Abstract - 8th AAS/AIAA Spaceflight Mechanics Conference
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Navigation Feasibility Studies for the Europa Orbiter Mission

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The proposed Europa Orbiter Mission has gained increasing importance recently because of speculations that liquid water oceans may exist below the ice surface of the Jovian moon Europa. The existence of liquid water is thought to be an integral part to the formation of life, so identifying a liquid water ocean elsewhere in the Solar System would be of great significance in the search for extraterrestrial life. The fundamental objective of the Europa Orbiter Mission is to place a spacecraft into orbit around Europa for the purpose of obtaining evidence as to the existence of such an ocean using a number of scientific instruments and precise orbit determination.

The current mission design for the Europa Orbiter calls for possible launches in 2002 or *2004.* The mission is characterized by four distinct phases: an Earth/Jupiter transfer phase (or "cruise phase"); a multisatellite tour phase in the Jupiter system (or "tour phase"); a Europa insertion phase (or "endgame phase"); and a Europa operations phase (or "orbit phase"). Each phase is subject to a different set of navigation constraints and capabilities. While some of these may have similarities to parts of other interplanetary missions past and present, the orbit phase presents unique navigation challenges. The orbit phase involves a near-circular, low-altitude (-100 km) orbit around the satellite of a huge planet with very little known about the satellite's gravity field.

In this study, preliminary navigation analyses are performed for each phase of the Europa Orbiter Mission. In order to quantify achievable navigation accuracies, orbit uncertainties are computed for varying amounts of simulated range and Doppler tracking coverage from NASA's Deep Space Network stations. The nominal tracking scenario includes Doppler data weighted at 0.5 mm/s for 60 second compression time and range data weighted at 10 meters. In addition, several cases are conducted using simulated single-station optical communication range tracking to assess its capabilities against those of traditional radiometric tracking.

Covariance analyses are performed to identify important model uncertainties and to determine sensitivity to Europa and Jupiter gravity field error. Because characteristics of the gravity field of Europa are almost entirely unknown, the gravity field model used in this analysis is a 40th degree and order normalized lunar gravity field scaled to the radius of Europa. A-priori uncertainties for most of the modeled gravity field coefficients are assumed to be 10W% of their nominal values. Coefficients under degree 3 are given smaller a-priori uncertainties, based on current Galileo Mission estimates of those coefficients from flybys of Europa.

Other navigation considerations are investigated for the orbit phase of the mission. The issue of spacecraft safety (surface impact avoidance) shortly after Europa orbit insertion is assessed by mapping radial orbit uncertainties for periods of time after insertion when it would not yet be possible to execute corrective maneuvers. This analysis is performed for a number of initial orbit altitudes. Another factor affecting orbit phase navigation is the operational orbit for the duration of the phase. Sensitivities to inclination, altitude and orbit plane orientation with respect to Earth are examined. In addition, covariance analysis results are presented summarizing the relative importance of orbit determination model error sources (including the gravity fields, GMs, orientations, and ephemerides of Europa and Jupiter) contributing to spacecraft orbit uncertainty during the orbit phase.

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