

Progress Towards Providing Heat-shield for Extreme Entry Environment Technology (HEEET) for Venus and Other New Frontiers Missions



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TPSM Project Manager*

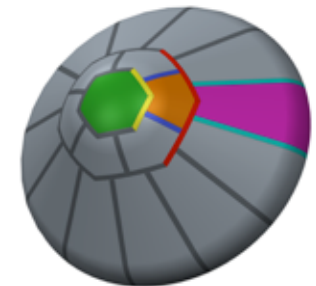
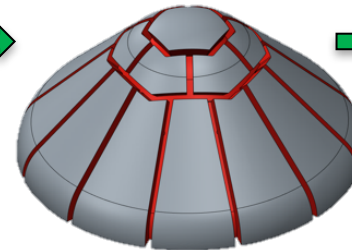
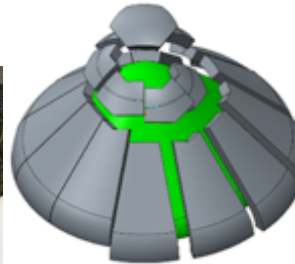
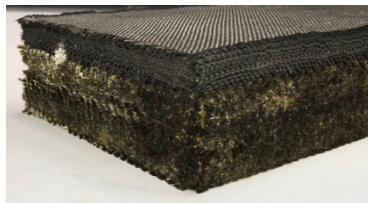
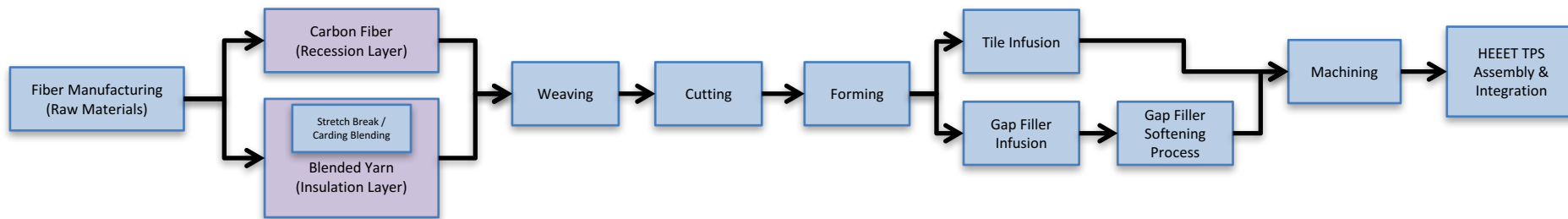
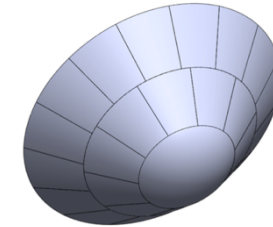
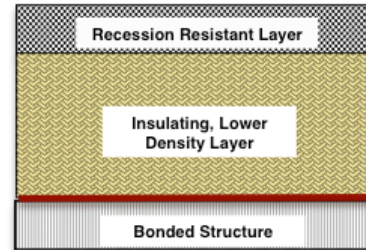
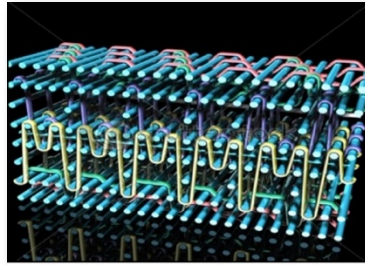
*Don Ellerby
HEEET Project Lead*

*Peter Gage
HEEET Lead System Engineer*

*Presented at the VEXAG- 15
Applied Physics Laboratory
Laurel, Maryland
November 15, 2017*



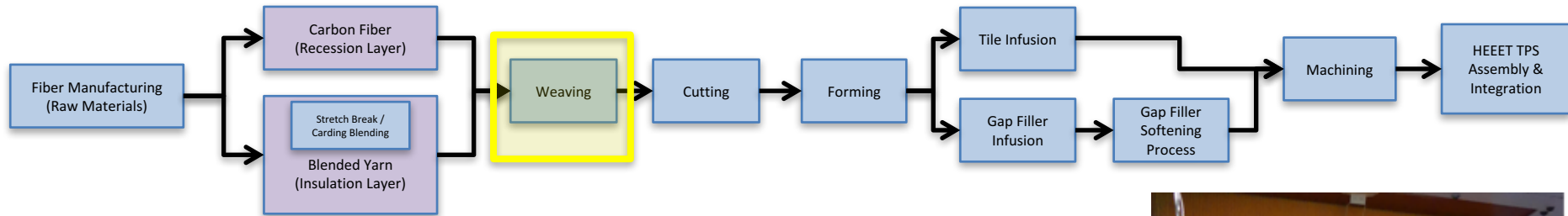
Heatshield for Extreme Entry Environment Technology Manufacturing and Integrated System



- 3-D, integrally woven, dual layer that is robust, mass efficient and capable of withstanding extreme entry environment
- Heat-shield system requires tiled approach with seams.

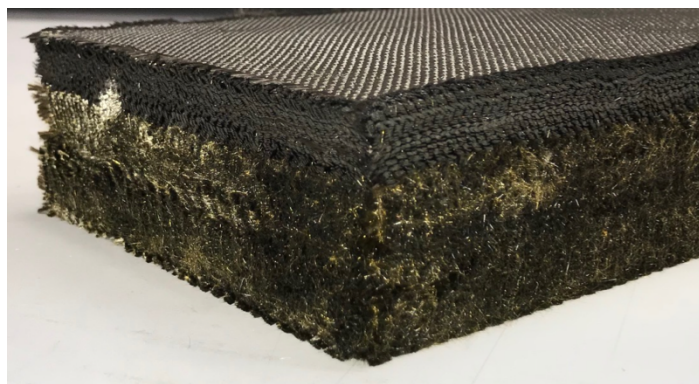


HEEET Manufacturing Development: 24" Weaving



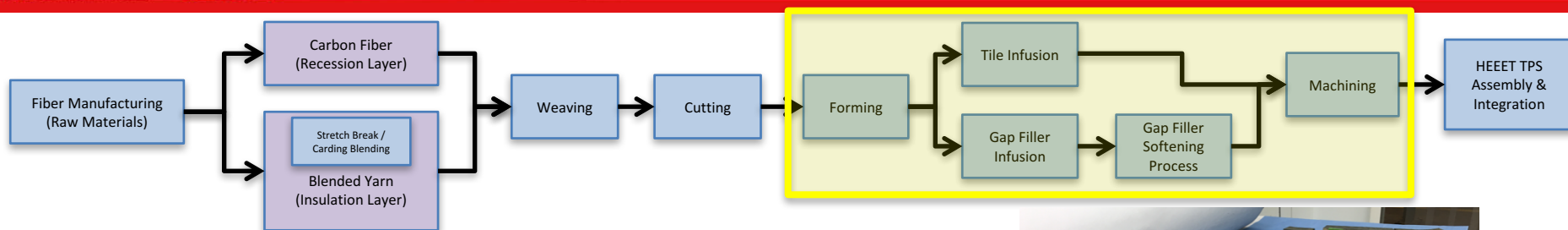
➤ Weaving: BRM

- ◆ 24" loom set-up complete
- ◆ BRM hosted event demonstrating 24" loom
 - Attendees included STMD AA and ARC Center Director
- ◆ Currently weaving





HEEET ETU Manufacturing: Acreage and Seam Tiles Fabrication

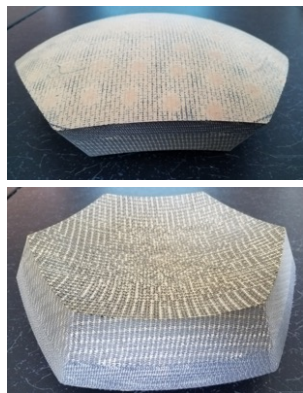
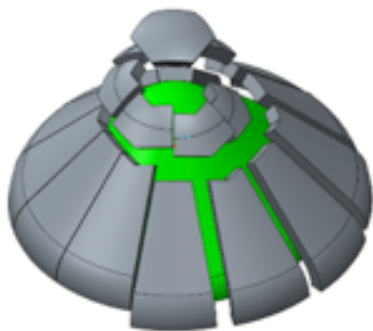


➤ ETU Tile/Gap Filler Manufacturing: FMI

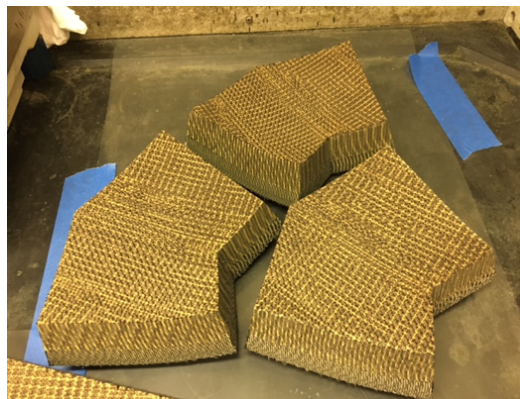
- ◆ 22 acreage tiles completed:
 - Forming/infusion
 - Machining
 - IML surface densification (ARC)
- ◆ 30+ Gap Fillers completed: FMI/ARC
 - Tech transfer of Gap Filler manufacturing to FMI completed



Radial Gap Fillers



Nose Cap

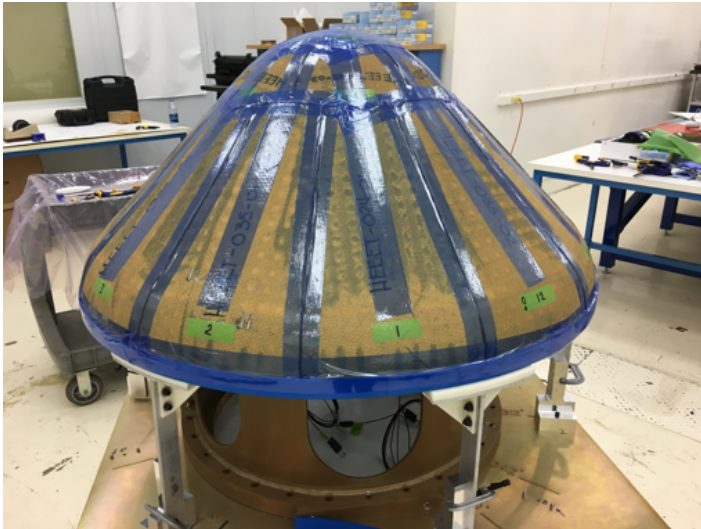


Inner Tile

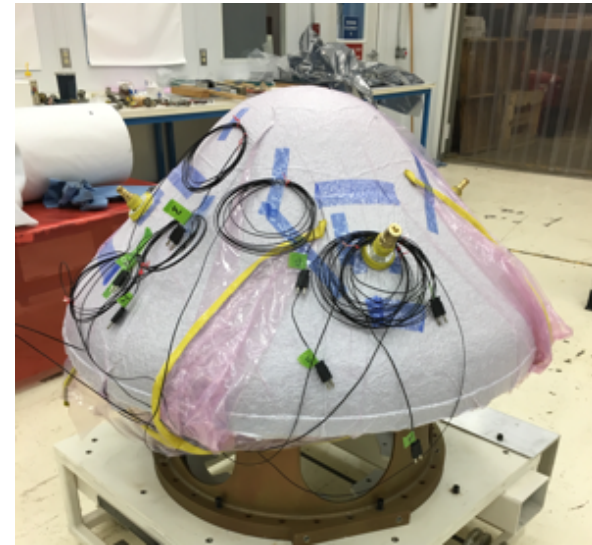


Outer Tile

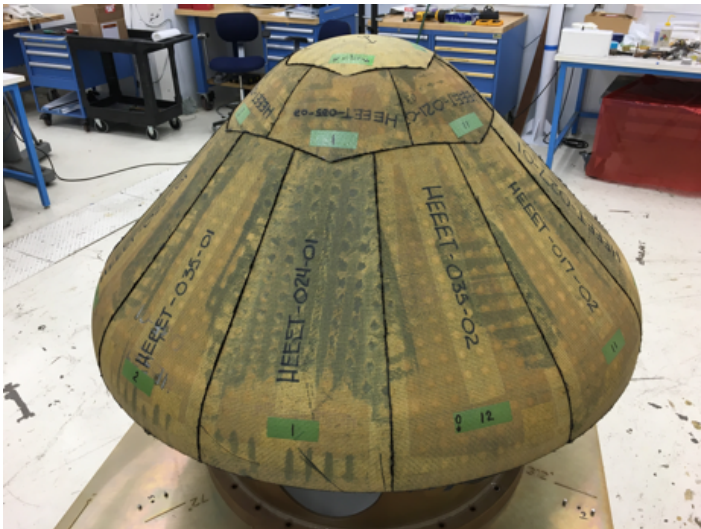
ETU: Acreage Tile Install Completed



Acreage Tiles on Carrier
Before Vac Bag/Cure



Vac Bag Prior to Cure



After Cure



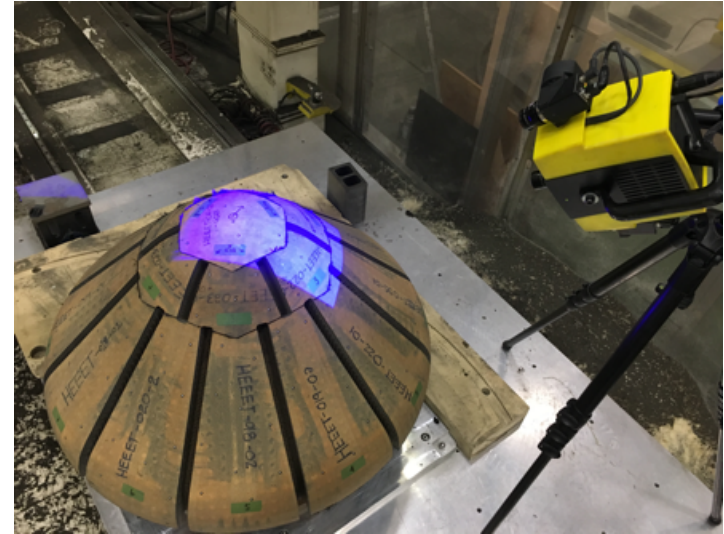
Good OML Match Between Tiles
No steps in tile to tile height



ETU: Radial ESH Install Completed



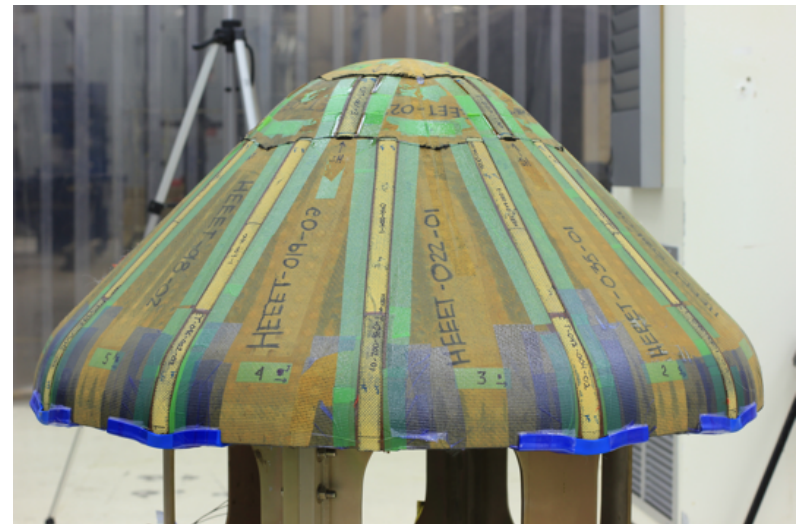
Routing Radial Channels



Laser Scan Inspection

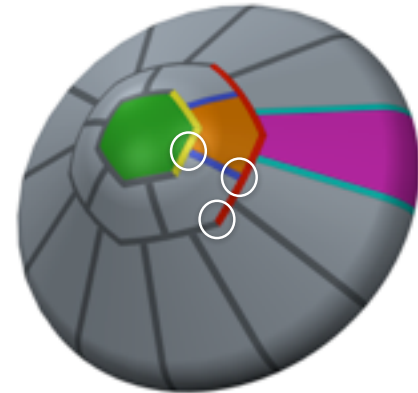


Radial Routing Completed

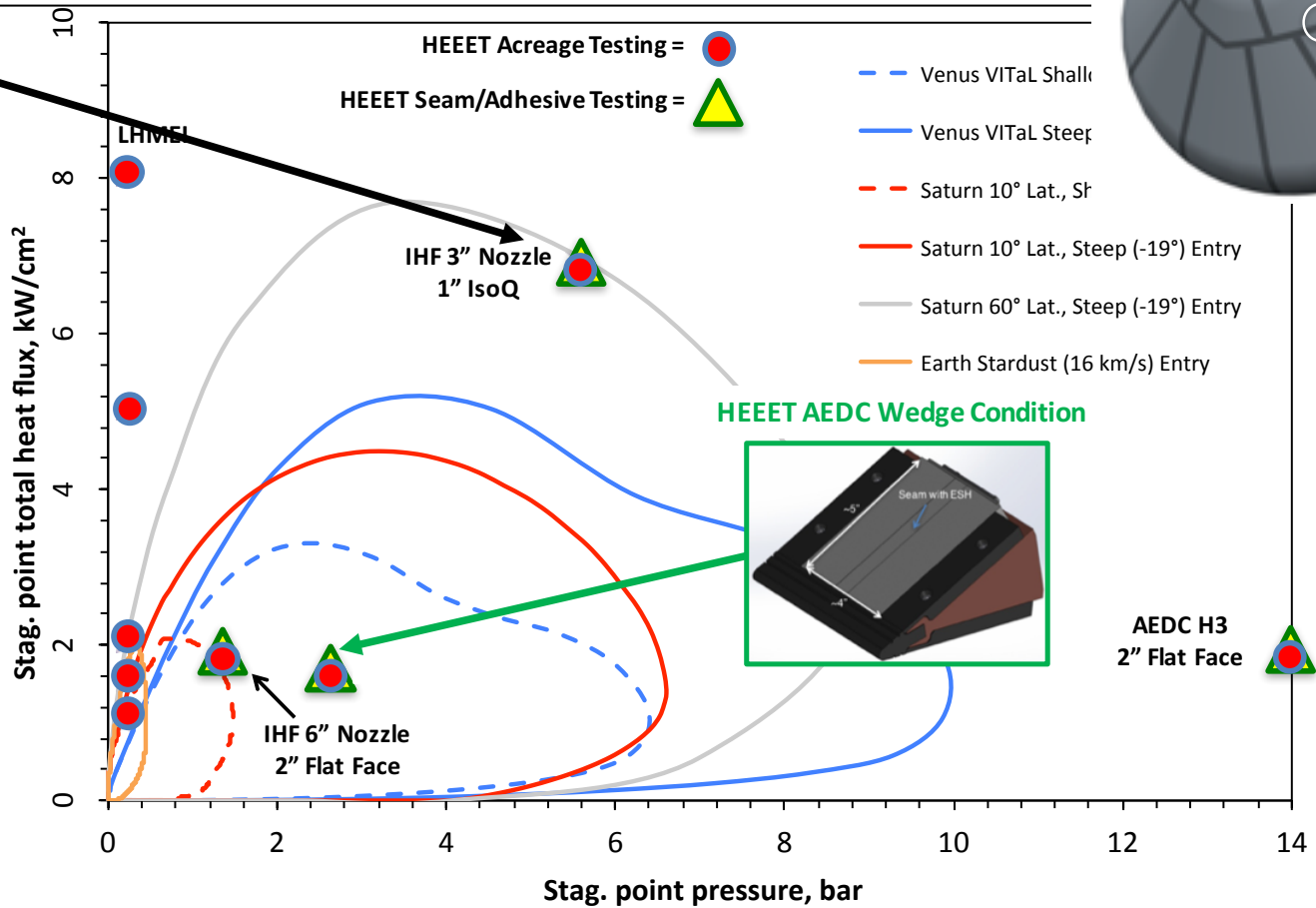


After Cure

Critical Features Thermal Testing at AEDC

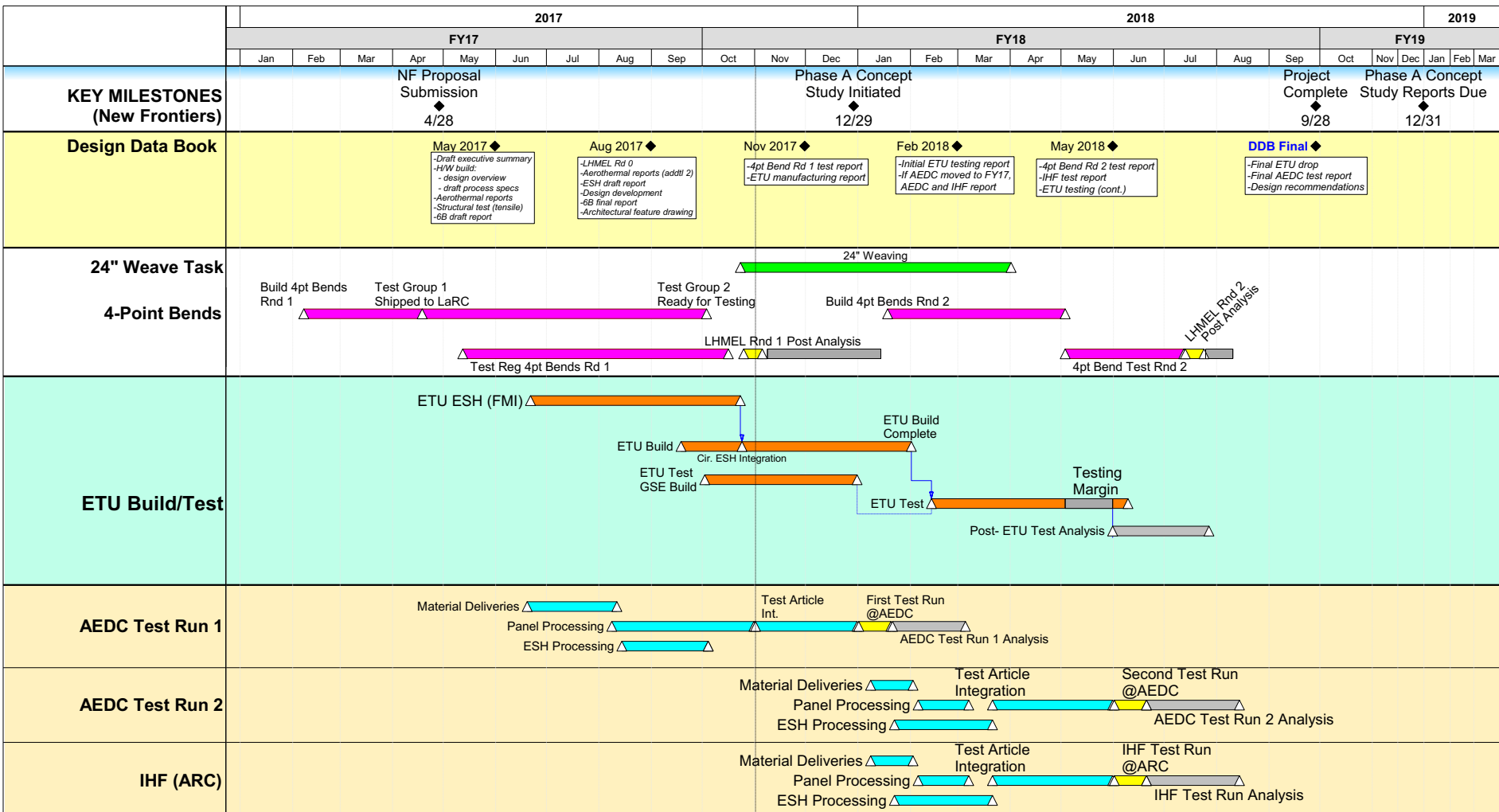


IHF 3" Nozzle





HEEET Development Schedule



Phase A and Beyond Commitments

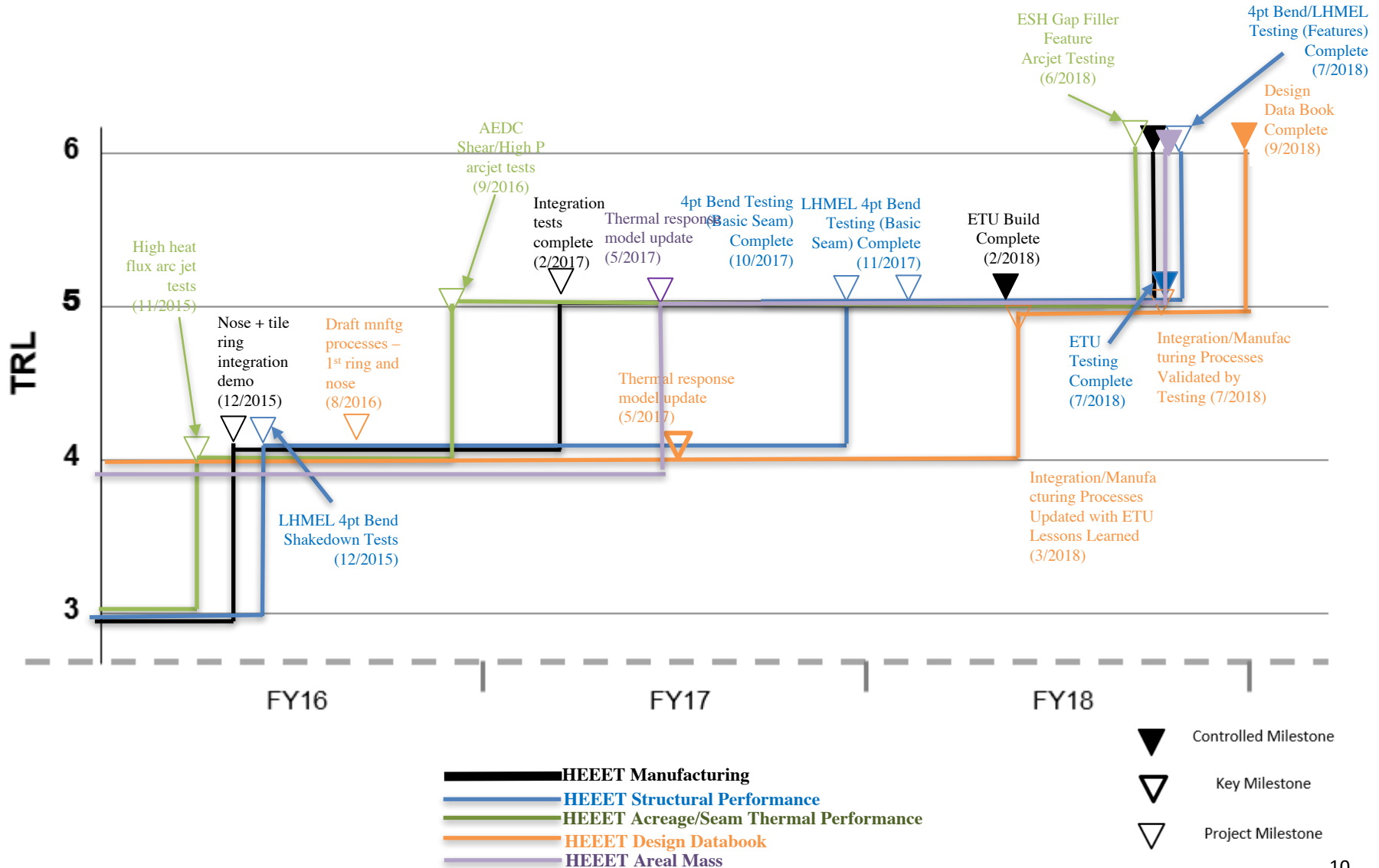
(from NF-4 AO Q&A #29)



The AO states that the risk of developing 3D woven TPS on time will not impact proposal evaluation (Table 4. Infusion strategies of NASA-developed technologies). However, it is unclear what risk NASA is shouldering to ensure readiness of HEEET. What is NASA's scope of TPS (thermal protection system) in this context and is there a specific TRL that applies? Please clarify that NASA will carry the risk through development of a mission representative engineering model or prototype heat shield tested in a relevant environment (to TRL 6) as implied in the Technology Workshop material?

- NASA is committed to delivering the HEEET TPS system at TRL 6, meaning that mission-representative prototype hardware will be built and tested in relevant environments in a timely manner.
 - ◆ TRL 6 for HEEET can be achieved with meaningful assemblies involving full-scale components, without requiring construction of a complete heatshield at scale for the selected mission.
- **For any proposal selected for a Phase A study, HEEET project personnel will be available to work with the proposal team on a TRL gap analysis between the generic ETU hardware built by the HEEET development project and the specific design for the mission.**
- **Where necessary, NASA will build, test and demonstrate HEEET elements at fully relevant scale to close any identified TRL gaps in a timely manner.**

HEEET Component and System TRL Assessment





Concluding Remarks



- **HEEET Development is progressing well**
 - ◆ Integration of 1m diameter engineering test unit is nearing completion
 - ◆ New Loom set-up is complete and weaving at 24” width
 - ◆ Significant testing will take place between Jan – July
 - Full scale Testing of ETU
 - Static Load testing,
 - Thermal-vac testing
 - Point-Load testing
 - AEDC arc jet testing for features
 - LHEML testing
- **NF-4 Phase A proposals**
 - ◆ HEEET Team plans to support the teams that have baselined HEEET
- **Goal is to complete testing and analysis and deliver HEEET by FY’18 at TRL**



HEEET Team



➤ NASA ARC:

- ◆ Don Ellerby - Lead
- ◆ Dave Driver
- ◆ Jay Feldman
- ◆ Matt Gasch
- ◆ Milad Mahzari
- ◆ Alberto Makino
- ◆ Frank Milos
- ◆ Owen Nishioka
- ◆ Keith Peterson
- ◆ Mairead Stackpoole
- ◆ Raj Venkatapathy
- ◆ Mike Wilder
- ◆ Zion Young
- ◆ **Neerim Corp:**
 - Peter Gage (Lead SE)
- ◆ **AMA, Inc. (@ ARC):**
 - Tane Boghozian
 - Jose Chavez Garcia
 - Greg Gonzales
 - Grant Palmer
 - Dinesh Prabhu
 - Joseph Williams
- ◆ **Science and Technology Corp (@ ARC)**
 - Cole Kazemba
 - Steve White

➤ NASA LaRC:

- ◆ Max Blosser
- ◆ Eric Burke
- ◆ Sarah Langston
- ◆ Carl Poteet
- ◆ Louis Simmons
- ◆ Scott Splinter
- ◆ **AMA, Inc. (@ LaRC)**
 - Will Johnston (@ LaRC)
 - Stewart Walker (@ LaRC)

➤ NASA JSC:

- ◆ Mike Fowler
- ◆ **Jacobs Technology Inc. (@JSC)**
 - Charles Kellermann

➤ NASA ARC, AEDC, LaRC and LHMEI test facilities and their crew

➤ Vendors:

- ◆ Bally Ribbon Mills (BRM), PA
- ◆ Fiber Materials Inc. (FMI), Maine