IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry & Landing Systems (3)

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SUBSONIC AERODYNAMIC ANALYSIS OF AN UNCONVENTIONAL RE-ENTRY VEHICLE

Abstract

This paper deals with the Computational Fluid Dynamic (CFD) analysis of six different lifting body aeroshapes developed for the optimal design of a Crew Return Vehicle (CRV) for Low Earth Orbit (LEO) support service. These configurations are designed specifically to perform support and supply missions for the International Space Station (ISS) and with the capability to safely land on a conventional runway. These six aeroshapes differ from each other in the presence of vertical tails and/or winglets, but for each of them the double delta wing is designed with a positive dihedral and sweep angle, low aspect ratio and rounded tips. Aeroshapes are the outcome of in-house developed Multidisciplinary Design Optimization (MDO) procedures aiming at providing unconventional blended wing bodies characterized by a higher aerodynamic efficiency compared to conventional wing body configurations or blunt body capsules. The optimized CRV configurations are characterized by rather blunt shapes with low aspect ratio wing and flat bottomed windside since they represent a figure of merit for the spacecraft at hypersonic speeds. This means that such aeroshape are expected penalized when the re-entry vehicle lands on a conventional runway. Therefore, this research effort focuses on the subsonic characterization of the aerodynamics of the six aeroshapes. The flowfield that takes place past those configurations will be investigated for different angles of attack and sideslip. Fully turbulent three-dimensional Reynolds Average Navier Stokes (RANS) CFD simulations will be carried out by exploiting the Shear Stress Transport (SST) k-ω model. The initial results obtained highlight that, at high angles of attack, the double delta wing leads to the formation of primary and secondary vortices, which are responsible of the strong flow expansion on the vehicle leeside (i.e., vortex lift phenomenon), with consequent increase in lift. As a result, the low-speed aerodynamics of the aircraft is significantly affected by the double delta wing planform shape, as expected. Aerodynamic force and moment coefficients and flowfield results in terms of longitudinal and lateral-directional stabilities will be provided and detailed described in the paper.