Challenges and Opportunities for Ensuring Entry System Technology Readiness for Ice Giants Probe Missions

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Abstract

The Ice Giants represent a distinct class of planets within our solar system, and appear to be similar to most exoplanets that have been detected thus far. Exploring Ice Giants in our Solar System would allow us to better understand their formation and evolution processes, and thus help establish scientific links to exoplanets. *In situ*exploration using probes similar to Galileo, along with an orbiter or a relay spacecraft, will require entry followed by deployment of the descent probe containing science instruments into Uranus or Neptune atmosphere. The challenge is not in the deployment of the probe, but in the atmospheric entry prior to deployment. The entry system has to have a capable, robust and efficient ablative thermal protection system (TPS) designed to protect the descent probe from the thermal and mechanical entry loads. Although entries into Ice Giants may not be as demanding as the Galileo entry at Jupiter, the entry environments will be more severe than environments for Mars, Sample Return missions, and Venus, and will therefore require robust TPS.

While Galileo Probe's success, nearly 25 years ago, should give us confidence, the recession data from the Galileo entry informs us that the entry environment was underpredicted and the design thickness was barely adequate. The lesson learned from Galileo probe for future Ice Giant missions will require us to be cautious and demand a more robust design. The TPS technology used on Galileo entry system no longer exists due to atrophy of manufacturing processes. Instead of attempting to revive Galileo-legacy TPS technology, NASA invested in a new and innovative TPS called HEEET (Heat-shield for Extreme Entry Environment Technology). HEEET has been matured, and is now ready to support future missions not only to the Ice Giants but also for Venus, high-speed sample return, and Saturn probe missions.

This lead talk, intended for the technology section of the workshop, will cover entry, descent, and deployment (EDD), with an emphasis on entry. A brief history of the TPS challenges for extreme entry missions will be given along with a quick overview of the concept of operations for EDD. The development and maturation of HEEET system capability will be described. Data gathered in ground-test facilities in the US will be highlighted to show that the technology is mature and ready for Ice Giant missions. All thermal protection systems carry some risk as a result of ground test limitations and Ice Giant missions present some unique challenges. These challenges are not only technical, but also due to limitations in the currently established manufacturing and integration. In addition, the concerns that arise

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due to potential for atrophy for future Ice Giant mission a decade or more from now will be analyzed. Plausible avenues for mitigation will be presented. There are two companion planned presentations by Dr. Prabhu and Dr. Hwang will dive deeper in the challenges and opportunities. This intended talk will set the stage for their presentations.

Keywords: Entry Descent and Deployment, Thermal Protection Material and System, Extreme Entry Environment, Ice Giants