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

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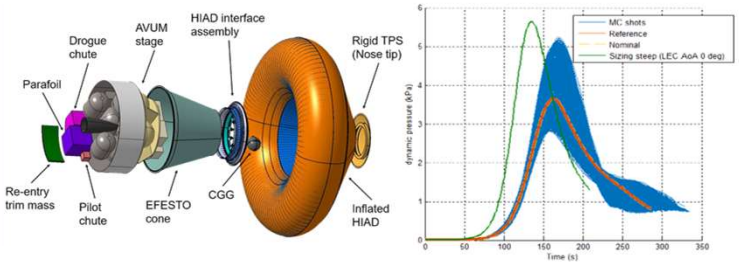
EFESTO: European Flexible hEat Shields: advanced TPS design and tests for future in-Orbit demonstration

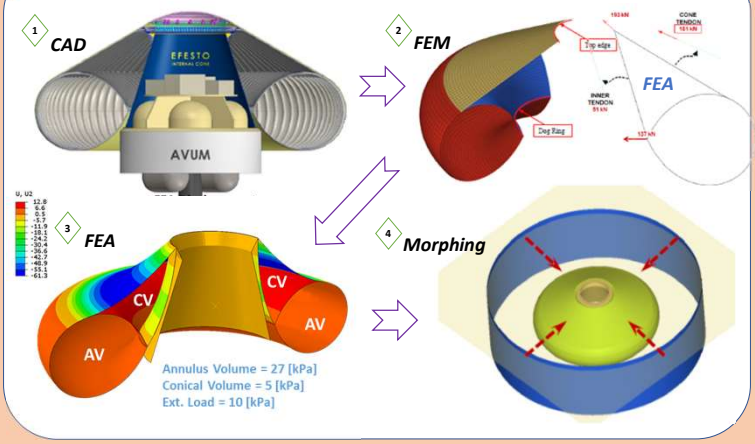
- The project aims at advancing the TRL of Hypersonic Inflatable Aerodynamic Decelerators (HIAD) for re-entry vehicles, relying on integration of Flexible Thermal Protection Systems (F-TPS) and Inflatable Structures (IS).
- The EFESTO Earth study-case is based on the recovery of VEGA's AVUM stage deorbited 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



System configuration and sizing dynamic pressure profile

Modelling and analysis of: inflation, deformation, and morphing

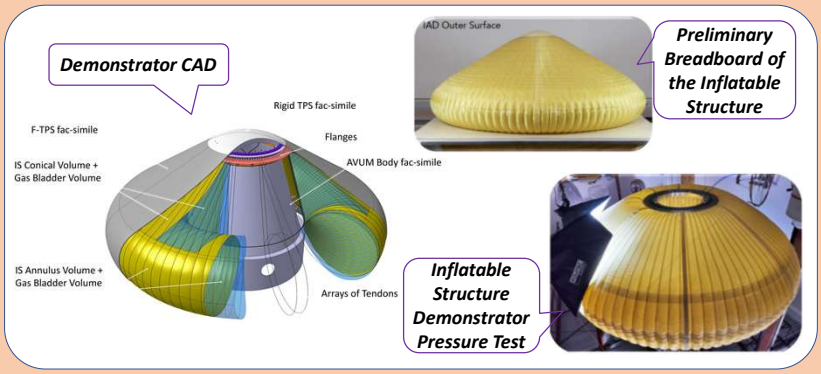


Earth-case Inflatable Structure Design

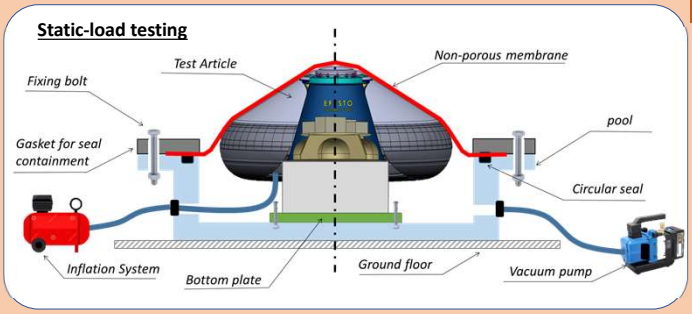
- After early trade-off, it was decided to adopt Thin Red Line Aerospace's patented UHPV architecture (Ultra High-Performance Vessel) for the Inflatable Structure, comprising a pressure restraining tendons array, and a carrier fabric enveloped inflatable gas bladder.
- CAD and FEM models were developed 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 deformation, structural loads, as well as shape morphing.
- Modeling results were translated into specifications for manufacture of a 1:2-scale ground Demonstrator.

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.



Static-load testing



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.