Thermal Testing of the Heatshield for Extreme Entry Environment Technology (HEEET) TPS

M. Gasch[1], M. Stackpoole[1], G. Gonzales[2], D. Prabhu[3] and D. Ellerby[4]

[1]NASA Ames Research Center, M/S 234-1, Moffett Field, CA 94035, [2]ERC at NASA Ames Research Center, M/S 223-3, Moffett Field, CA 94035, [3]ERC at NASA Ames Research Center, M/S 229-3, Moffett Field, CA 94035, [4]NASA Ames Research Center, M/S 229-3, Moffett Field, CA 94035: matthew.j.gasch@nasa.gov.

Introduction: The present talk provides an overview of recent thermal/arcjet testing of the 3D woven dual layer thermal protection system (TPS) material that is being developed under NASA's Heatshield for Extreme Entry Environment Technology (HEEET) project. The goal of the HEEET project is to develop a woven TPS technology to TRL 6 by the end of fiscal year 2017 to enable in-situ robotic science missions recommended by the NASA Research Council (NRC) Planetary Science Decadal Survey (PSDS) committee. Recommended science missions include Venus probes and landers, Saturn and Uranus probes, and high-speed sample return missions. For these missions, NASA has decided to invest in new technology development rather than invest in reviving "heritage" carbon phenolic. To further incentivize the adoption of this new TPS technology by the community, NASA's Science Mission Directorate has offered the woven TPS being developed under HEEET for mission infusion into the Discovery 2014 mission proposers with added monetary incentives.

The HEEET project has prioritized a woven dual layer TPS architecture for maturation. This architecture consists of a high density all carbon surface layer (designed to manage recession) below which is a lower density layer composed of a blended carbon and phenolic yarn insulating layer, intended to manage heat load. This woven architecture is then infused with a resin. A layer-to-layer weave is utilized, which mechanically interlocks the different layers together in the thru-the-thickness direction. This dual layer allows tailoring the two layers independently to meet various mission requirements. For example, a mission to Venus may choose a steeper or a shallower entry flight path angle and vehicle mass can be optimized by changing weave thickness of either layer.

It is always a challenge to demonstrate TPS traceability from ground testing to actual flight. The power requirements to produce test conditions using existing set ups (nozzle, test chamber and/or diffuser geometry) present additional constraints on the size of test models, including what can be measured and how measurements are interpreted. Thus, to verify that a TPS material can withstand the harsh aerothermal environment of atmospheric entry, thermal testing in multiple arcjet and laser facilities is critical. This is especially true for the HEEET project. With a focus on demonstrating the capability of a dual layer 3D woven TPS that is not tied to a single mission or destination, thermal testing at *multiple* facilities is an essential means of gathering performance data that allows for the development of a robust thermal response model of the TPS material.

The material architecture being developed under the HEEET project demands special consideration in testing because it is not simply a new monolithic material development project but rather the development of a system. Hence system integration challenges have to be addressed. In particular, the integrated heatshield will have seams as shown in Figure 1. Thus, in addition to characterization of the acreage, thermal testing needs to be conducted that establishes the behavior of the seams, including failure modes, if any. Optimizing total heatshield mass will require thermal performance and recession prediction models for the combined system.

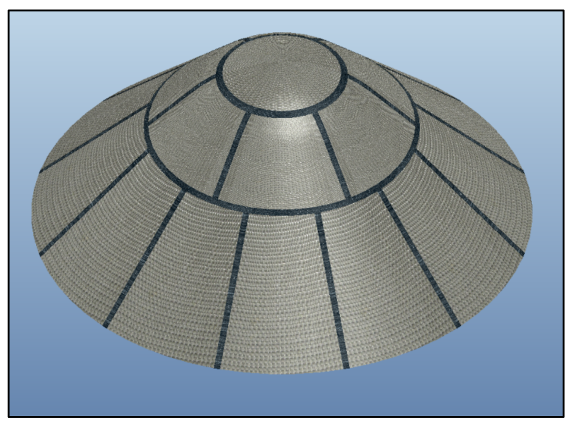

Figure 1 – Schematic of notional HEEET tile layout showing location of seams in the heatshield.

Several test campaigns have been conducted to evaluate the thermal performance of HEEET materials to-date and several more are planned in the coming years. Early testing has concentrated on qualitative screening of candidate architectures. Some tests have concentrated on mission-relevant conditions, while others have applied extreme heating rates and pressures to check that the system response is robust beyond the expected load environments. A summary of the various tests is shown in Figure 2. The key results, along with future plans, will be presented at the IPPW-12.

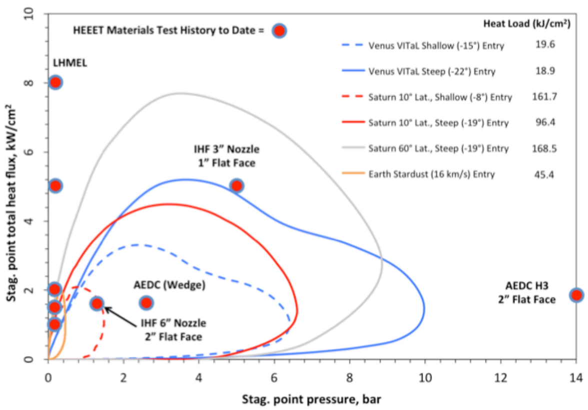

Figure 2 - Heat flux / pressure plot for potential Venus and Saturn missions showing conditions at which the HEEET TPS has been previously evaluated.