

## SATURN RING OBSERVER

Thomas R. Spilker, Jet Propulsion Laboratory, California Inst. of Technology

This paper describes Saturn Ring Observer (SRO), an innovative mission concept that uses prolonged close-up observation of specific locations within Saturn's rings to obtain fundamental new information about ring dynamics and unique insight into planetary system formation.

In cooperation with NASA's Solar System Exploration Subcommittee and its working groups, JPL is studying the feasibility of planetary science missions proposed for launch at the end of the next decade. Results will focus resources on developing technology that enables a set of missions in which extraordinary scientific advances, such as the SRO mission, reward meeting severe technological challenges. The paper describes options studied and the resulting mission concept.

The overarching goal is to understand ring processes and evolution as a model for the origin of planetary systems. This involves:

- Making DIRECT observations of microphysical kinematic processes and parameters in the rings, including: particles' 3D random velocities and spin states; ring scale height,  $H$ ; coefficient of restitution in typical collisions; the clumping/sliding/shearing behavior of particle agglomerations, preferably in the A ring, as seen in numerical simulations.
- Making DIRECT observations of the physical nature and distribution of the particles -- shape, roughness scales, particle size frequency distribution in the 1 cm to 1 km radius range, including possible size segregation effects ("dredging") -- across several (preferably at least 3) diverse regions. Regions of interest include density and bending waves, a sharp satellite-shepherded edge like the B ring outer edge, and a narrow non-circular ringlet like the Huygens ring, to test density/bending wave models and shepherding theory predictions.
- Mapping the optical depth profile at high ( $\sim 10$  m) resolution across the regions in 1A above; repeat, if possible, at several co-rotating longitudes to sample the azimuthal pattern and to test models of wave production, shepherding, and ring confinement.

The primary constraint on the trans-Saturn trajectory is the ring opening angle as seen from the approaching spacecraft, which sets an arrival time window at Saturn. Saturn orbit insertion uses a single-pass ballute aerocapture followed by direct insertion above the Huygen's gap at apoapsis. The innovative mission concept calls for placing the spacecraft in a ring-particle-like orbit with a very small inclination, then using four small plane-change maneuvers per orbit to "hover"  $3 \pm 0.5$  km above the ring plane. One month of science operations follow insertion. After the initial positioning, the propellant budget allows four changes in radial position totaling 10,000 km.

Key spacecraft design features include use of SEP, X2000 3rd delivery technology for the spacecraft bus, an aerocapture ballute estimated at 25% of the entry mass, and an advanced radioisotope power source (ARPS). The total launch mass is consistent with the capability of an Atlas 5 or Delta 4 class launch vehicle. Critical technologies for this concept include:

- Aerocapture using either a ballute (assumed here) or an advanced entry system (lifting body).
- SEP performance improvements with substantial cost reductions. Solar sailing may be an important alternative.
- Continued development of ARPS capability and efficient, low-cost solar arrays for SEP stages.
- Across-the-board advances in microspacecraft technologies.

Propulsion element costs dominate cost estimates for this mission, marginally within the bounds of Outer Planets Program guidelines. This problem is not unique to this concept but does impact it more than most of the other high-priority concepts in the SSE Strategic Plan. Driving down these missions' propulsion costs is an important facet of the technology program.

This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.