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AERODYNAMIC ANALYSIS OF THE USV3 VEHICLE FROM HYPERSONIC TO LANDING FLIGHT CONDITIONS

Abstract

Since 2000 CIRA is being involved in research activities related to in-flight demonstration of key technologies for re-entry systems in the framework of national and international programs. Within the national USV program the flights of two vehicles, Castore and Polluce, have been accomplished in 2007 and in 2010 with the aim to demonstrate the mission capability from supersonic regime to splashdown, with parachute opening in the last phase of descent flight. Next challenging step is presently under investigation. With USV3 project, the CIRA goal is the design and development of an autonomous, unmanned vehicle able to perform an end-to-end mission from launch, on-orbit operations, re-entry and landing on conventional runway. Adequate characteristics for flying over hypersonic, supersonic and subsonic regimes must be ensured. This is a critical aspect considered that the vehicle acts as a spacecraft and lands as an aircraft. System analyses have been performed in order to satisfy the requirements of the mission, and a suitable configuration has been identified. Aerodynamic evaluation of the performances is carried out by means of engineering and CFD methods. Particular attention is paid to landing capabilities. The vehicle is launched by VEGA and must fit its fairing, with a strong impact on the aspect ratio of the lifting surfaces. A complete aerodynamic database taking into account for the effects of Mach number, Reynolds number, angle of attack, side slip angle, and deflection of control surfaces is built by engineering tools, according to the space-based design approach. Ground effect and landing gear are considered as well. CFD simulations for critical points of the re-entry trajectory are also performed in order to assess accuracy of engineering-based results, and to get key information on the flow field past the vehicle concept. Several in-house developed codes are employed to address USV3 aerodynamic performance at each flow regimes experiencedby the vehicle during descent, from hypersonic free molecular flow to subsonic continuum conditions. Different strategies will be used for these analyses as structured multi-block methods and cartesian immersed boundary techniques. Cartesian approach results to be particularly useful for analyzing complex configuration with geometrical details like flap deflection and landing gear extended.

The coupling between the numerical and experimental data will ensure the reliability of the investigations, and the fulfillment of performances in compliance with constraints and mission requirements. With this aim, wind tunnel campaigns for all the flight regimes and in different facilities have been planned.