Submitted to OPAG for Panel Discussions:

Seeking Advocacy and Support for White Papers to the Decadal Survey

On Sustaining Mission Critical TPS and Continuing Investment in Innovative New Entry Technologies

On behalf of the
Entry Systems and TPS Technology Community

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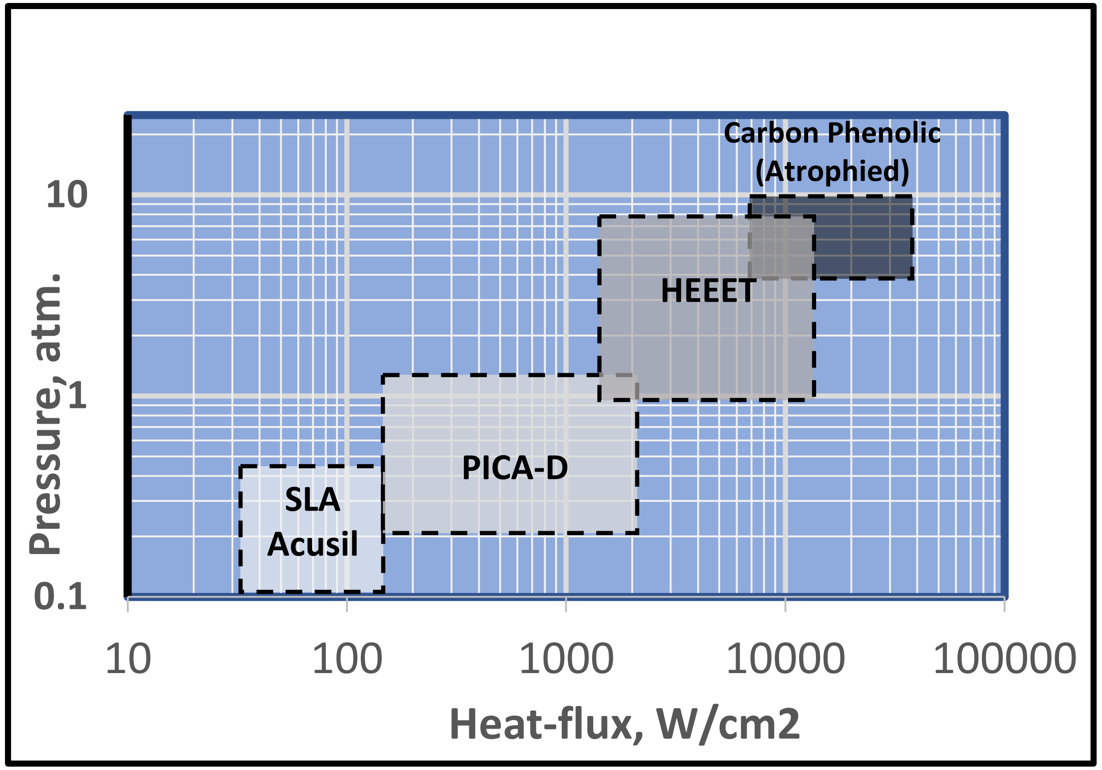
Context and Background

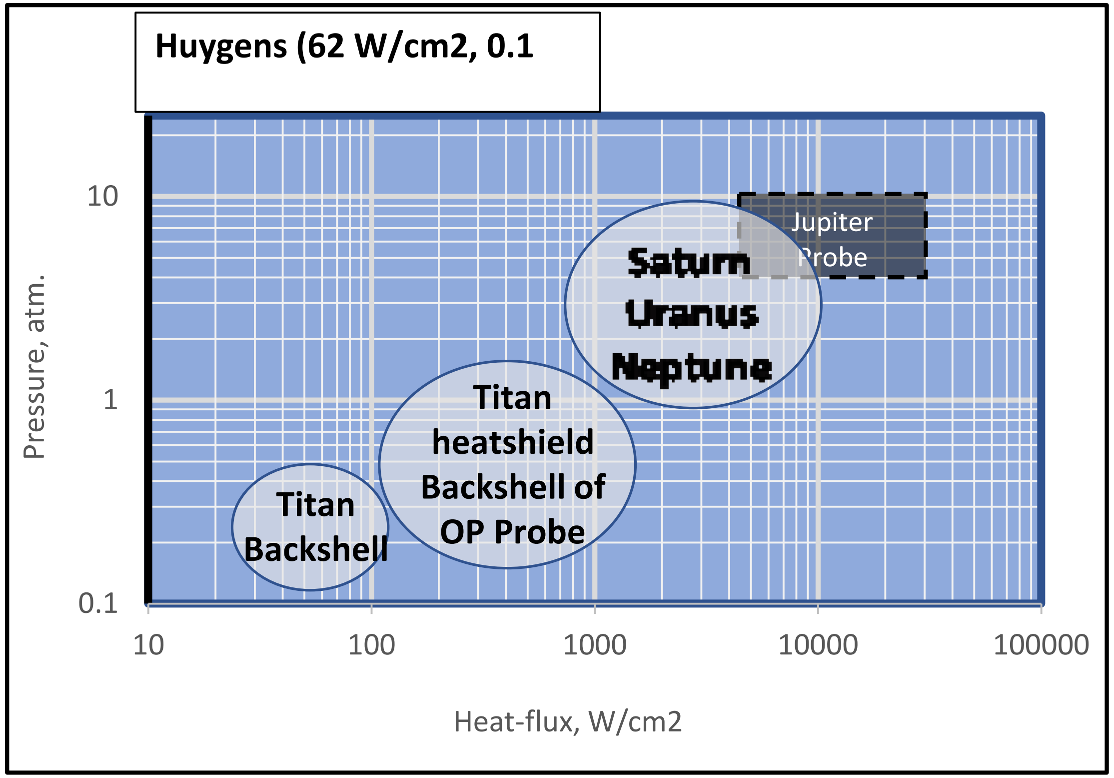
- Entry systems and TPS technologies are mission critical for in situ science and sample return missions.
  - Outer Planet missions, especially Gas and Ice Giants, require extreme entry capable and efficient TPS.
  - None other than NASA has need for it.
- Sustaining Technologies or developing alternate for atrophied technologies ahead of mission need, requires active planning, periodic risk assessment and employing mitigation, as necessary.
  - Past history tells us we need to pay attention to Sustainability.
  - Need and use-frequency sustains the Technology – OP Missions have need but not the cadence.
  - Even simplest of ablative TPS and materials require a number of constituent materials, and involved processing and integration.
  - Flight proven TPS has a long life span if maintained, e.g., SLA and PICA
  - New TPS development requires nearly a decade and 10’s $M, e.g., HEEET

TPS Needed for Outer Planet Missions

Capability



Mission Environment



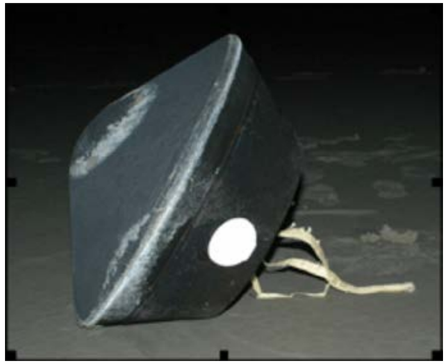
Proven and capable TPS are few and they need to be preserved

- If any one of these PICA, HEEET, etc. are not sustained, OP Missions will require alternate materials and system development. Sustaining becomes necessary given the time line of next decade for the Ice Giant missions

Example – PICA

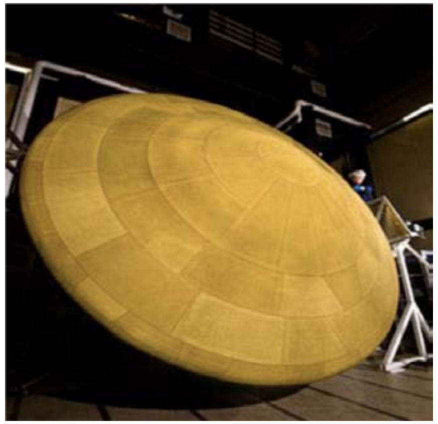
- PICA is one of the simplest heatshield materials, used in a variety of missions, and it has had many close calls.
  - Chopped carbon fibers from rayon and phenolic are processed into PICA (Phenolic Impregnated Carbon Ablator).
  - PICA is a low Density TPS, and very efficient for moderate to low heating conditions.
  - PICA enabled Stardust and came very handy for MSL, when SLA failed.
  - Currently used on OSIRIS-REx, Mars 2020, and will be needed for Dragonfly, MSR EEV and MSR SRL.

Stardust (OSIRIS-REx)
Single Piece (~0.8m)



- History:
  - Discontinued production → NASA had to switch (and requalify) Rayon multiple times.
  - Recently, NASA Ames (working with FMI) qualified a drop-in replacement for PICA from Lyocell, a domestic rayon source that has very large commercial market → addresses sustainability.
  - FMI (the only qualified company and supplier of PICA for all of NASA Missions) recently decided to divest from making their commercial fiber form → would have impacted Dragonfly, MSR EEV and MSR SRL.
  - With support from NASA SMD-PSD, NASA Ames is working with FMI to ensure FMI will reestablish PICA-D (Domestic rayon) product line in time to support Dragonfly, MSR EEV and MSR SRL.

MSL (Mars 2020) – Tilted (4.5m)



Example – HEEET

- History: Carbon Phenolic and HEEET
  - Carbon Phenolic (CP) enabled Galileo and Pioneer-Venus.
    When the rayon manufacturer went out of business (factory burnt down), NASA (and DoD) lost the capability.   After Galileo, there was no NASA need for CP for over 20 years.
  - MSR (1997- 2002) needed heritage CP (no longer available) and we discovered rayon was no longer available and the processing and manufacturing have atrophied.
  - In 2011, NASA (STMD and SMD) began to invest in a new material/system development and as a result 3-D Woven/HEEET project got started in 2013.
  - HEEET is 50% lighter, and more robust, compared to CP. Maturity at TRL 6 and ready for mission use.
  - **<u>HEEET is an enabling technology for Ice Giants Probe missions.</u>**
- Need to ensure HEEET can be sustainably manufactured (2020's – 2030's). Failure impacts Ice Giant Probe missions.
  - HEEET is a bit more complex than PICA.
  - Sustenance for Ice Giant or Gas Giant Missions requires attention to availability of raw material, 3-D weaving, processing and integration.

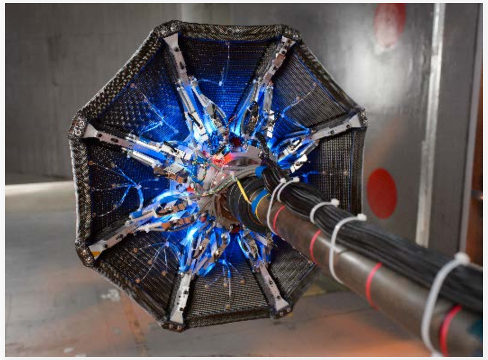
3-D Woven Pre-form

HEEET – Engineering Test Unit
(1 m dia)

Example – ADEPT, a new Entry System

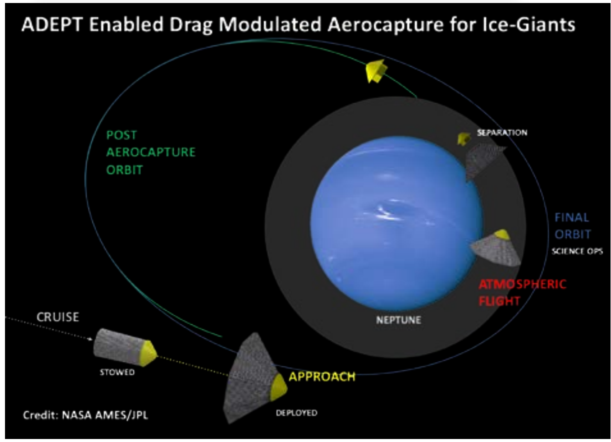
History: Rigid vs Deployable heatshield

- To date, All NASA missions have used a rigid aeroshell that fits within launch system. Missions live with the limitations of rigid aeroshell
- NASA has invested in development of deployable (ADEPT) technology (not constrained by Launch System diameter)
- ADEPT is scalable. From delivery of small satellite as secondary payload (to Venus), to very large payload to Ice-Giants are feasible.



Need:

- Deployable entry system to enable new paradigm - science mission architectures that is not possible with a rigid aeroshell
  - ADEPT-enabled Drag Modulated Aerocapture may be able to deliver orbiter and probe, allowing deployment of probe from orbit. Current studies are exploring the potential
- NASA to continue development, especially if missions studies prove the potential.



Concluding Remarks

We see the need for white papers that are directly relevant to ensure future, next decade and beyond, Outer Planet missions.

White Papers to specifically address:

- Active assessment and risk mitigation in sustaining critical TPS technologies for OP mission.
- Continued investment in maturing and demonstrating innovative Entry Systems to enable science missions not feasible otherwise.

We seek OPAG's feedback, advocacy and support .