A Discussion of the Need to Sustain Mission Ready TPS and for Continued Development of Innovative Entry System Technologies.

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Flight proven entry system and TPS technologies are critical for the successful execution of *in situ* science missions at Venus. Emerging new technologies point to new possibilities and offer innovative approaches to delivering small satellites for orbital science. Venus entry can be very demanding and there are only a few flight proven TPS materials, some developed by Industry and others by NASA, capable of meeting the mission needs. NASA-developed TPS technology has largely been transferred to Industry under the assumption that industry would maintain the fabrication capability. However, lack of mission needs could result in obsolescence of TSP fabrication capability, or NASA's expertise could be diverted to other higher priority objectives thereby impacting the readiness of particular material systems. Atrophy of capabilities can come about in other ways as well, such as changes to raw materials. Even small manufacturing process changes could result in requalification of materials and/or reduction in TRL. Carbon-Phenolic is a textbook example.

After a long period of absence of US Venus missions, VEXAG and the Science community is making the case for future missions. It is insufficient to assume the TPS technologies will be there in 5 or 10 years without active and continual planning and assessment. After Galileo, Carbon-Phenolic materials and fabrication skills were allowed to atrophy. Then when missions needed it, in early 2000, it was no longer possible to make the heritage Carbon-Phenolic.

What do we need to do? The first step is to advocate for the establishment of TPS readiness assessment. VEXAG needs to advocate for active monitoring of needed capabilities, assessment of emerging risks, development of risk mitigation strategies, and implementation plans. Such an approach reduces the threat of material obsolescence and helps maintain the availability of entry system and TPS technology capabilities, both old and new.

Venus probes, landers, balloons and other variable altitude missions, skimmer missions, such as, "Cupid's Arrow," as well as aerocapture missions to deliver small spacecraft, require qualified entry systems and ablative TPS. VEXAG advocated for HEEET in 2013/2014 and the community is well versed with the need to sustain it. However, other TPS that need to be sustained may not be apparent to VEXAG community.

The following figure summarizes the ablative TPS capabilities *vs*. Venus mission needs for both primary heatshield and backshell.

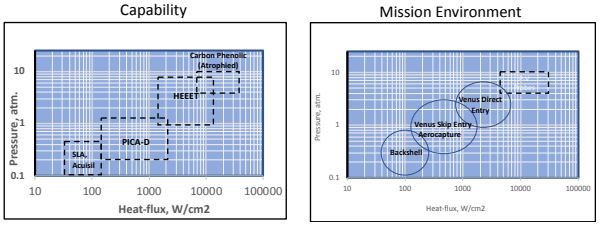

Figure 1. Mission ready TPS capability vs Venus entry conditions.

The list of ablative TPS that needs to be sustained contains just a few materials, but each material is unique, *i.e*., there is no alternate. This makes it even more important that VEXAG advocate for sustaining flight-ready TPS. The VEXAG community may not be aware that PICA has been impacted by raw material (rayon) availability. In 2016, NASA learned that the rayon supplier (foreign) was going to discontinue production and SMD-PSD was advised to invest in the establishment of a PICA based on domestic rayon. A three-year effort with FMI starting FY16, culminated in establishment of PICA-D (Domestic) as a "drop-in replacement" for the heritage PICA. Unfortunately, a few months ago, FMI's parent company decided to discontinue the production of carbon FiberForm™, which is the substrate for the PICA TPS. With missions such as Dragonfly, MSR SRL and MSR EEV needing PICA-D for missions in 2026, NASA has had to work with FMI to fund an activity to ensure FMI will reestablish PICA-D production just to meet NASA needs.

The continued advocacy for new approaches, drag modulated aerocapture with the deployable entry system technology (ADEPT), which is showing promising approaches to deliver small spacecraft (cube sats and bigger) and delivery of balloons using direct entry with ADEPT, can enable innovative missions.

The intent of the poster is to make the case for white papers on "Sustaining Mission Ready TPS and Continuing Development of Innovative Entry System Technologies."