NAVIGATIONAL CHALLENGES FOR A EUROPA FLYBY MISSION

Tomas J. Martin-Mur[(1)], Rodica Ionasescu, Powtawche Valerino, Yungsun Hahn, Kevin Criddle, Ryan Park, Ralph Roncoli
Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91104, 818-393-6276, tmur@jpl.nasa.gov

Keywords: *Navigation, tour, Europa, flyby*

ABSTRACT

This paper will describe the navigation analysis that is being performed for a possible NASA mission to the Europa, one of the four Galilean moons of Jupiter. The mission being studied would perform a series of flybys of Europa in order to investigate its habitability by characterizing its ice shell and possible subsurface water, by studying its composition and chemistry, and by mapping its surface. A number of trajectory designs have been performed, utilizing gravity assists from other Galilean moons to decrease the period of the orbit and shape it in order to provide a globally distributed coverage of different regions of Europa. Navigation analyses have been performed on these trajectories to assess the total propellant that would be needed to complete the mission, and to study how accurately the flybys could be performed. The orbit determination analyses need to take into account the uncertainties in the ephemeris and other parameters that model the Jovian system, as well as other dynamic and measurement modeling uncertainties. The maneuver analyses need to model the execution errors of the orbit shaping maneuvers in order to estimate the flyby trajectory errors and the required propellant for the mission. Part of the task is an iterative process between trajectory design and navigation, in which navigation assesses new trajectory designs and proposes changes in order to make the mission less difficult to navigate. Europa has an orbital period of just 3.55 days, compared with about 15.9 days for Titan, so a Europa flyby mission could be more challenging than the Cassini mission because it could have a much more compressed operational timeline. Every flyby of a sizeable moon amplifies the trajectory errors that were present before the flyby. A number of maneuvers, typically three, are scheduled between each two consecutive flybys. The first maneuver after a flyby is called the cleanup maneuver, as it is typically used to remove the perturbation introduced by the previous flyby due to trajectory and moon modeling errors, but it could have a deterministic component; the second maneuver is called the targeting maneuver as it removes trajectory and maneuver execution errors to target for the next flyby; the third maneuver is called the approach maneuver, a final opportunity to refine the trajectory prior to the flyby. Not all of these maneuvers would have a deterministic component, but all of them have to be designed using data after the previous flyby or maneuver, in order to target the next flyby. Certain trajectory shaping strategies, such as pi-transfers or a flyby of one moon closely followed by a gravity assist by another moon, could be very challenging from the point of view of operations, since they would consist of a close succession of flybys, orbit determinations, and maneuvers. Failure in performing all the required tasks could require a whole redesign of the tour, or even mean the end of mission if the spacecraft would impact a flyby target. Analyses need to be performed, among other things, to assess how much tracking would be needed for the tour, since the spacecraft could be power limited and may not be able to transmit continuously.