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MATERIAL CHARACTERIZATION AND PLASMA TESTING FOR AN INFLATABLE HEATSHIELD FOR THE EARS REUSABLE SMALLSAT PLATFORM

Abstract

The EARS project, funded under the Horizon Europe programme, aims at the development of an affordable, flexible platform that can be reused and easily produced in large numbers, targeting the low-cost SmallSat market. The EARS spacecraft is conceived to be launched in Low Earth Orbit to support microgravity manufacturing and a variety of small experiments. Then the spacecraft is planned to de-orbit, to perform a controlled re-entry and to be recovered to deliver its products and results back to the Earth. The concept of operations of EARS involves a controlled re-entry and therefore calls for an advanced heatshield, maximizing the reusability of the platform. For that purpose, an inflatable concept has been considered. Differently from state-of-the-art rigid heatshields, an inflatable heat shield enjoys several advantages, like a lower ballistic coefficient that reduces thermal loads. The envisioned inflatable heatshield is made of two main parts: a rigid nose, and a flexible thermal protection system (FTPS), which will be inflated during the re-entry. The latter is a multilayer structure made by an outer layer, which is exposed to the highest temperatures, an insulation layer, which prevents the diffusion of the heat to the internal structure of the system, and eventually a gas barrier, to prevent any hot gas from reaching and damaging the underlying inflatable structure. The current material candidates include IsiComp Ceramic Matrix Composite (CMC) for the rigid nose, woven Refrex 1420 for the FTPS outer layer, Sigratherm GFA5 soft graphite for the FTPS insulative layer, and Kapton for the gas barrier. Preliminary numerical analyses performed in FreeFEM++ show this combination of materials maintains the underlying structure below 70°C considering a constant heat flux of 275 kW/m^2 for 80 s, representing the trajectory heat load. To advance heat-shield-related technologies, specific test procedures have been designed to characterize the selected materials. The test strategy consists of Simultaneous Thermal Analysis (STA) for specific heat capacity determination, and high-enthalpy Plasmatron tests for material characterization in a representative Earth re-entry environment. Stagnation point experiments will provide the material performance at high temperature, and flat plate experiments the material response with aeromechanical load. Results of the test campaign will be shown in the paper, demonstrating that an innovative inflatable TPS can be used in future reusable small satellite missions.