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EUROPA CLIPPER MISSION ANALYSIS: INTERPLANETARY TRAJECTORY DESIGN

Abstract

Europa is one of the most scientifically interesting targets of the solar system, as it may possess what are thought to be the three necessary ingredients for life: an extensive ocean of liquid water, an energy source, and a suite of biogenic elements. To explore the habitability of Europa, NASA is developing the Europa Clipper mission to be launched in October 2024. Europa resides deep inside the gravity well of Jupiter, where the highly radiative environment is detrimental to spacecraft electronics. Europa Clipper will utilize a high number of Europa flybys, connected by resonant and non-resonant transfers to build up global surface coverage. Science data is collected during high-radiation Europa flybys, and returned to Earth during the rest of the highly elliptical Jovian orbits, at a much lower radiation dose exposure.

Europa Clipper will get to the Jupiter system utilizing a Mars-Earth Gravity Assist (MEGA) interplanetary trajectory, with the opening day of a 21-day launch period on October 10, 2024. Once at Jupiter, Europa Clipper will embark on a complex sequence of flybys designed to meet the 300 requirements levied on mission design.

This paper presents the mission analysis work for the development of the reference interplanetary trajectory, the launch period computation and selection, and backup trajectory options. The 2024 Mars-Earth gravity assist interplanetary trajectory (MEGA) was designed following NASA's selection of the SpaceX Falcon Heavy as Europa Clipper's launch vehicle. Mars gravity assist in early 2025 is used to leverage the v-infinity relative to the Earth, so that the Earth flyby in late 2026 can be used to direct the spacecraft to Jupiter orbit. Because of Mars planetary protection and Earth impact requirements, the planetary flyby aimpoints are biased and deterministic maneuvers are included and optimized in the trajectory. Also, a JOI-Demo maneuver is optimized in the transfer to exercise the flight system in preparation for the large Jupiter Orbit Insertion maneuver in April 2030. While the cruise phase ends at Jupiter approach, the interplanetary trajectory is optimized up to the third Ganymede flyby in the tour, which is fixed for all days of the launch period. Finally the paper will present back-up options for launch in 2025 and 2026, together with the launch periods for both the nominal and back-up options.