

TPS for Future Outer Planet Missions

Urgency and the Need to Weave HEEET Preforms

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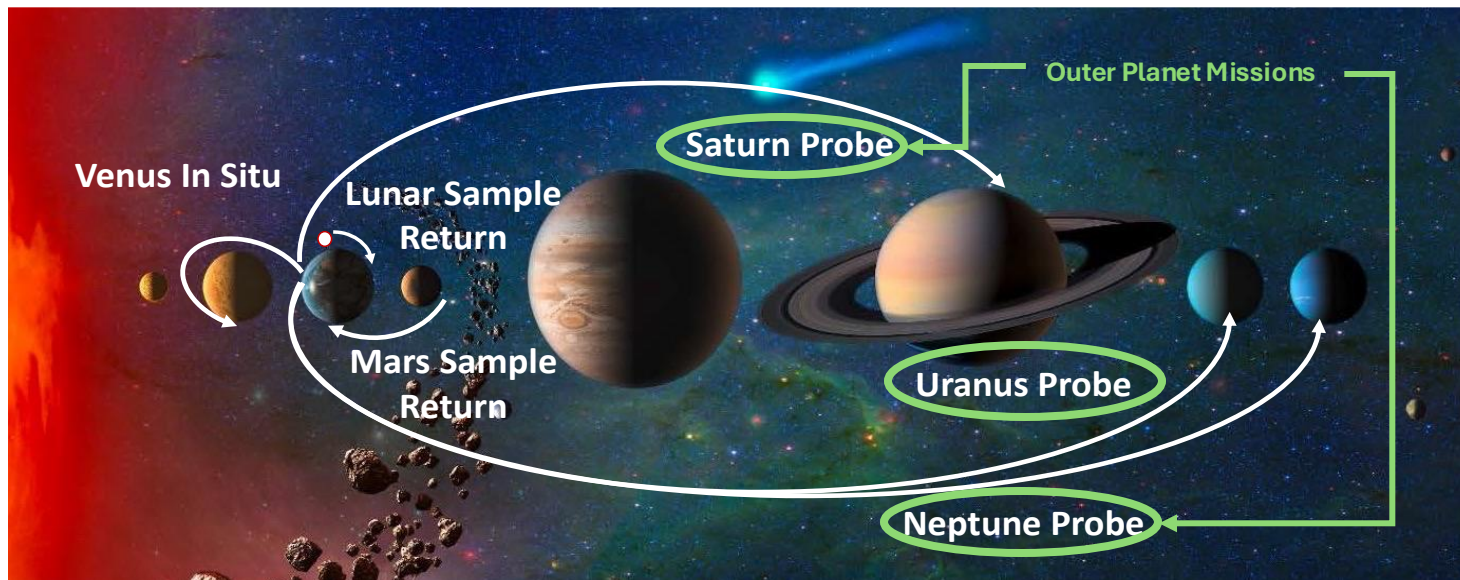
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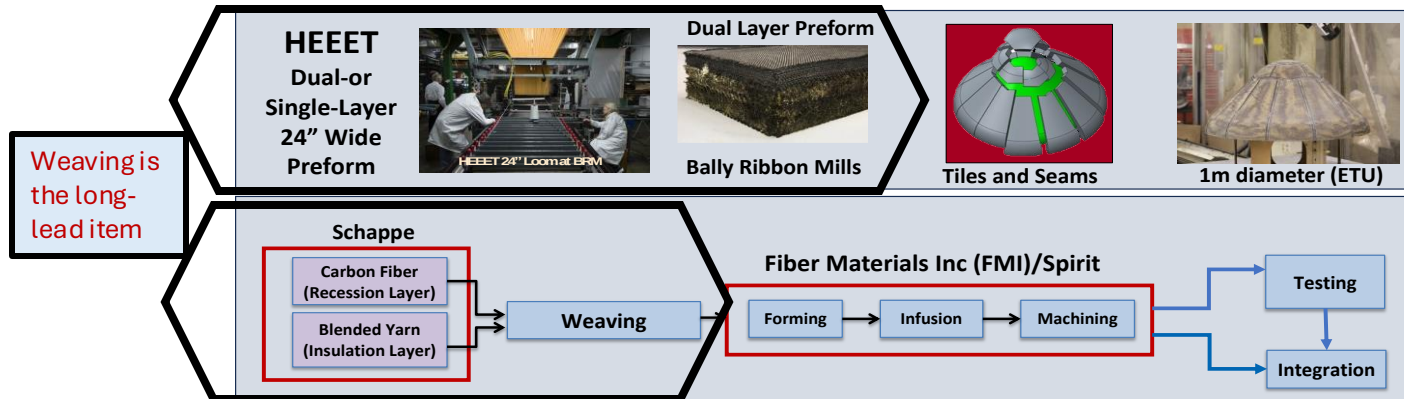
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HEEET is the only TRL 6 option for Outer Planet Missions



- NASA invested in the development of Heatshield for Extreme Entry Environment Technology (HEEET).
- HEEET is essential for Saturn and Uranus Orbiter Probe. No alternate TPS at TRL 6.
- HEEET was incentivized in the past Discovery and New Frontiers AOs.
- **Risk:** Given that it will be 5+ years before mission selection, there is a high probability that BRM, a small business, will reallocate or reconfigure the HEEET loom to other customers. **Risk mitigation: “Weave soon for use Later”**

HEEET - Steps Involved - From Yarn to HEEET Heatshield



Steps involved in delivering an integrated HEEET heatshield:

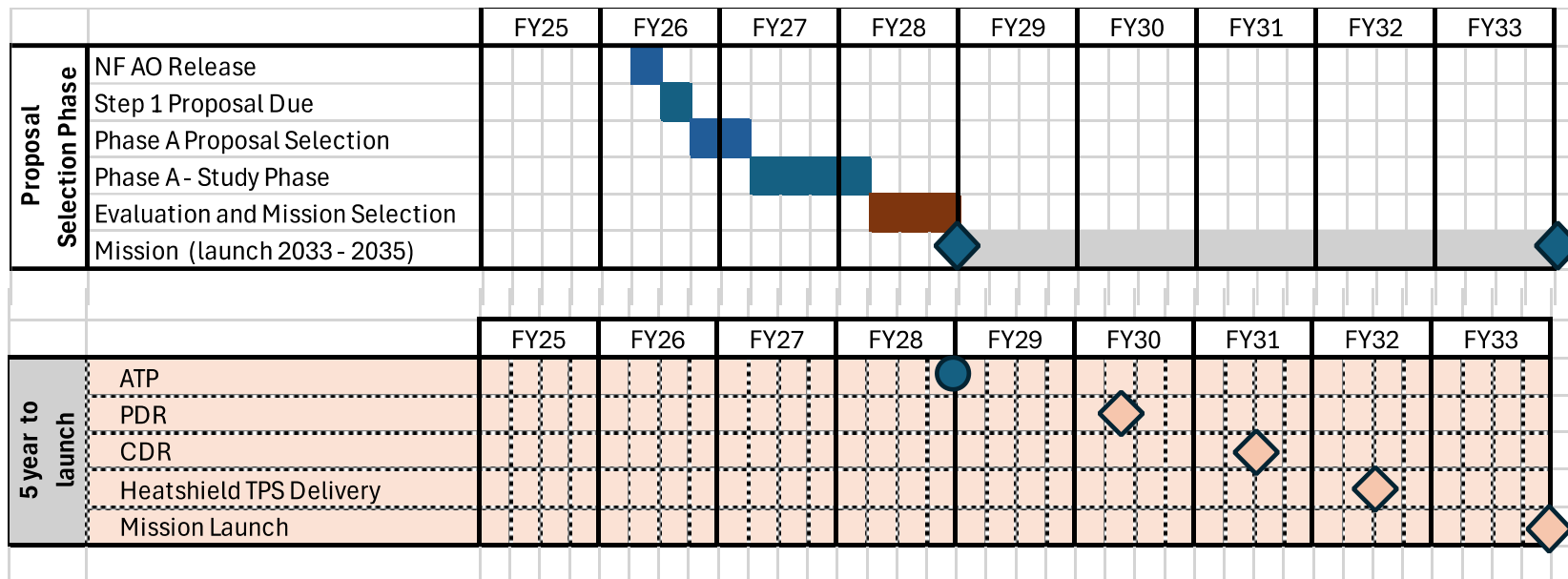
- Weaving takes 4 years** : Dual-layer 3-D woven preform – involves establishing contract specification, procuring and processing the yarn, loading the 60,000 heddles individually, and debugging the automated loom operations, and weaving 250 sq ft sufficient for a 2.0m diameter heatshield including an MDU, 2 Flight Units and for all testing.
- Forming, infusion, and machining tiles and seam gap filler** (“ESH” - Expanding Softened HEEET) will take additional time.
- Integration onto the heatshield structure is a complex**, multi-step process requiring precision machining of gaps, integration of seams, and bonding. By the time of mission selection it will be ~12+ years since the HEEET ETU was fabricated.
 - Any future mission will need to allocate sufficient time in the schedule to produce a Manufacturing Demonstration Unit prior to manufacturing a flight heatshield.

NF-5 AO to Mission Selection to Launch

UOP:

For a launch in FY35 – FY37, heatshield TPS delivery must be FY33 – FY35.

NF-5/6:

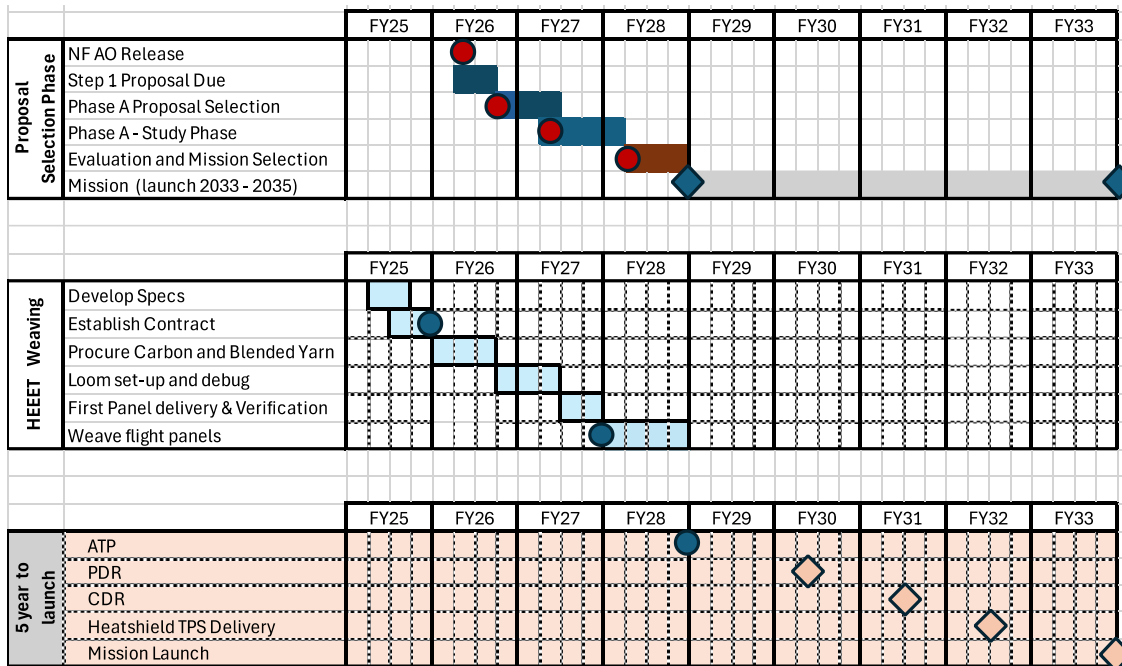


Weave and Store Woven Preform to Enable Outer Planet Missions

Proposers do not have a TRL 6 alternate to HEEET and are not selectable if HEEET preforms are not in hand

It takes ~ 4 years to set up the loom and weave HEEET preforms

Weaving HEEET preforms ahead and storing mitigates schedule risks associated with weaving long lead time and MDU build



Our recommendation is: "Weave soon for use later"

Questions and Answers:

Q: What will you weave today to meet the future mission TPS thickness requirements?

A: The HEEET loom was designed to accommodate the thickness for a Saturn shallow entry (very high heat-load). HEEET thickness is more than adequate for Saturn, UOP, and Neptune Probe missions. We will weave the maximum thickness. When the required TPS thickness is known, then resin infused parts can be machined to meet the design thickness.

Q: What about aeroshell scale?

A: HEEET is a tiled-with-seams architecture. During the HEEET project a 1m Engineering Test Unit (ETU) was fabricated that incorporated all the key interfaces of a larger aeroshell. Aeroshells (any scale, 0.3 m and above) can be made with successive rows of tiles.

Q: How long can you store the HEEET preforms.

A: Preliminary assessment is that the yarn and the woven preforms, if stored properly, will last decades. TPS is not a structure, but it protects the structure underneath from heat. Hence, thermal performance is most critical and not affected due to aging. We plan to perform aging studies to show this.

Q: What is the cost of weaving? Is that significant/showstopper?

Actions Taken and Seeking OPAG's Advocacy

- We have informed SMD-PSD and STMD leadership about the risk of losing weaving capability and its potential impact.
- To minimize the impact on UOP and NF5/6, we recommend the strategy of “weave soon for use later.”
- Both SMD and STMD are engaged in addressing this issue.
- Budget challenges are real, and given current uncertainties it is unclear when actions can be taken to address these challenges.

- We seek OPAG's advocacy to ensure Outer Planet in situ missions are not unduly impacted.
- Risk mitigation is for NASA to “weave soon for use later.”