A Common Probe Design for Multiple Planetary Destinations

Helen H. Hwang
Entry Systems and Technology Division, NASA Ames Research Center, Moffett Field, CA USA

Introduction: Atmospheric probes have been successfully flown to planets and moons in the solar system to conduct *in situ* measurements. They include the Pioneer Venus multi-probes, the Galileo Jupiter probe, and Huygens probe. Probe mission concepts to five destinations, including Venus, Jupiter, Saturn, Uranus, and Neptune, have all utilized similar-shaped aeroshells and concept of operations, namely a 45° sphere cone shape with high density heatshield material and parachute system for extracting the descent vehicle from the aeroshell. The current paradigm is to design a probe to meet specific mission requirements and to optimize mass, volume, and cost for a single mission. However, this methodology means repeated efforts to design an aeroshell for different destinations with minor differences. A new paradigm has been explored that has a "common probe" design that could be flown at these different destinations and could be assembled in advance with multiple copies, properly stored, and made available for future NASA missions. Not having to re-design and rebuild an aeroshell could potentially result in cost and schedule savings and reduce the risk of losing technologies and skills difficult to sustain over decades.

The NASA Planetary Science Division has funded a study in 2018 to determine feasibility of a common probe design that meet most, if not all, mission needs to the five planetary destinations with extreme entry environments. The Common Probe study involved four NASA Centers (Ames Research Center, Goddard Space Flight Center, Jet Propulsion Laboratory, and Langley Research Center) and addressed these issues. Also investigated were, design constraints and inefficiencies that occur in specifying a common design versus designing for specific mission and target destination.

Study methodology: First, a notional payload of instruments for each destination was defined based on priority measurements from the Planetary Science Decadal Survey. Steep and shallow entry flight path angles (EFPA) were defined for each planet based on qualification and operational *g*-load limits for current, state-of-the-art instruments. Interplanetary trajectories were then identified for a bounding range of EFPA.

Next, 3-DoF simulations for entry trajectories were run using the entry state vectors from the interplanetary trajectories. Aeroheating correlations were used to generate stagnation point convective and radiative heat flux profiles for several aeroshell shapes and entry masses. High fidelity thermal response models for various TPS materials were used to size stagnation point thicknesses, with margins based on previous studies. Backshell TPS masses were assumed based on scaled heat fluxes from the heatshield and also from previous mission concepts. The resulting notional probe design is shown in Figure 1.

Presentation: An overview of the study scope, highlights of the trade studies and design driver analyses, and the final recommendations of a common probe design and assembly will be presented. The limitations that the common probe design may have for the different destinations will also be discussed, as well as the considerations for implementing missions.

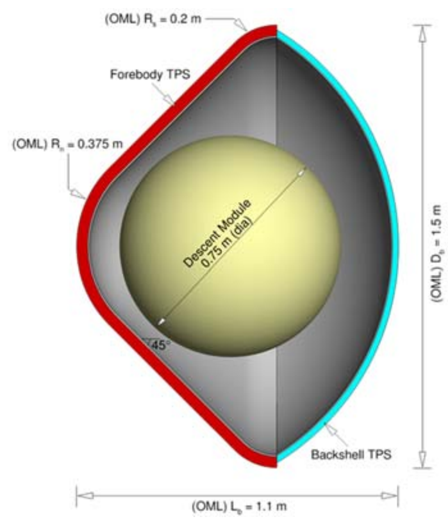

Figure 1. Common aeroshell design studied for multiple planetary destinations.