I. Nomenclature

AOA	=	Angle of Attack	C_T	=	thrust coefficient
CFD	=	Computational Fluid Dynamics	D	=	propeller diameter
DAF	=	Design of Aircraft and Flight Technologies	e	=	span load efficiency factor
FL	=	Flight Level (altitude in hundreds of feet)	J	=	propeller advance ratio
IRON	=	Innovative turbopROp configuratioN	K_v	=	electric motor constant (RPM/Volt)
ISA	=	International Standard Atmosphere	n	=	revolutions per second
mac	=	mean aerodynamic chord	P	=	power
MXCL	=	Max Climb condition	q	=	dynamic pressure
MXCR	=	Max Cruise condition	Q	=	torque
NTO	=	Normal Take-Off condition	Re	=	Reynolds number
RANS	=	Reynolds-Averaged Navier-Stokes	S	=	reference planform area
RPM	=	Revolutions Per Minute	T	=	thrust
SFC	=	Specific Fuel Consumption	T_c	=	alternative thrust coefficient
			V	=	flow speed
b	=	wing span			
c	=	wing chord	β	=	blade geometric pitch angle
$C_{L\alpha}$	=	lift curve slope coefficient	ρ	=	flow density
C_{MCL}	=	stability derivative	η	=	propeller efficiency
C_Q	=	torque coefficient	λ	=	model scale ratio
C_P	=	power coefficient	σ	=	flow density at altitude over sea level ratio

II. Introduction

The main purpose of this paper is to assess the longitudinal stability characteristics and aerodynamic derivatives for an innovative turboprop aircraft configuration. The research work is framed in the Innovative turbopROp configuratioN (IRON) project that complies with the European Union topic JTI-CS2-2015-CPW02-REG-01-03 (Green and cost-efficient Conceptual Aircraft Design including Innovative Turbo-Propeller Power-plant) as part of the Clean Sky 2 program for Horizon 2020. The topic leader is Leonardo Aircraft Company and several core-partners are involved into the project. CIRA (Italian Aerospace Research Center) is the coordinator of this project. The Design of Aircraft and Flight technologies DAF research group of the University of Naples is a core partner of the project, which main activities deal with the aerodynamic assessment and the performance evaluation of the aircraft model.

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