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Investigating Trojan Asteroids at the L4/L5 Sun-Earth Lagrange Points

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Investigations of Earth's Trojan asteroids will have benefits for science, exploration, and resource utilization. By sending a small spacecraft to the Sun-Earth L4 or L5 Lagrange points to investigate near-Earth objects, Earth's Trojan population can be better understood. This could lead to future missions for larger precursor spacecraft as well as human missions. The presence of objects in the Sun-Earth L4 and L5 Lagrange points has long been suspected, and in 2010 NASA's Wide-field Infrared Survey Explorer (WISE) detected a 300 m object [1].

By exploring a wide field area, a small spacecraft equipped with an IR camera could hunt for Trojan asteroids and other Earth co-orbiting objects at the L4 or L5 Lagrange points in the near-term. By surveying the region, a zeroth-order approximation of the number of objects could be obtained with some rough constraints on their diameters, which may lead to the identification of potential candidates for further study. This would serve as a precursor for additional future robotic and human exploration targets. Depending on the inclination of these potential objects, they could be used as proving areas for future missions in the sense that the delta-V's to get to these targets are relatively low as compared to other rendezvous missions. They can serve as platforms for extended operations in deep space while interacting with a natural object in microgravity. Theoretically, such low inclination Earth Trojan asteroids exist [2].

Earth co-orbiting objects such as Trojan asteroids could make ideal candidates for near-term low velocity fly-bys and rendezvous missions. Currently, the only known Earth Trojan asteroid, 2010 TK7, has such a large inclination (20.9°) that the delta-V required (9.4 km/s) would make it challenging to visit [1]. However, the absolute magnitude, diameter, and assumed albedo of 2010 TK7 indicate that it is comparatively large among near-Earth asteroids [1]. It is very possible that more Earth co-orbiting objects exist in the L4 or L5 Lagrange points.

A Mission to L4: A small 6U CubeSat could be launched as a secondary payload on a rideshare program. The mission concept assumes the launch providers can perform an escape burn with their upper stage after deployment of their primary payload. The spacecraft would have an IR wide field-of-view camera and a small micro-ion propulsion system capable of about 200 m/s delta-V for course correction or further maneuvering. Assuming the launch vehicle provides the escape velocity, the small spacecraft could get to Sun-Earth L4 (or L5 on another launch) from either a low inclination launch (e.g. Eastern Test Range) or a polar launch (e.g. Vandenburg). The IR camera would look for trapped asteroids that may be too small or too dark to detect from Earth surface observation. A small high gain deployable antenna system would then be used to transmit images and data.

It is feasible that low inclination Earth co-orbiting objects reside at the Sun-Earth L4 and L5 points. Numerical and dynamical models suggest it is likely. Searching for the objects from the ground is not realistic, and space telescopes will only discover objects under the right lighting, object albedo, and object size conditions. To investigate Earth Trojan asteroids, a near-term, inexpensive spacecraft needs to visit and survey the L4 and L5 regions. In-situ characterization of Earth Trojans could yield immediate benefits in science, exploration, and resource utilization.