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# ESA F-CLASS COMET-I: TRAJECTORY DESIGN TO INTERCEPT A YET-TO-BE-DISCOVERED COMET

**Abstract**

While the scientific return of past comet missions is unquestioned, all previously visited comets had approached the Sun on many occasions and, consequently, have also undergone substantial compositional and morphological modifications. ESA's recently selected Comet Interceptor (Comet-I) aims to intercept and explore an undiscovered *Long Period Comet* (LPC), which ideally would be visiting the inner Solar System for the first time; i.e. a *Dynamically New Comet* (DNC).

Comet-I current baseline involves three spacecraft elements working together to ensure a low-risk bountiful scientific return through unprecedented multipoint measurements. A main spacecraft (S/C A) would make remote observations of the target from afar, to protect it from the dust environment and act as the primary communications hub for all other mission elements. Two smaller daughtercraft (JAXA's S/C B1 and ESA's S/C B2) would venture much closer to the target, carrying instruments to complement and enhance the scientific return.

A key aspect of Comet-I is the need to be designed without an identified target, or rather Comet-I must be designed to intercept a yet-to-be-discovered comet. Hence, a sufficiently large number of comet interception trajectories must be optimised and studied, in order to inform the spacecraft design with a statistical underpinning. The present paper will analyse trajectories to two different population of comets; a set of 45 historical hyperbolic comets and a synthetic LPC population of 1700 objects with q<2 au, as provided by Boe et al.

Comet-I will be deployed in a Sun-Earth L2 quasi-halo orbit in 2028+, as a co-passenger of ESA's M4 ARIEL Mission. Once deployed, it will remain up to 3 years near the L2 point and depart towards a targeted comet once suitable conditions are available. The paper will discuss the statistical probability that a suitable LPC target will be found by analysing the results of a large set of three-manoeuvre intercept-transfer optimisation in patched-conics dynamics. The statistical results show that the probability to have an opportunity to intercept such a comet is good even with modest $\Delta$v capabilities of around 1 km/s. However, it is important to benefit from the unstable dynamics near the L2 point in order to achieve the highest effective C3 at Earth's SOI departure. The leverage available through Moon swing-by departure

conditions is also analysed in patched CR3BP. Finally, low thrust intercept trajectories are computed and the benefits of extra $\Delta$v capability at the expense of longer thrusting arcs is discussed.