IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures III Design, Development and Verification (Orbital infrastructure for in orbit service & manufacturing, Robotic and Mechatronic systems, including their Mechanical/Thermal/ Fluidic Systems) (3)

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EXPERIMENTAL ANALYSIS OF A SPACE RE-ENTRY VEHICLE AT LANDING CONDITIONS

Abstract

The aim of this paper is the low-speed wind tunnel analysis of a Crew Return Vehicle (CRV) for Low Earth Orbit (LEO) support services. Six different aeroshapes have been developed considering well-established Multi-disciplinary Optimization (MDO) methodologies. The proprietary SBISO (Skeleton-based Integral Soft Object) technique was applied to the aeroshape design in order to improve both longitudinal and lateral-directional stability of the vehicle. The SBISO methodology employs primitives, i.e., mathematical objects based on a morphological skeleton, that irradiate several field functions to arbitrary modify a host domain Ω (i.e., a user-defined grid), able to model the prescribed structure to analyze. A parametric geometry model, defined using the SBISO technique, was included within a proprietary optimization procedure to find the best aeroshape arrangement of winglets, vertical tail and/or V-tail that minimizes the mass satisfying, at the same time, main functional constraints, i.e., lateral-directional derivatives, heatshield allowable temperature, structural load factor, cross range, and max touch-down speed. Low and high speed aerodynamic performances of these configurations, as part of the optimization process, have been assessed by means of panel methods, namely APAME and HySIM, respectively. The former is a public domain panel method based on the potential flow theory for subsonic regime. The latter is an in-house developed tool that exploits the surface inclination methods, such as Modified Newtonian, Tangent-Cone, Tangent-Wedge, and Modified Newtonian + Prandtl-Meyer, to analyze the vehicle aerodynamics at hypersonic speeds. The wind tunnel test models were built using reconfigurable assemblies of three-dimensional printed pieces fabricated using NupBox® 3D printers available in the FabLab of the University of Sydney. The NupBox 3D printer is based on Fused Filament Fabrication (FFF) and Fusion Deposit Modelling (FDM) technology. PolyLactic Acid (PLA) filament was used to print the models. Subsonic experimental characterization of the six aeroshapes aerodynamics has been carry out to verify their ability to perform a safe landing on a conventional runway. Investigations are performed in the 4 x 3 ft low-speed wind tunnel at the School of Aeronautical Engineering of the University of Sydney. Test champaigns and their results in terms of aerodynamic force and moment coefficients for both longitudinal and lateral-directional flight conditions will be provided and detailed discussed in the paper.