National Aeronautics and Space Administration

Tool for the Study of InterStellar Object Rendezvous Missions with Hybrid Propulsion Systems

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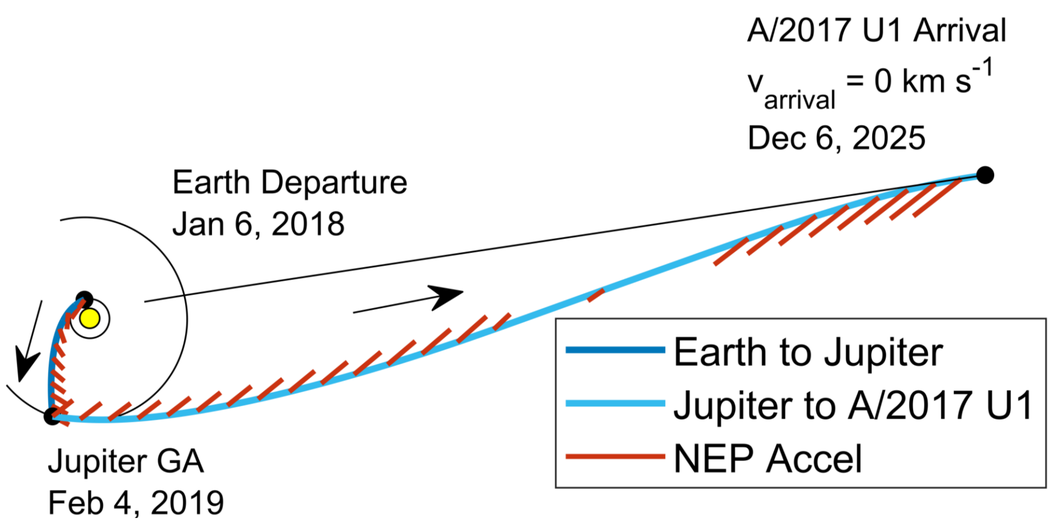
Program: FY22 SURP
Strategic Focus Area: GNC and Mission Design

Objectives: Develop a trajectory optimizer that designs rendezvous missions to interstellar object (ISO) populations.

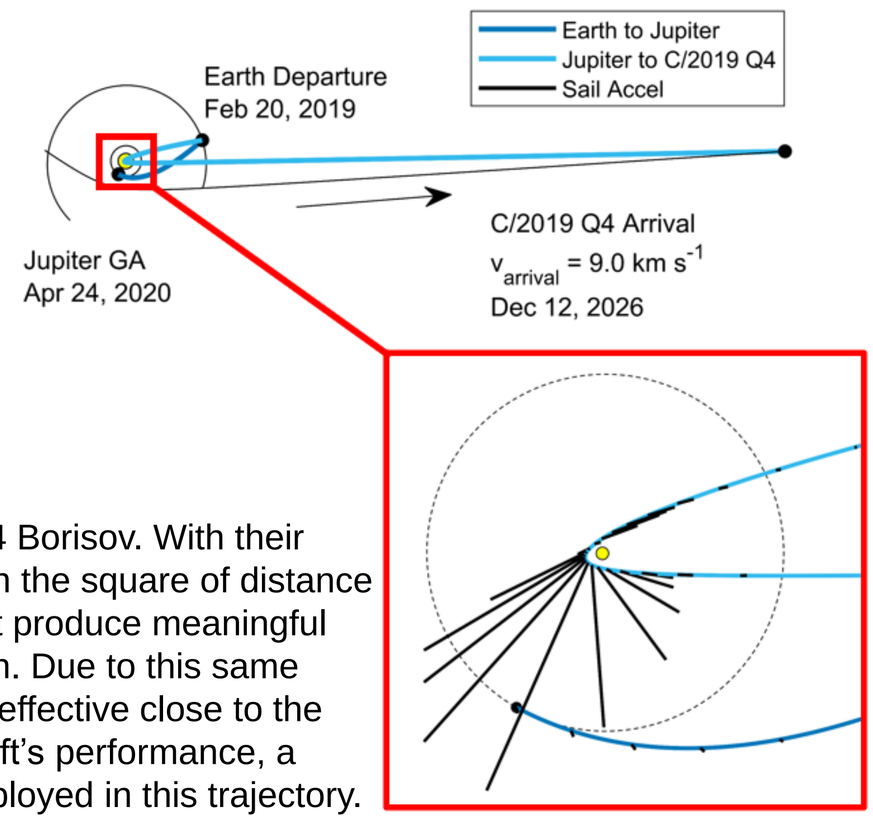
Background: ISOs offer unique insight to the nature of extrasolar objects, but rendezvous is difficult to achieve.

Approach and Results: The new trajectory optimizer employs hybrid propulsion, which combines solar sail with either chemical or electric propulsion. Such systems expand the trade space between flight time and payload mass fraction.

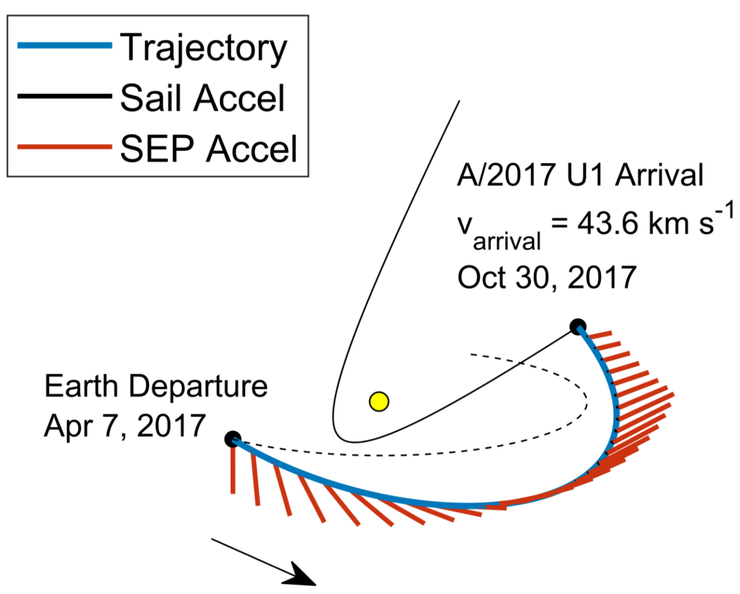
Significance/Benefits to JPL and NASA: With the expected discovery of many new ISOs in the coming years, new propulsion systems and trajectory designs provide unprecedented opportunity to explore this new class of target.



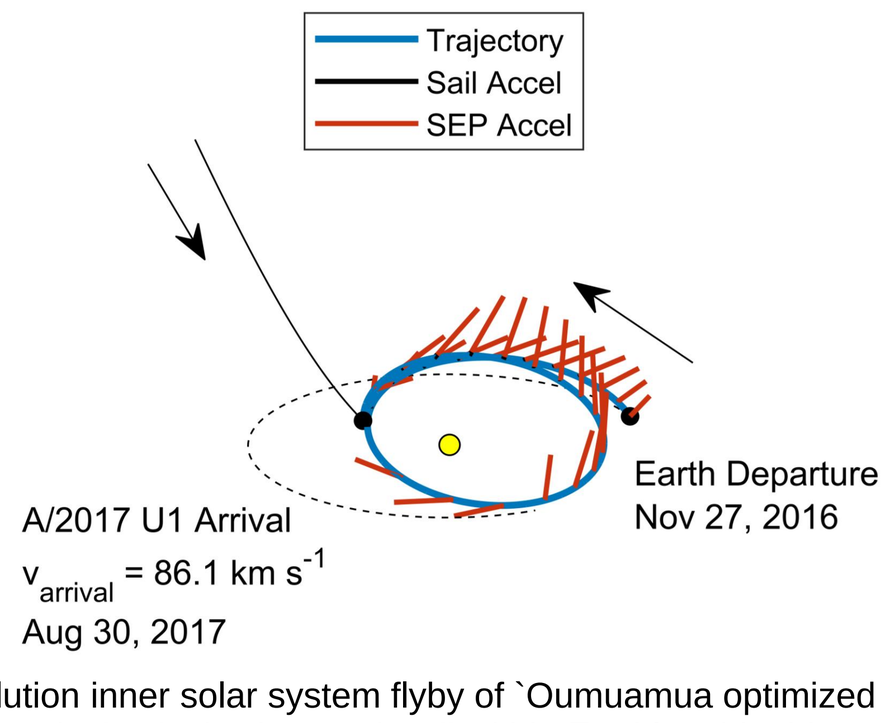
NEP-only Rendezvous of A/2017 U1 `Oumuamua. By separating power generation from the Sun, the use of nuclear power permits the electric thruster to operate throughout the entire flight. Rendezvous occurs here at the maximum permitted distance of 50 au.



Sail-only Flyby of C/2019 Q4 Borisov. With their performance decreasing with the square of distance to the Sun, solar sails do not produce meaningful acceleration far from the Sun. Due to this same relationship, they are highly effective close to the sun. To maximize the sailcraft's performance, a close pass of the Sun is employed in this trajectory.



Inner solar system HLTP flyby of `Oumuamua optimized for minimum arrival velocity. Due to the object's retrograde orbit, it is not possible to orient the trajectory with the target's velocity vector. To minimize the arrival velocity, it is therefore necessary to approach the ISO at a perpendicular angle to its trajectory.



A multi-revolution inner solar system flyby of `Oumuamua optimized for minimum arrival velocity. Located well within Earth's orbit, this should provide a very active target. Note that the SEP system provides an order of magnitude greater acceleration than the sail, thus making the sail's acceleration vectors difficult to see.

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