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Doctoral Dissertation
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Methodology and Tools for High-Speed Vehicles Conceptual Design to Support Environmental Regulations

By

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Abstract

In recent years, there has been a growing interest in high-speed passenger transportation systems. Consequently, there is a compelling need to develop rapid and reliable methods to be applied during the initial phases of design, when the selected configuration remains susceptible to potential changes. This thesis seeks to introduce innovative methodologies and tools for the conceptual design of high-speed vehicles, in support to environmental regulations. The accurate estimation of the aerodynamic features of high-speed vehicles is a pivotal aspect of preliminary design. To address this, the methodology presented here aims at enhancing the evaluation of aerodynamic characteristics in the early stages of design, when more advanced aerodynamic analyses, such as Computational Fluid Dynamics (CFD) simulations, are not yet available. The work is based on models already available in the literature, which are modified to better adapt to the vehicle configurations considered in the analysis. Depending on the flight regime, two main configuration types can be considered: the typical wing-body configuration for cruise Mach number in the low supersonic regime (i.e. from Mach 1.5 to Mach 3) and the waverider configuration for the hypersonic regime with Mach greater than 5. The workflow includes static stability and trim analysis for a complete preliminary vehicle characterization. Moreover, even if mission simulation is typically reserved for later stages of the design process, the proposed methodology involves the exploitation of mission simulation since the very early phases of the conceptual design.

The research activity has been carried on within the field of two Horizon 2020 European Union funded projects, the STRATOFLY and the MORE&LESS projects. The case studies considered in those projects are exploited for the test and validation of the methodology developed during the research.

The technical data collected from the different analyses can then be used as input to support the development of environmental regulations specifically tailored for

high-speed aircraft, focusing on the CO_2 certification emission standards. At the moment, those standards are defined for subsonic aircraft only, since no high-speed aircraft is currently flying in the airspace. For that reason, it is important to work towards the definition of a specific certification standard for supersonic concepts. The proposed methodology suggests the exploitation of mission simulation data, to evaluate to what extent the present regulations are capable of representing supersonic aircraft behaviour and, in case this is not verified, to support the work towards the definition of emission standards specifically tailored for high-speed vehicles.