Saturn Ring Observer. T. R. Spilker, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109-8099, tspilker@mail1.jpl.nasa.gov.

Introduction: Answering fundamental questions about ring particle characteristics, and individual and group behavior, appears to require close-proximity (a few km) observations. Saturn's magnificent example of a ring system offers a full range of particle sizes, densities, and behaviors for study, so it is a natural choice for such detailed investigation. Missions implementing these observations require post-approach ΔV of ~10 km/s or more, so past mission concepts called upon Nuclear Electric Propulsion [1], [2]. The concept described here (presented at the Intern'l Conf on Low-Cost Plan Missns, 2000; published in those proceedings [4]) reduces the propulsive ΔV requirement to as little as 3.5 km/s, difficult but not impossible for high-performance chemical propulsion systems.

Science Objectives: For this mission the Astrophysical Analogs CSWG provided a prioritized list of science objectives [3] grouped in three categories:

1.A (minimum mission, unique) Determine the physical nature and kinematics of ring particles and agglomerations of particles

1.B (mission enhancing, unique) Determine the mass distribution over a wide radial and azimuth range. Collect data to test models of wave production, shepherding, and ring confinement

2.A (mission enhancing, extension of Cassini) Determine the rings' electromagnetic environment, dust distribution, and neutral and ionized "atmosphere" distribution

Measurement objectives that support the 1.A science objectives include particles' physical nature (shape, roughness, etc.) and 3D random velocities and spin states, coefficients of restitution in collisions, agglomeration clumping/sliding/shearing behavior, and ring scale height. These objectives directly address many not-yet-understood phenomena in planetary ring systems, and find important applications in understanding astrophysical systems, such as protostellar and protoplanetary accretion disks, with direct bearing on the origins of our solar system and the planets within it.

Payload: The 1.A and 1.B objectives can be accomplished by narrow- and wide-angle imaging and a radar or lidar altimeter also needed for near-ring navigation and maneuvering. The 2.A objectives require additional instruments, such as a mass spectrometer, a dust detector, and electric and magnetic fields sensors.

Mission Design: Figure 1 illustrates the most important aspects of the initial orbit insertion at Saturn. After arrival via a "standard" transfer to a slightly inclined hyperbolic approach to Saturn, the spacecraft aerocaptures as it crosses the ring (equatorial) plane, net ΔV ~7 km/s. Immediately after atmosphere exit, the onboard autonomous system uses a chemical propulsion stage to perform a clean-up maneuver of <0.5 km/s to cancel residuals. The captured orbit has an equatorial line of apsides, with its apoapse radius at the initial target region of the rings. As it nears apoapse, the propulsion stage performs a final, 3 km/s maneuver to place the spacecraft in the initial "hover" orbit.

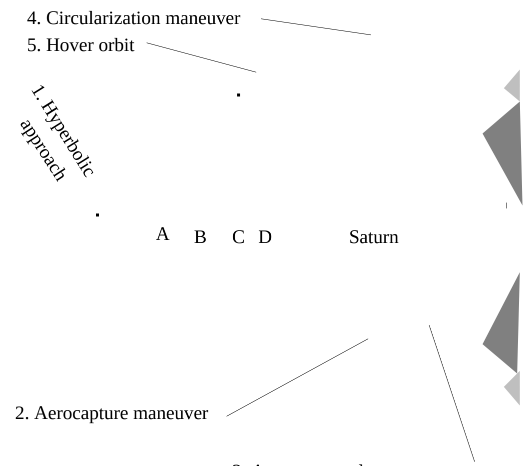

Figure 1

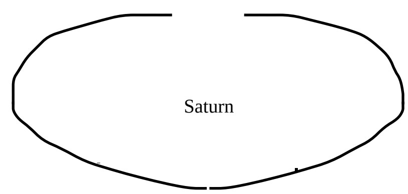

Figure 2 *Not to scale!*

From that point, small (<1 m/s) maneuvers every few hours maintain the hover orbit as shown in Figure 2, where the small open circles locate the maneuvers, and the light line on the ring plane is the hover orbit projected onto that plane. Using bipropellant thrusters with a propellant mass fraction of 10% maintains the orbit for nearly two months [4], [5]. Additional propellant permits changing the orbit radius to investigate various interesting regions of the rings.

Data Relay. The spacecraft is placed on the sunlit and Earth-facing side of the rings, allowing continuous data downlink except for brief Saturn-occulted periods.

References: [1] Wells W.C. and Price M.J. (1972) *A survey of candidate missions to explore Saturn's rings*, IIT Rsch Inst Rpt M-31. [2] Nock K.T. (1989) *Rendezvous with Saturn's rings*, JPL internal publication. [3] Porco C. et al. (1999) *Science Objectives for Saturn Ring Observer*, AACSWG communication to JPL's Team X. [4] Spilker T.R. (2000) *IAA Conf Low-Cost Plan Miss IV*, L-0604. [5] Oberto R. et al. (1999) JPL Team X report, *Saturn Ring Observer.*