A Common Probe Design for Multiple Planetary Destinations

Helen H. Hwang
Entry Systems and Technology Division, NASA Ames Research Center, Moffett Field, CA 94035

Introduction and Background

The Planetary Science Division of the NASA Science Mission Directorate funded a study from October 2017 – June 2018, involving 4 NASA Centers (ARC, GSFC, JPL, and LaRC), to address if a common aeroshell design could be utilized at multiple destinations instead of optimizing a design for a specific mission. If this common design were built with several copies, what efficiencies and risks would be involved?

Study Scope and Assumptions

- Venus, Jupiter, Saturn, Uranus, and Neptune considered as destinations
- Atmospheric probe missions (no large landers at Venus)
- Carrier Spacecraft provides power and telecommunications (details not studied)
- Details of science instrumentation and high-fidelity analysis; use mid-fidelity tools for design estimates

Study Team Members

NASA Ames Research Center (ARC)
- Gary A. Allen, Jr. (AMA, Inc.)
- Antonella I. Alunni (AMA, Inc.)
- Jay D. Feldman
- Frank S. Miles
- Keith H. Peterson
- Dinesh K. Prabhu (AMA, Inc.)
- Todd R. White

NASA Goddard Space Flight Center (GSFC)
- Michael J. Amato
- Greg C. Mann
- Kyle R. Pugsley

NASA Langley Research Center (LaRC)
- John R. Cruz
- Robert A. Drinan
- Soumyo Dalal
- Alicia Dahm-Ciaccia

Jet Propulsion Laboratory (JPL)
- David A. Atkinson
- Bernie J. Bienstock
- John O. Elliott
- Mark D. Hofstadter
- Marcus A. Lobbia
- Kim R. Rh

Descent module of 0.75 m diameter estimated to accommodate Tier 1 and Tier 2 science instruments to all destinations

Assumptions:
- Launch vehicle with current all-chemical capabilities (ΔV)
- Time of flight < 15 years
- “Shallow” (50-g) and “steep” (150 – 200-g) trajectories for each destination

Interplanetary Trajectories

- Two different scenarios examined:
  - 1 main conical ribbon parachute, 2 m diam
  - 1 pilot (1 m) + 1 main, sized for each destination

Entry and Descent Concept of Operations

- Both options are feasible, indicating mission design flexibility.

Thermal Protection System (TPS) Sizing

- Aerothermodynamic environments (radiative + convective heating) estimated on the forebody stagnation point using a 3D computation, TRAJ
- 2 forebody materials considered: HEEET and FDCP, sized using FIAT
- Backshell TPS assumed to be PICA: mass estimated based on forebody stagnation point environments
- Common TPS thickness viable for 4 destinations but not Jupiter (heat loads 10x higher)

Summary and Future Work

- A common atmospheric probe design for Venus, Saturn, Uranus, and Neptune missions is feasible
- Missions to Jupiter should be considered separately due to out-of-family heat loads
- Follow-on activities are recommended:
  - Should a smaller descent module and aeroshell be studied?
- Higher fidelity tools (CFD, structural analysis, etc) for better mass estimates
- Better cost estimates
- Final report is in progress, will be submitted to PSD
- Community feedback is desired—what other activities are desired by mission designers?
Is it possible to “disrupt” the atmospheric probe mission design paradigm by designing and building an aeroshell that could be flown at Venus, Jupiter, Saturn, Uranus, and Neptune? Come find out!