

Saturn Deep Atmospheric Entry Probes Delivered by INSIDE Jupiter Derivative Spacecraft. T. R. Spilker, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109-8099, tspilker@mail1.jpl.nasa.gov.

Introduction: *In situ* probes are the most reliable means for sampling composition and conditions deep in giant planet atmospheres. Deep constituent abundances at the giant planets offer clues to conditions in the solar system's protoplanetary disk and variations with heliocentric distance. Currently *in situ* atmospheric data are available from only one giant planet, Jupiter, and probes that penetrate deeper than the *Galileo* probe are needed there to measure the deep abundances of such important species as H_2O and H_2S . Deep probes at Saturn would extend the sampled heliocentric range to Saturn, providing important constraints on the conditions and variability of the protoplanetary disk, and would provide significant new information about Saturn and its evolutionary processes. Such a probe mission could be implemented using a derivative of the INSIDE Jupiter mission's spacecraft [1] as the Carrier/Relay Spacecraft (CRSC), with probes per JPL/Team X [2] and other design studies.

Science Objectives: The primary science goals are to understand:

1. Bulk composition & its gradients, especially as related to solar system formation & planetary evolution
2. Atmospheric chemistry
3. Atmospheric structure & dynamics
4. Spatial variability in the troposphere & deeper

These are supported by the mission's measurement objectives, in rough priority order:

1. Mixing ratios of the primary C, O, N, & S bearers, as a function of depth
2. Cloud composition, density, & particle size
3. Atmospheric temperature, pressure, & density as a function of depth
4. Bulk flow (wind) as a function of depth
5. Vertical radiant energy flux as a function of depth
6. Ortho- to para- H_2 ratio
7. Noble gas & disequilibrium species mixing ratios; isotopic ratios for selected elements

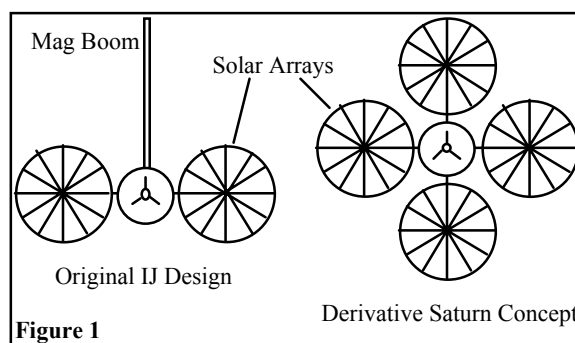
The objectives address all three major topics of the SSE Roadmap Quest, "To Explain the Formation and Evolution of the Solar System and Earth."

Payload: Candidate instruments: GCMS; net flux radiometer; nephelometer; atmospheric structure package with thermometers, pressure transducers, and accelerometers; sound speed instrument, for ortho-/para- H_2 ratios; USO for Doppler wind experiments.

Mission Design: About six months before arrival via a "standard" transfer to Saturn, the spacecraft deploys one or two ~100-kg atmospheric entry probes. If one probe is delivered, the mission design could closely resemble that of the *Galileo* orbiter and probe

at Jupiter. Deploying two probes would use a strategy similar to that of the Multiple Deep Jupiter Probes mission described in this forum [3]. In either case, Saturn orbit insertion is not necessary.

Spacecraft: Considerable mass and power savings are realized relative to the original INSIDE Jupiter spacecraft design by removing equipment specific to the Jupiter orbital mission, such as the MAG instrument boom, parts of the telecom subsystem, and notably the large (>500 kg) primary propulsion module, whose main function is JOI. The mass savings allow adding equipment needed for the Saturn probe(s) mission. Figure 1 illustrates some of the changes: with the mag boom gone, an additional set of two solar arrays adds to the power available and also to spin stability.



The Saturn mission benefits from avoiding Jupiter's radiation environment. The original IJ design had solar arrays sized for EOL power, significantly degraded from the BOL power by radiation. A Saturn mission suffers much less degradation, such that doubling the array area provides sufficient power to operate the spacecraft. This requires further study to verify that recent progress in LILT arrays are capable of attaining the requisite efficiency at Saturn distances.

Removing the JOI propulsion system provides multiple options for attaching and deploying probes, including options that permit attaching a SEP stage if the Earth-Saturn transfer should so require. The solar arrays produce enough power at 1 AU to operate up to three NSTAR engines. This would require adding a 3-axis-stabilized mode, which could be controlled from the SEP stage.

Data Relay. Data sent from the probes to the CRSC is stored for playback from heliocentric orbit.

References: [1] Jonaitis J. et al. (2000) *IAA Conf Low-Cost Plan Miss IV*, L-0601. [2] Oberto R. et al. (1997) JPL Team X report, *Outer Planet Probes*. [3] Spilker, T.R. et al. (2001), this forum.