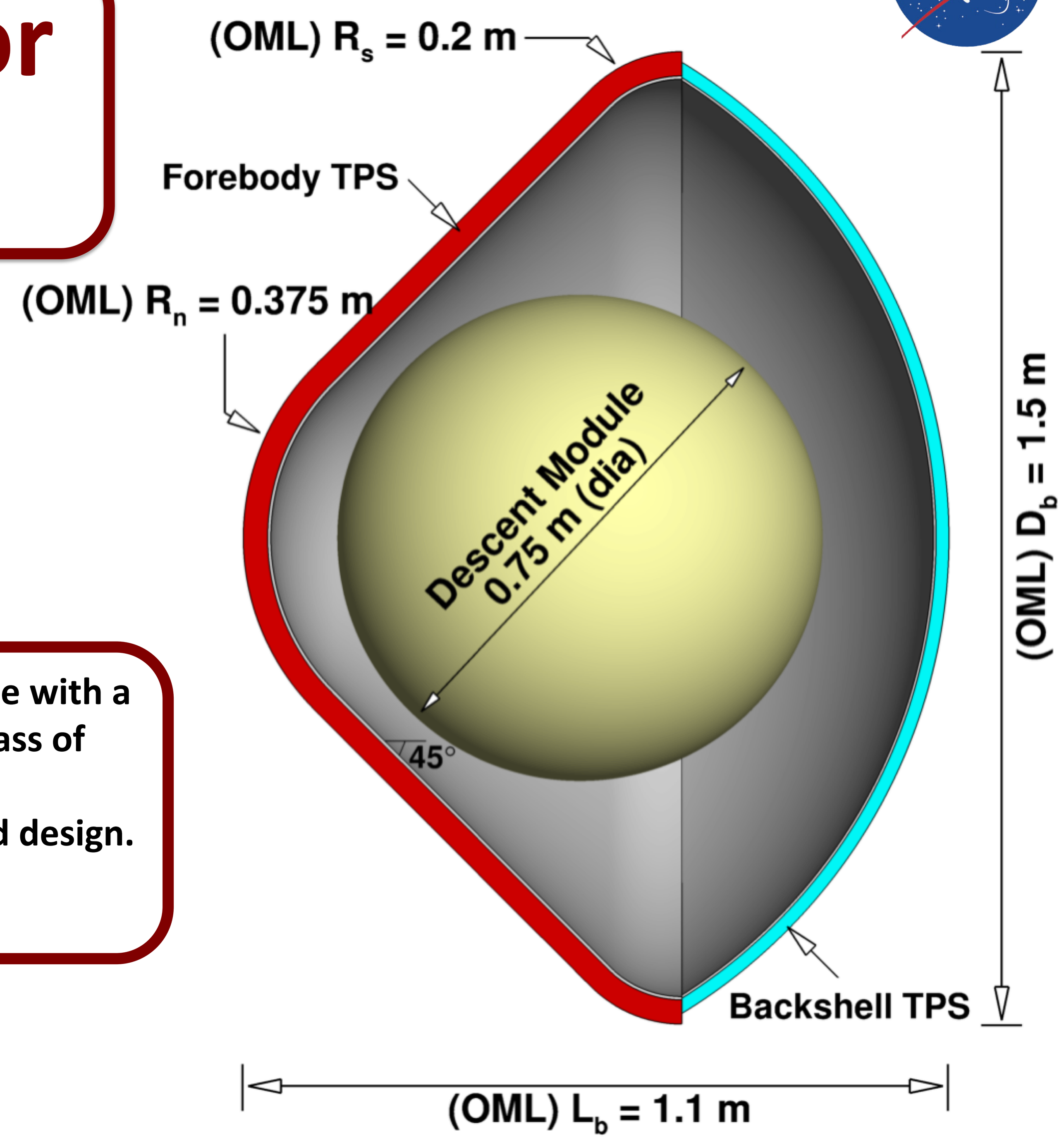
15th International Planetary Probe Workshop, 11-15 June 2018/Boulder, CO, USA

Aerothermal Design of a Common Probe for Multiple Planetary Destinations

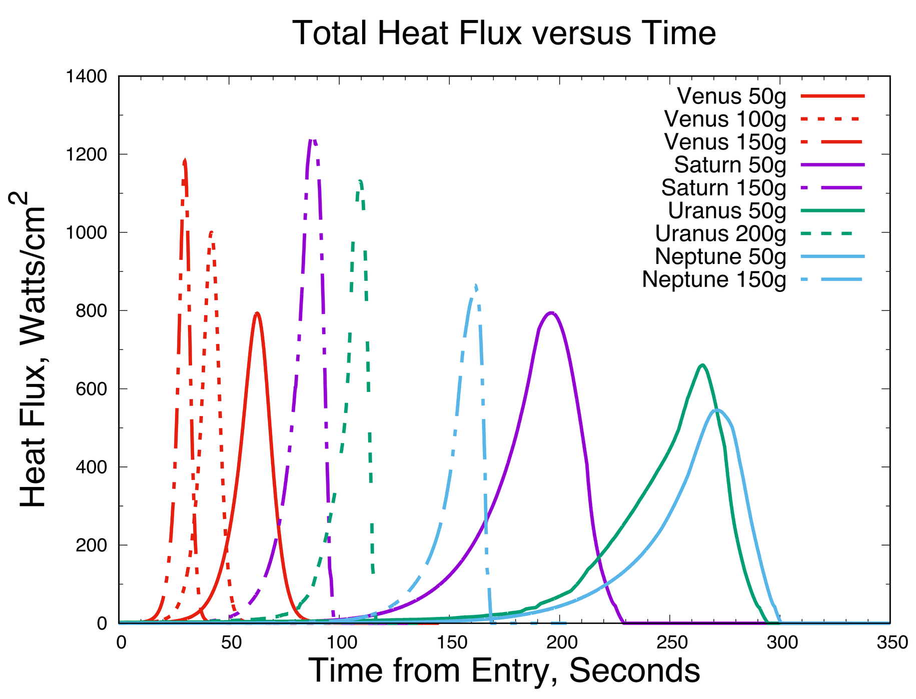
Gary A. Allen, Jr.,** Frank S. Milos,* Todd R. White,* and Helen H. Hwang*
Entry Systems and Technology Division
*NASA Ames Research Center, Moffett Field, CA 94035, USA
**AMA, Incorporated at NASA Ames Research Center, Moffett Field, CA 94035, USA

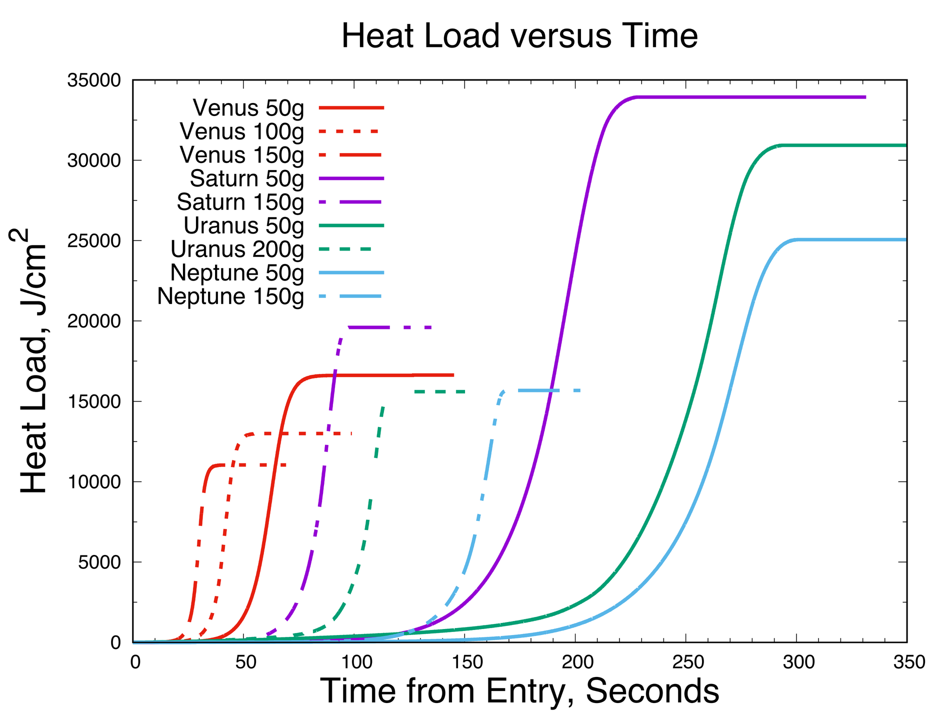


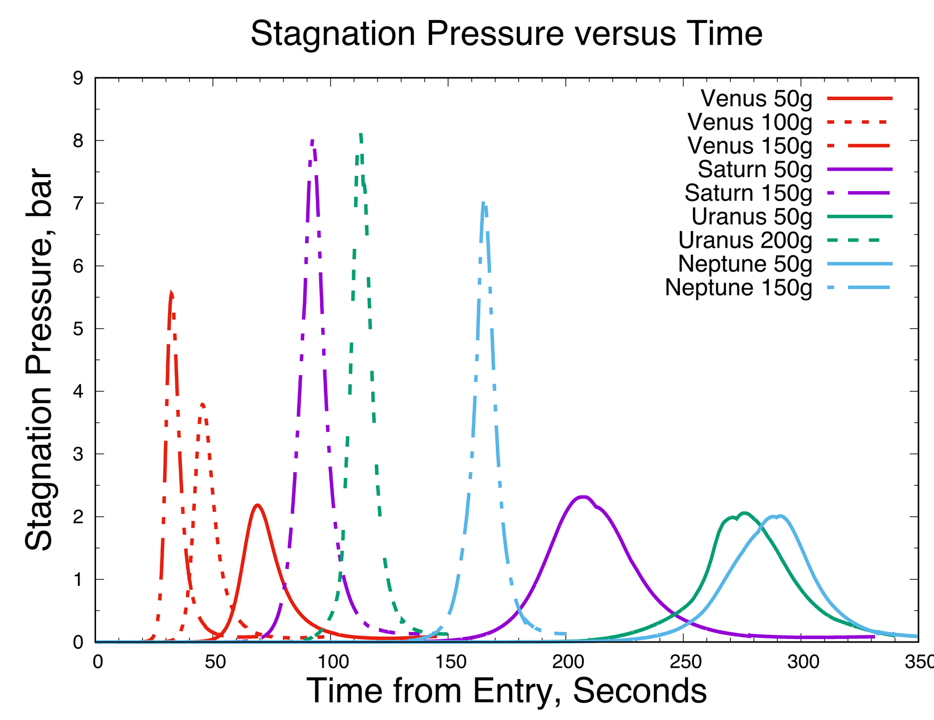
Objective & Process

Objective: Estimate the mass of the Thermal Protection System (TPS) for a *single design construct* of an atmospheric entry probe with a rigid aeroshell, which could be used at five destinations, i.e. Venus, Saturn, Uranus, Neptune, and perhaps, Jupiter. The entry mass of the probe is 400 kg with a ballistic coefficient of 216 kg/m².

Process: The 3DoF trajectory simulation program *Traj*, coupled with the TPS response program *FIAT* was used for simulation and design. The assumed atmospheric models were VIRA (Venus-GRAM) for Venus, the Julianne Moses' model for Saturn, a NASA Ames engineering model for Uranus, Neptune-GRAM for Neptune, and Galileo Probe (Al Seiff's) result for Jupiter.

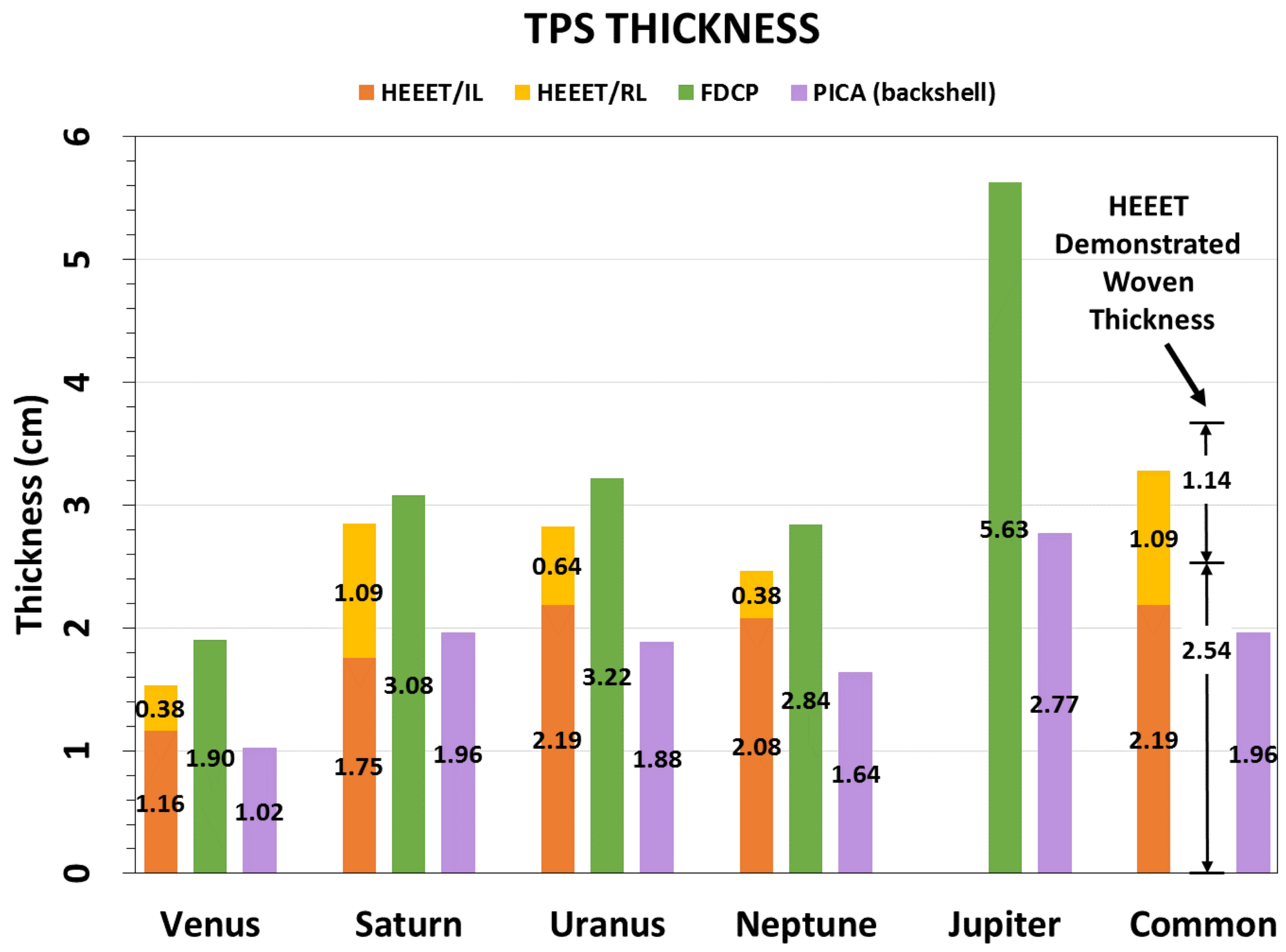




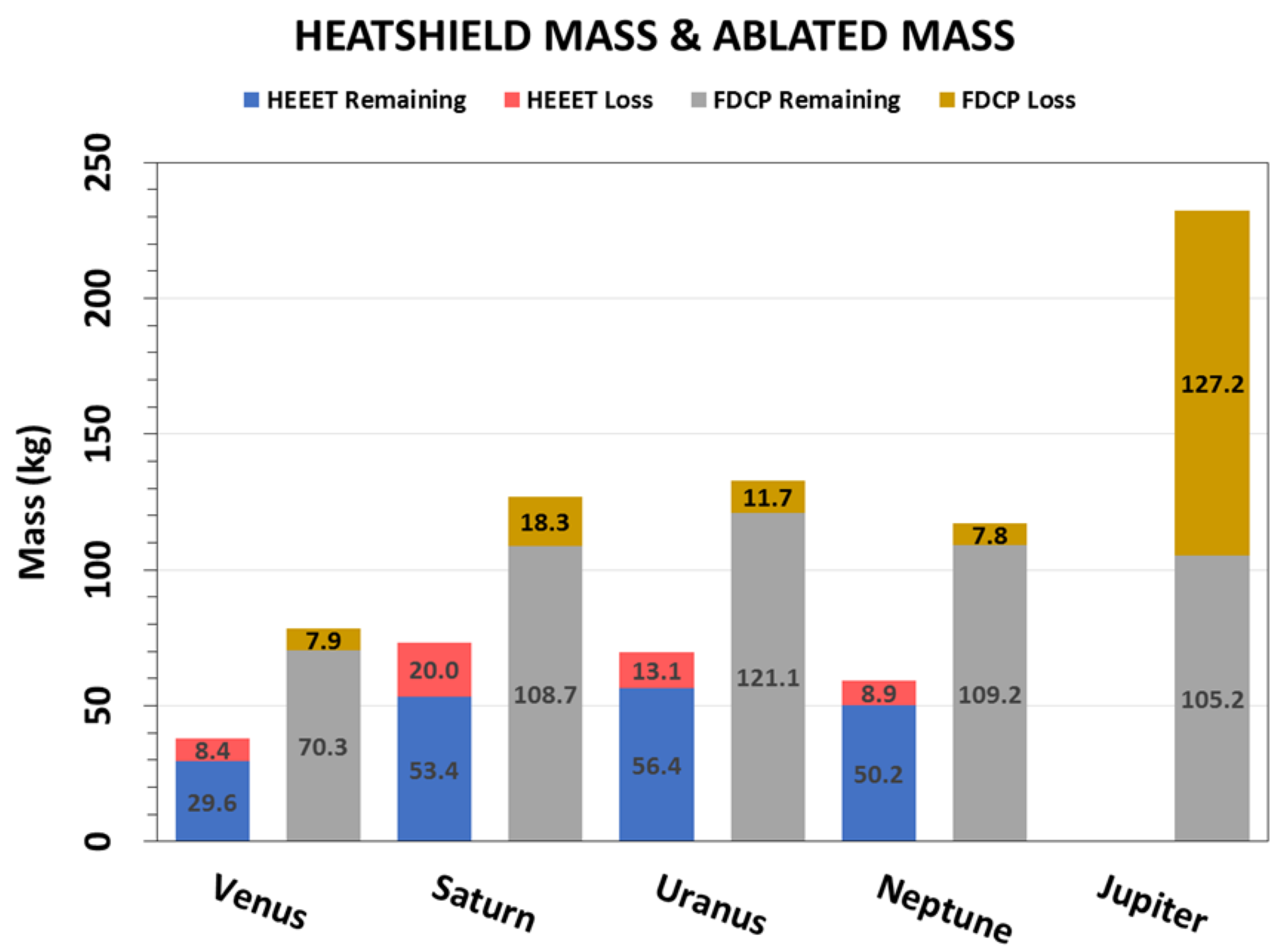


- 3DOF trajectories computed for entry states provided by NASA JPL and GSFC.
- Entry flight path angles constrained to limit peak g loads between 50 and 200.
- TPS sized to estimated stagnation point heat loads but materials not tested to all *q*, *p* limits.
- Margined TPS thickness computed for Fully Dense Carbon Phenolic (FDCP) and Heatshield for Extreme Entry Environment Technology (HEEET) using coupled *Traj-FIAT* process.
- Phenolic Impregnated Carbon Ablator (PICA) used as backshell TPS.

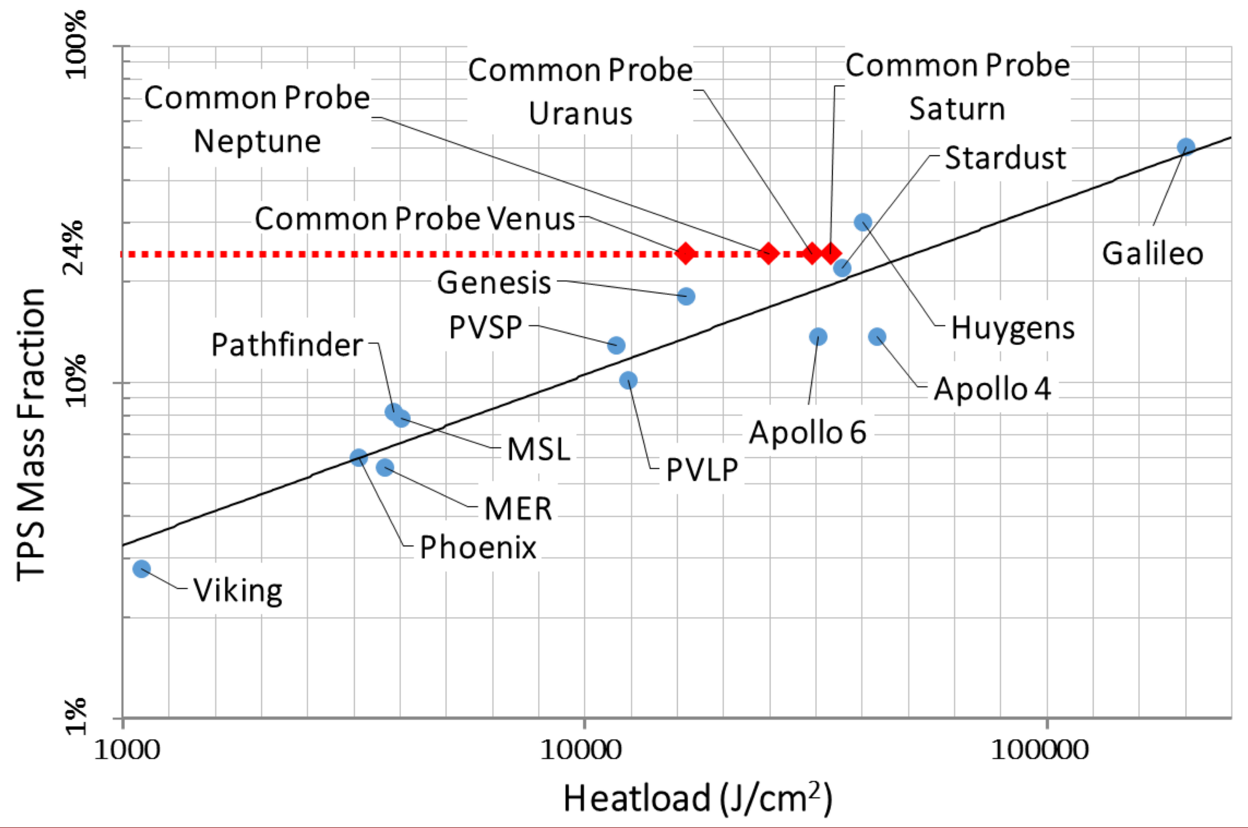
- TPS thicknesses driven by shallowest entry at each destination
- Backshell sized to environments scaled from forebody stagnation point



- Maximum mass loss at Jupiter – recession dominated entry



- TPS mass fractions for the Common Probe using HEEET compare well with previous experience



Aerothermal Design Summary

- A *single* atmospheric entry probe with a rigid aeroshell appears feasible for four destinations, i.e. Venus, Saturn, Uranus, and Neptune.
- Jupiter entries have an order of magnitude higher heat load with extreme heating on the forebody, making FDCP the only viable option for the trajectories considered.
- Stacking worst-case thicknesses of Insulation Layer (IL), 1.09 cm, and Recession Layer (RL), 2.19 cm, across destinations yields a common design for HEEET on the forebody at the stagnation point.
- Total HEEET thickness is similar to demonstrated HEEET weavability to date.
- The common design for backshell TPS thickness of PICA is scaled from 15% of forebody environments and is within heritage manufactured thicknesses.
- Recommend follow-on analysis with CFD to determine flank and backshell sizing which could drive increased TPS thicknesses.

Acknowledgments

The authors are grateful to Julianne Moses (SSI, Boulder, CO) and Tommi Koskiken (LPL, U Arizona, AZ) for providing us with profiles of Saturn atmosphere, which were invaluable to the present work. The authors thank team members from NASA Jet Propulsion Laboratory, NASA Goddard Space Flight Center, NASA Langley Research Center, NASA Ames Research Center for illuminating discussions and collaboration, and the HEEET project at NASA Ames Research Center for materials information and data.

*AMA Incorporated supported by the Entry Systems and Technology Division under contract NNA15BB15C.