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A ROBUST SINGLE PART HEAT SHIELD SOLUTION FOR HIGH ENERGY ENTRY PROBES

Abstract

ArianeGroup is well known for the launchers it operates and develops, respectively Ariane 5 and Ariane 6. In support of this core business, ArianeGroup masters thermo-mechanics and high temperature resistant materials and technologies that are necessary for the design and production of nozzles for rocket engines and motors as well as for the thermal protection of launchers.

Thanks to these capabilities ArianeGroup has been responsible for the heat shield of every reentry mission performed so far by Europe: ARD, Beagle 2, Huygens, Exomars, and IXV. ArianeGroup is also responsible for defense applications in this field and gathers in a single company a world-wide unique expertise ranging from heat shield material design, processing and characterization, modelling and analysis, production, testing including plasma wind tunnel, to integration to the vehicle.

Under an ESA contract, ArianeGroup is now working on an enhanced heat shield technology which will provide adequate solutions for currently foreseen missions such as Mars Sample Return, Ice Giants, and other Sample Return missions.

As far as sample return from Mars is concerned, one of the critical issues of the Earth Entry Vehicle (EEV) is the planetary protection specification which drives very high reliability requirements at heat shield level, with in particular its capacity to resist to the heat flux resulting from the hyper velocity of the reentry. The seams between tiles are the Achille's heel of classical heatshield designs, e.g. tiles of insulating material (carbon-phenolic or other) bonded on a carrying structure. Moreover, the qualification of these seams is a very big challenge since the existing ground testing facilities do not allow performing sufficiently representative and reproducible tests.

The other critical issue related to planetary protection is the capability of the heat shield to survive MMOD (micro meteoroids orbital debris) impacts, since it will be exposed to such an environment during some phases of the mission, without jeopardizing the re-entry phase.

Similarly to the MSR mission, the mission to Ice Giants will result in a 17 year duration exposure of the probe to the potential impact of micro meteoroids. The hypervelocity entry will also generate

very high heat fluxes on the heat shield (in the range of 100 MW/m) while entering in a H2/He rich atmosphere. Considering the fact that no ground testing facility exists to simulate such entry conditions, this constitutes a huge challenge to qualify the heat shield and in particular the seams.

To solve these challenges, ArianeGroup is developing a monolithic heat shield, that is to say a heat shield made in one single part without any seam. The heat shield technology is a high density structural 3D and non-brittle carbon-phenolic composite which has significant flight heritage for nozzle applications as integrated insulating-structural components.

Combining the monolithic design (i.e. without seam) with the high density structural 3D non-brittle composite leads to a very robust heat shield design. The paper will describe the ongoing delta development aiming at adapting the existing process capability to the specific shape of a representative scale 1 heat shield. It will also address preliminary testing of the material under hyper velocity impact tests and under relevant plasma wind tunnel test conditions. In addition, the paper will discuss preliminary mass assessment of a heat shield sized for typical sample return mission requirements.