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AERODYNAMICS AND AEROTHERMODYNAMICS ANALYSES OF A EARTH-RE-ENTRY CAPSULE FOR SAMPLE RETURN MISSION IN THE FRAMEWORK OF RASTAS SPEAR PROJECT

Abstract

A combination of aerodynamic and aerothermodynamic analyses are employed to determine the feasibility of an Earth re-entry capsule for a Sample Return Vehicle (SRV), in the framework of the RASTAS SPEAR project. The design utilizes a spherically blunted 45-degree half-angle cone forebody with an ablative heat shield; the potential failures of a parachute terminal descent system are circumvented by replacing it with passive energy absorbing material to cushion the extraterrestrial samples during ground impact. Aerodynamic and aerothermodynamic design analyses refer to the loading condition of the flight scenario foreseen for the SRV concept and are used to address vehicle aerodynamic and aerothermodynamic databases. Indeed, CFD simulations are performed at several discrete points of a reference re-entry trajectory according to the trajectory-based design approach. The range between Mach 3 and 42 was analyzed, considering only continuum regime (supersonic and hypersonic speed ranges) with the air modeled as a mixture of several gas species. In particular, twenty six trajectory points have been considered for a total number of 32 CFD simulations. Those points refer to three design tasks, namely the assessment on SRV aerothermal performances of aeroshape modification, radiation on heatshield and surface mass blowing. The first design task is related to the impact of the heat shield surface recession due to ablation. The second task is addressed to evaluate the impact of the radiative heat flux coming from the hot plasma flow surrounding the SRV, due to the high-speed Earth re-entry. For both tasks the CFD computations have been performed considering the air as a mixture of 13 species in thermo-chemical non-equilibrium conditions. The last task aims to address the impact on capsule aerothermal performances of the flowfield contamination by the chemical species coming from heat shield ablation. The chemical model proposed considers the air and the blowing species coming from heat shield ablation as a mixture of 32 species in thermo-chemical non-equilibrium conditions. The results obtained from the CFD analyses are typical of a Superorbital Earth re-entry trajectory. The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n 241992.