Geophysical Research Abstracts
Vol. 14, EGU2012-3172-1, 2012
EGU General Assembly 2012

A Shallow Entry Probe Mission to Saturn

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Entry probe missions to the giant planets are needed to discriminate among competing theories of solar system formation and the origin and evolution of the giant planets and their atmospheres, to provide for important comparative studies of the gas and ice giants, and to provide a valuable link to exoplanetary system studies. Within the well-mixed upper tropospheres of the giant planets material from the epoch of solar system formation can be found, providing clues to the local chemical and physical conditions existing at the time and location at which each planet formed. The giant planets therefore represent a laboratory for studying the atmospheric chemistries, dynamics, and interiors of all planets, including Earth and exoplanets. In situ measurements at Jupiter by the Galileo entry probe, remote sensing and interior structure of Jupiter from the Galileo orbiter and Juno missions, and interior structure of Saturn during the upcoming Cassini Solstice Mission's proximal orbits provide three of the four required components of the data set needed for meaningful comparison of Jupiter and Saturn. In situ studies of the composition, structure, and dynamics of Saturn's upper troposphere with a Saturn entry probe would fill the remaining gap.

Recognizing the importance of giant planet research, the National Research Council's 2012 Planetary Science Decadal Survey lists Saturn entry probes as a mission concept of exceptional scientific value. The Survey's highest priority science goals for Saturn are tightly focused: noble gas and key isotopic abundances, and the thermal structure of Saturn's atmosphere. Lower priority objectives include the dynamics of Saturn's atmosphere and precision measurement of key disequilibrium species and specific isotopes within the atmosphere. All of the high priority and most of the lower priority objectives can be met with a mission comprising one or more small, shallow (<10 bar) entry probes carrying instruments to measure the atmospheric composition and structure of Saturn's upper troposphere, and ultrastable oscillators on the probe and carrier relay spacecraft to provide measurements of Saturn's atmospheric dynamics by Doppler tracking of the probe.

No new technologies are needed to conduct a Saturn entry probe mission. Although significantly less demanding than the Galileo Jupiter entry environment, Saturn entry requires a Thermal Protection System similar to that used for the Galileo probe. The pressure, temperature, and radiation environments at the locations of interest at Saturn are relatively benign and require no extreme environment technology development. Since Saturn does not have a Jupiter-like synchrotron noise environment, and the microwave opacity of Saturn's atmosphere increases approximately as frequency squared, a Saturn probe mission can use lower telecom frequencies to reduce attenuation with data rates that surpass the Galileo probe data rate. Additionally, the Decadal Survey noted significant flexibility in Saturn probe delivery trajectories. Maintaining a disciplined approach to the payload could enable a probe equal to or smaller than the Galileo Probe.

This research was carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA. Government sponsorship acknowledged.