Paper ID: 79467
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (2) (7)

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OPTIMIZING LAUNCH WINDOW OPPORTUNITIES FOR ESA'S COMET INTERCEPTOR MISSION USING PRIME VECTOR THEORY

Abstract

Comet Interceptor (Comet-I) was selected in June 2019 as the first ESA F-Class mission and aims to explore a pristine comet, which will visit the inner Solar System for the first time. Comet-I will hitch a ride to a Sun-Earth L2 quasi-halo orbit, as a co-passenger in ESA's M4 ARIEL's launch, in 2029. It will then remain there awaiting the right departure conditions to leave definitively and intercept a newly discovered comet. Comet-I will be the first mission to be designed and launched without an already identified target, a key aspect of its trajectory design.

Preliminary studies of transfer trajectories have been conducted in the past, however, the all-important launch window element has yet to be considered. A novelty exploration of the launch windows is presented, which relies not only on the optimal delta-V (the mission's driving requirement) but also on the launch options that satisfy Comet-I's current boundary conditions and flyby constraints. A trajectory optimization process was designed for Comet-I that uses a multiple revolution and multiple deep space manoeuvre (DSM) strategy based on Prime Vector Theory. A revision of the analysis of accessible intercept regions is made, which previously only explored the use of a single DSM. Trustworthy observations for astrometry and activity confirmation are essential to ensure that the target is suitable. As such, a late departure from the L2 point, while still meeting all requirements, is preferred to allow for more accurate measurements. Likewise, an assessment is conducted on the expected latest possible time for a DSM for near intercept trajectory correction, to increase the chances of mission success. The encounter conditions are contemplated, such as the geometry of the flyby, the sensitivity of the encounter solar phase angle and the possibility of solar conjunction, which would render data transmission impossible. The flexibility and trade-offs resulting from the n-DSM approach are analyzed throughout. The analysis is based on both historic and synthetic long-period comet populations and has been refined with the 11 discovered comets since 2020, time at which Comet-I Target Identification team began analyzing new comet discoveries. Finally, this refinement is also used for a re-examination of the likelihood of mission success.