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ADVANCED EUROPEAN RE-ENTRY SYSTEM BASED ON INFLATABLE HEAT SHIELDS: DETAILED DESIGN (EFESTO PROJECT)

Abstract

The European Union H2020 EFESTO project is coordinated by DEIMOS Space with the end goals of improving the European TRL of Inflatable Heat Shields for re-entry vehicles (from 3 to 4/5) and paving the way towards further improvements (TRL 6 with a future In-Orbit Demonstrator, IOD). This paper presents the project objectives and the initial results of the detailed design of atmospheric entry missions based on the applications of advanced thermal protection systems implementing inflatable heat shields (flexible TPS and inflatable structures), according to aerothermodynamics constraints for future in-orbit demonstration. Placing the future IOD mission in the context of ongoing and future efforts in the European context is also one of the project goals. Two key applications, Mars Robotic Exploration and Reusable Small Launchers Upper Stages, have been identified. For the Mars Application, the robotic exploration mission class resulted in a 10 m diameter Hypersonic Inflatable Aerodynamic Decelerator (HIAD) class, combined with Supersonic Retro-Propulsion (SRP, activated about Mach 2.3) to deliver about 2800 kg of payload at MOLA +2 km. For the Earth Application, the VEGA upper stage (AVUM) has been selected as baseline case study. The current mission foresees a deorbiting from SSO orbit, a controlled entry phase (BC of about 30 kg/m2) and combines the use of a HIAD (4.5m diameter class) with parachutes and parafoil for Mid-Air-Capturing (MAR) with a helicopter. Beyond feasibility of the entry mission phase and system design with an inflated IAD, integration aspects have a key impact in the specific design solutions adopted, due to the nature of an inflatable heatshield. For both considered application cases feasible architectures are developed responding to the challenge of integrating the HIAD into the system in compliance with geometric and functional requirements. While the HIAD in folded state prior to inflation must fit in the available volume, it has limitations with respect to the density imposing a minimum cross section of the stowage volume. Simultaneously requirements with respect to the centre of gravity position during re-entry with an inflated HIAD must be respected for stability and controllability reasons. Other architectural considerations such as payload integration for the application on a launcher upper stage must be considered. Finally, heat loads constraints are considered for the trajectory and TPS deign choices due to important fluid-structure interactions. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 821801.