1. HEET Background/NG Proposal Team Interaction

- HEET is a game changing core-technology that is being designed with:
  - Broad mission applicability and long term sustainability
  - Substantial engagement with TPS community
  - HEET goal is to develop a woven TPS technology to TRL 6 by the end of Fiscal year 2017
  - HEET leverages a mature weaving technology that has evolved from a well-established textile industry
  - Dual layer design allows some tailoring ability of TPS for mass efficiency across a wide range of entry environments

Interaction with NF-4 Proposal Teams

- Provide in-depth briefing on HEET technology development
  - Focus on core technology-TIPS integration and analysis required for specific mission design
  - Conduct a Workshop targeted towards NF-4 Proposal teams planning to provide more information on HEET

2. Architecture and Engineering Testing Unit (ETU) Manufacturing Plan

- HEET Project has prioritized a dual layer TPS architecture for Maturation. A layer-to-layer weave is utilized, which mechanically interlocks the different layers together in the trans-thickness direction
  - High density all carbon surface layer developed to manage re-entry
  - Lower density layer is a blended yarn to manage heat load

- Woven architecture is then infused with an ablative resin

3. Thermal /Arcjet Test Plan

- The HEET thermal / aerothermal test campaign spans four facilities and at least twelve test conditions

4. Structural Testing

- Element, subcomponent, component and subsystem level testing are being performed to verify the structural adequacy of the ETU
  - Analytical work will be used to evaluate vehicles > 1 meter diameter

- Component Test Objectives:
  - Verify structural performance on a large scale with anticipated ETU representative stress levels

- Subsystem Testing: ETU testing will verify the performance of the HEET design for the given thickness under all mission loading events except acoustic environments and entry

5. TPS Sizing for Saturn

- Stagnation point analysis
  - 200 kg, 1 meter diameter, 45-deg spherocone entry vehicle with a nose radius of 25 cm
  - Inertial entry velocities of 36 and 38 km/s. Entry flight path angles of -8, -16, -20 and -24 deg
  - Equalateral entry in the eastern direction

- Areal mass of the 2-_layer HEET TPS is ~58% of the mass of fully dense carbon phenolic
  - Analysis holds true for a broad range of conditions

- Sizing results are for zero margin utilizing preliminary thermal response model

6. Recent Accomplishments

1) Manufacturing
  - FMI under contract for Forming/Infusion for MDU
  - FMI completed machining study on Nosecap Pathfinder

2) seams
  - Completed seam arcjet testing @ >5000 W/cm² and 5 atm
  - Completed shakedown test on LHMEL 4pt Bend testing
  - Maturing Seam/Tile integration analysis

3) MDU/ETU: composite carrier structure is in fabrication

4) HEET Independent Reviews (Reviews: AP, Goddard & JPL)

5) ETU system requirements review (Sep 2014)

6) Design review (February 2015)

7) Thermal test plan review (June 2015)

8) Structural test plan review (February 2016)

7. Summary

- Woven TPS is a game-changing approach to manufacturing, and integrating a TPS for extreme entry environments by tailoring the material (layer thicknesses) for a specific mission

- A comprehensive set of requirements have been developed which is guiding testing/analysis required for verification

- Given constraints on weaving technology a heat shield manufactured from the 3D Woven Material will be assembled from a series of panels, which results in seams between the panels
  - Seam design needs to meet both structural and aerothermal requirements
  - Baseline use of Softened HEET (SH) as a gap filler in the seam design
  - Seam approach has demonstrated excellent performance in the arcjet at >5000 W/cm² and 5 atm
  - Requires thin adhesive bond line between acreage sites and SH gap filler
  - Project is currently on target to mature HEET to TRL 6 in support of next New Frontiers