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US Decadal Survey Outer Solar System Missions: Trajectory Options

T. R. Spilker (1), D. H. Atkinson (1,2), N. J. Strange (1), and D. Landau (1)

(1) Jet Propulsion Laboratory, MS 301-170S, Pasadena, United States (thomas.r.spilker@jpl.nasa.gov, 001-818-393-9815), (2) Univ. of Idaho, Moscow, ID, USA

The report of the US Planetary Science Decadal Survey (PSDS), released in draft form March 7, 2011, identifies several mission concepts involving travel to high-priority outer solar system (OSS) destinations. These include missions to Europa and Jupiter, Saturn and two of its satellites, and Uranus. Because travel to the OSS involves much larger distances and larger excursions out of the sun's gravitational potential well than inner solar system (ISS) missions, transfer trajectories for OSS missions are stronger drivers of mission schedule and resource requirements than for ISS missions. Various characteristics of each planet system, such as obliquity, radiation belts, rings, deep gravity wells, etc., carry ramifications for approach trajectories or trajectories within the systems.

The maturity of trajectory studies for each of these destinations varies significantly. Europa has been the focus of studies for well over a decade. Transfer trajectory options from Earth to Jupiter are well understood. Current studies focus on trajectories within the Jovian system that could reduce the total mission cost of a Europa orbiter mission. Three missions to the Saturn system received high priority ratings in the PSDS report: two flagship orbital missions, one to Titan and one to Enceladus, and a Saturn atmospheric entry probe mission for NASA's New Frontiers Program. The Titan Saturn System Mission (TSSM) studies of 2007-2009 advanced our understanding of trajectory options for transfers to Saturn, including solar electric propulsion (SEP) trajectories. But SEP trajectories depend more on details of spacecraft and propulsion system characteristics than chemical trajectories, and the maturity of SEP trajectory search tools has not yet caught up with chemical trajectory tools, so there is still more useful research to be done on Saturn transfers. The TSSM studies revealed much about Saturn-orbiting trajectories that yield efficient and timely delivery to Titan or Enceladus orbits. PSDS studies suggest there is significant flexibility in trajectory options for a Saturn entry probe. Many different trajectory approaches and a wide range of trajectory parameters yield probe-to-carrier data relay communications of sufficient duration and at data rates surpassing those of the 1995 Galileo probe at Jupiter. Research into trajectories to Uranus and within the Uranian system is the least mature. SEP and chemical transfer trajectories have been examined but the searches are not yet comprehensive, though the fundamentals of such transfers are fairly well understood. Study of orbital tours within the Uranian system suggests they can be analogous to such tours in the Jovian system, though in the time frame of launches within the next couple of decades arrivals at Uranus would be from high declinations, so the transition from an initial orbit to an equatorial satellite tour could be lengthy. This paper will present results from the most recent work on these trajectories.

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