Heatshield for Extreme Entry Environment Technology: Results from Acreage and Integrated Seams Arcjet Testing

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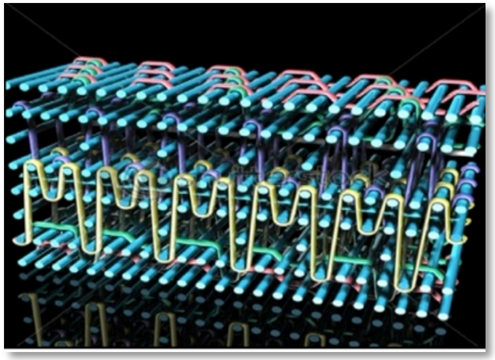
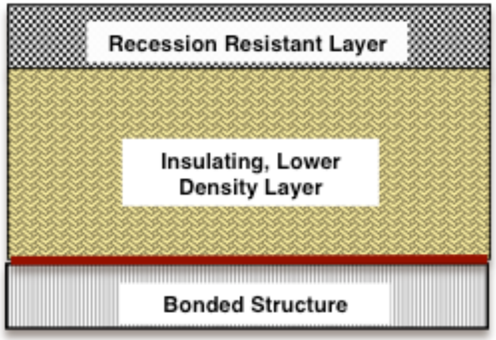
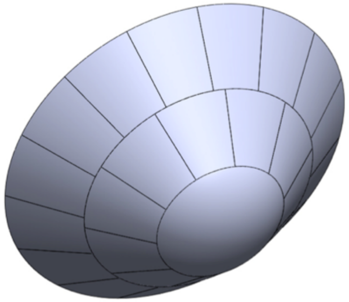
- **Vendors:**
  - Bally Ribbon Mills, PA
  - FMI, Maine

Heatshield for Extreme Entry Environment Technology (HEEET) Project

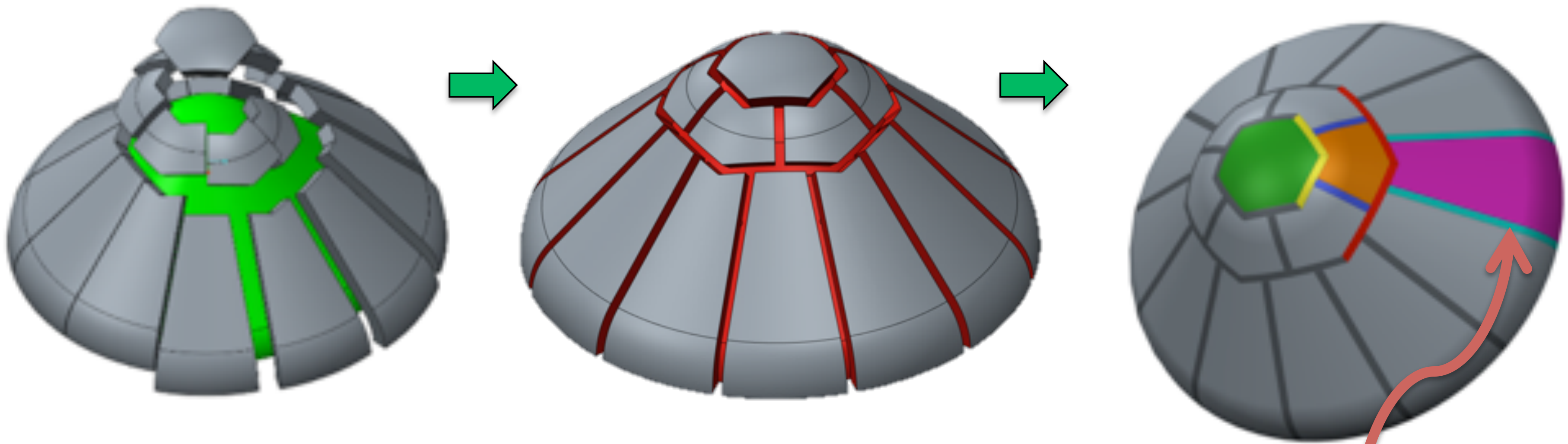
- **Goal: Mature HEEET system in time to support New Frontiers – 4 opportunity (mission infusion)**
  - Target missions include Venus Lander and Saturn Probes
  - Capable of withstanding extreme entry environments:
    - Peak Heat-Flux >> 1500 W/cm^2; Peak Pressure >> 100 kPa (1.0 atm)
  - Scalable system from small probes (~1m scale) to large probes (~3m scale)
  - Develop Integrated system, including seams
    - Culminates in testing 1m Engineering Test Unit (ETU)
      - Integrated system on flight relevant carrier structure
      - ETU used to validate structural models
      - Arcjet testing of cores from Manufacturing Demonstration Unit (MDU)







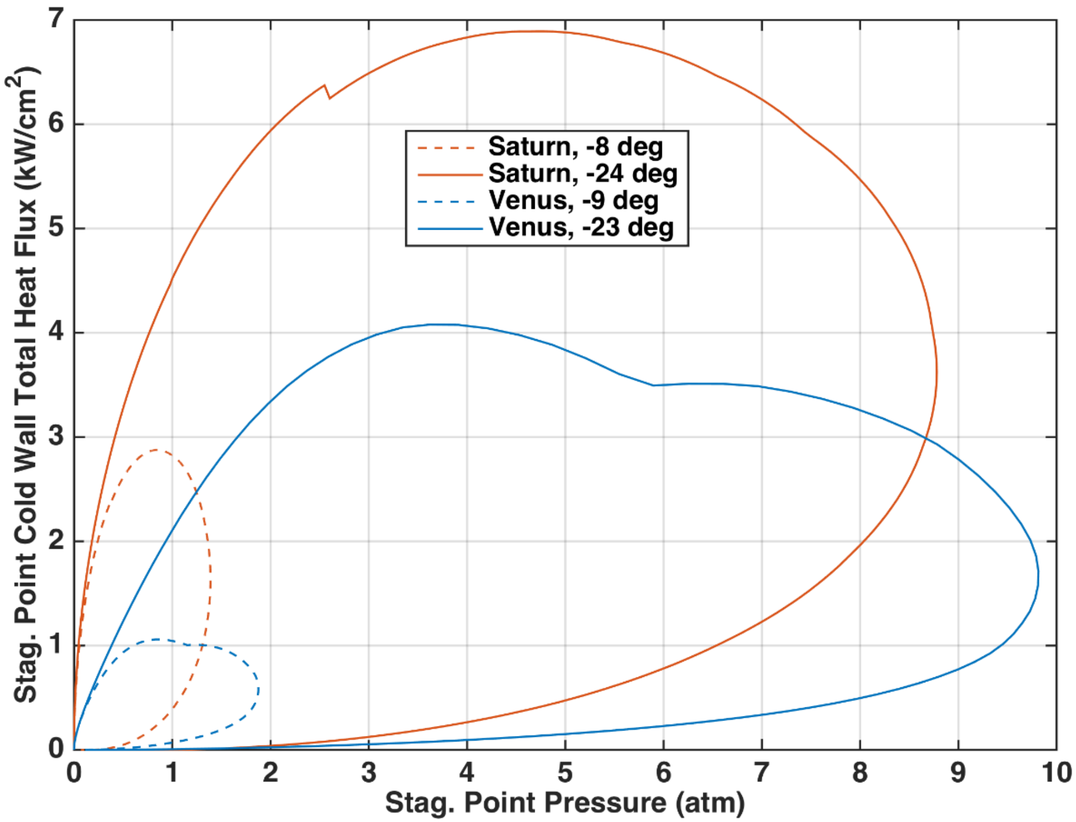
HEEET Acreage and Seam Integrated System Design Challenges



- **Integrated acreage and seam performance**
  - Seam Design (Gap Filler + Adhesive) performs 2 primary functions:
    - Provides structural relief for all load cases by increasing compliance at the seam (Compliant Gap Filler)
    - Provides an aerothermally robust joint:
      - adhesive widths <0.010”
      - recession performance in family with acreage material
- **No ground test facility is capable of combined thermo-structural testing at extreme entry conditions**

Mission Relevant Heat Flux and Pressure Environment

- The reference mission used to size the carrier structure is a 1 meter, 38 km/sec entry into Saturn at a -24° EFPA
  - Stagnation point environments from Venus, Saturn and Earth entry missions shown below.
- Key Notes:
  - High latitude Saturn entry has the highest heat flux
  - Venus steep entry has the highest surface pressure loading
  - Saturn missions have the highest heat load (TPS thickness)



Saturn and Venus Stagnation Point Entry Environments

Mission Relevant Heat Flux and Pressure Environment Testing

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  - High latitude Saturn entry has the highest heat flux
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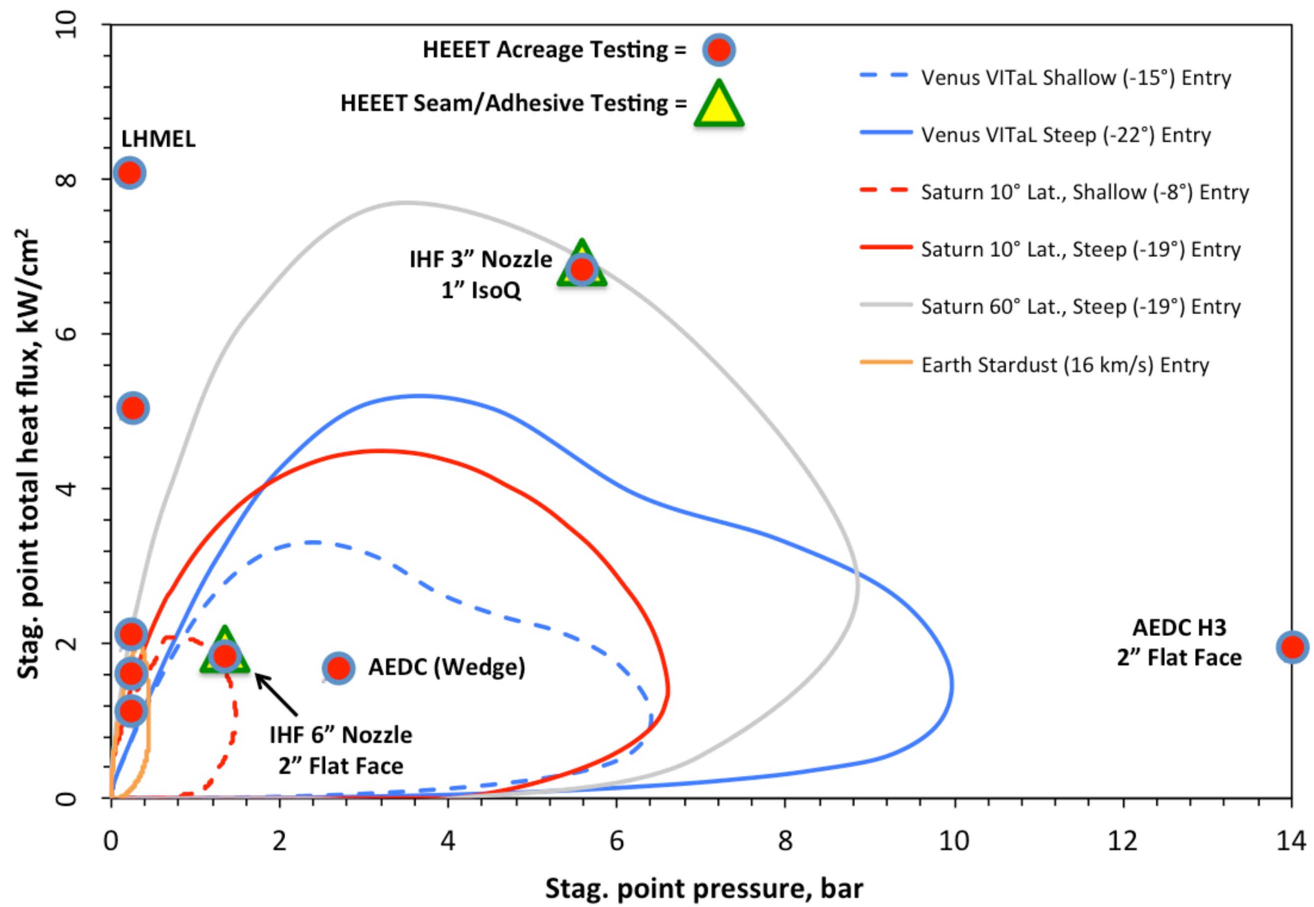

Highlights from the Arcjet Test Campaigns

Movies from IHF- 3” nozzle Tests, IHF-6” Nozzle Tests,

IHF-13” Nozzle Tests and AEDC Stagnation and AEDC Wedge Tests will be shown at this juncture.

Concluding Remarks

- **Arc jet testing performed with both acreage alone and integrated acreage and seams:**
  - Successful testing at extreme conditions - relevant for Venus and Saturn missions
  - While the acreage and integrated seam performance tests show no failure (no runaway failure modes), limitations due to test article size and the data acquired requires very methodical investigation that is underway
    - Confidence in seam design from the preliminary analysis
  - In the future we will present results from combined thermo-structural testing in 4pt bending at the Laser Hardened Materials Evaluation Laboratory (LHMEL as Wright Patterson Airforce Base) that addresses structural performance of the seam during entry
- **Plan to perform improved arc jet testing from lessons learned and on cores from 1-m integrated Manufacturing Demonstration Unit in FY18.**