Overview of Heatshield for Extreme Entry Environment Technology (HEEET)

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The objective of the Heatshield for Extreme Entry Environment Technology (HEEET) projects is to mature a 3-D Woven Thermal Protection System (TPS) to Technical Readiness Level (TRL) 6 to support future NASA missions to destinations such as Venus and Saturn. Destinations that have extreme entry environments with heat fluxes > 3500 W/cm^2 and pressures up to 5 atmospheres, entry environments that NASA has not flown since Pioneer-Venus and Galileo.

The scope of the project is broad and can be split into roughly four areas, Manufacturing/Integration, Structural Testing and Analysis, Thermal Testing and Analysis and Documentation. Manufacturing/Integration covers from raw materials, piece part fabrication to final integration on a 1-meter base diameter 45-degree sphere cone Engineering Test Unit (ETU). A key aspect of the project was to transfer as much of the manufacturing technology to industry in preparation to support future mission infusion. The forming, infusion and machining approaches were transferred to Fiber Materials Inc. and FMI then fabricated the piece parts from which the ETU was manufactured.

The base 3D-woven material consists of a dual layer weave with a high-density outer layer to manage recession in the system and a lower density, lower thermal conductivity inner layer to manage the heat load.

At the start of the project it was understood that due to weaving limitations the heat shield was going to be manufactured from a series of tiles. And it was recognized that the development of a seam solution that met the structural and thermal requirements of the system was going to be the most challenging aspect of the project. It was also recognized that the seam design would drive the final integration approach and therefore the integration of the ETU was kept in-house within NASA. A final seam concept has been successfully developed and implemented on the ETU.

The structural testing and analysis covers from characterization of the different layers of the infused material as functions of weave direction and temperature to sub-component level testing such as 4pt bend testing at sub-ambient and elevated temperature and culminates in testing of the ETU results from which will validate the structural models developed using the element and sub-component level tests. Given the seam has to perform both structurally and aerothermally during entry a novel 4pt bend test fixture was developed allowing articles to be tested while the front surface is heated with a laser. These tests are being utilized to establish the systems structural capability during entry.

A broad range of aerothermal tests (arcjet tests) were performed to develop material response models for predicting the required TPS thickness to meet a missions needs and to evaluate failure modes and establish the capability of the system.

The final aspect of the project is to develop a comprehensive Design and Data Book such that a future mission will have the information necessary to adopt the technology.

This presentation will provide an overview for each of these areas and argue that HEEET has successfully achieved TRL 6.