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# Thermal Protection System Technology and Facility Needs for Demanding Future Planetary Missions.

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NASA has successfully launched science missions to Venus and Jupiter and the knowledge gained from those missions have been invaluable yet incomplete. Future missions will be built on what we have learned from the past missions but they will be more demanding from both the science as well as the mission design and engineering perspectives. The Solar System Exploration Decadal Survey (SSEDS) produced for NASA by the National Research Council identified a broad range of science objectives many of which can only be satisfied with atmospheric entry probes. The SSEDS recommended new probe/lander missions to both Venus and Jupiter.

The Pioneer-Venus probe mission was launched in August 1978 and four probes successfully entered the Venusian atmosphere in December 1978. The Galileo mission was launched in October 1989 and one probe successfully entered the Jovian atmosphere in December 1995. The thermal protection system requirements for these two missions were unlike any other planetary probes and required fully dense carbon phenolic for the forebody heat shield.

Developing thermal protection systems to accomplish future missions outlined in the Decadal Survey presents a technology challenge since they will be more demanding than these past missions. Unlike Galileo, carbon phenolic may not be an adequate TPS for a future Jupiter multiprobe mission since non-equatorial probes will enter at significantly higher velocity than the Galileo equatorial probe and the entry heating scales approximately with the cube of the entry velocity. At such heating rates the TPS mass fraction for a carbon phenolic heat shield would be prohibitive. A new, robust and efficient TPS is required for such probes. The Giant Planet Facility (GPF), developed and employed during the development of the TPS for the Galileo probe, was dismantled after completion of the program. Furthermore, flight data from the Galileo probe suggested that the complex physics associated with the interaction between massive ablation and a severe shock layer radiation environment is not well understood or modeled. The lack of adequate ground test facilities to support the development and qualification of new TPS materials adds additional complexities.

The requirements for materials development, ground testing and sophisticated modeling to enable these challenging missions are the focus of this presentation.