Inflatable Structure design, development and testing for the EFESTO project Earth-application heat shield


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EFESTO: European Flexible hEAt Shields: advanced TPS design and tests for future in-Orbit demonstration

▪ The project aims at advancing the TRL of Hypersonic Inflatable Aerodynamic Decelerators (HIAD) for re-entry vehicles, relying on integration of Flexible Thermal Protection Systems (F-TPS) and Inflatable Structures (IS).

▪ The EFESTO Earth study-case is based on the recovery of VEGA’s AVUM stage deorbited from Polar Orbit and decelerated during re-entry by a 4.8m diameter HIAD.

▪ The system engineering tasks provided the key inputs to design the Inflatable Structure: size and geometry, thermal load, and dynamic pressure time-history.

EFESTO Earth scenario

▪ After early trade-off, it was decided to adopt Thin Red Line Aerospace’s patented UHPV architecture (Ultra High-Performance Vessel) for the Inflatable Structure, comprising a pressure restraining tendons array, and a carrier fabric enveloped inflatable gas bladder.

▪ CAD and FEM models were developed to perform a full design loop and to consolidate solutions for key aspects of the Inflatable Structure such as architecture, materials, and mechanical interfaces.

▪ Very promising outcomes were obtained with respect to investigation of inflation and deflation, structural loads, as well as shape morphing.

▪ Modeling results were translated into specifications for manufacture of a 1:2-scale ground Demonstrator.

Earth-case Inflatable Structure Design

Demonstrator Design And Manufacturing

▪ The 1:2 scale Demonstrator of the Earth mission entry system includes a high-fidelity Inflatable Structure and prototype Flexible TPS, integrated with a likewise scaled VEGA AVUM.

▪ The Demonstrator features a significant similitude with the operational system in terms of: geometry, configuration, structural architecture, and interfaces.

▪ Both a Breadboard and a Demonstrator have been fabricated at 1:2 scale.

Demonstrator Testing

▪ A demanding test campaign was carried out in two stages using a specifically designed and manufactured test-rig.

▪ The 1st test stage supported folding, stowing, deployment, and inflation studies.

▪ The 2nd stage supported verification of static strength of the Inflatable Structure under re-entry flight representative loads.

▪ Test results were used to verify and validate numerical models.

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