**MISSION DESIGN AND TRAJECTORY OPTIMIZATION FOR ELECTRIC PROPULSION UPPER STAGES**

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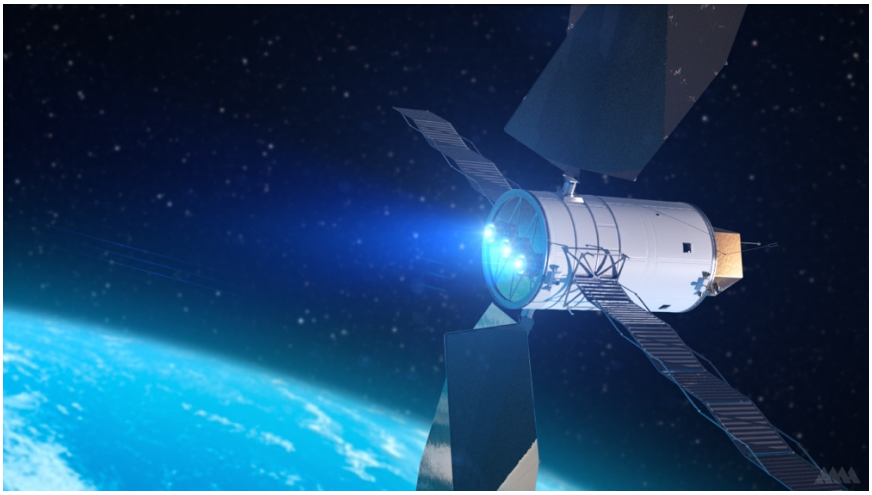

*Figure 1. Artist's concept of a solar-electric propulsion stage, image credit: NASA.*

Advances in electric and multimode propulsion systems may enable a new class of upper stages that reduce launch cost through improved propulsive efficiency. Current launch systems are based entirely on high-thrust chemical rockets. While high-thrust systems are required for the early stages of launch, they are inefficient relative to electric propulsion technologies. Switching to a high-efficiency, electric propulsion system as soon as possible may provide significant increases in delivered mass or reductions in cost at the expense of increased time of flight.

This project will evaluate the feasibility, costs, and benefits of using high-efficiency electric propulsion and/or multi-mode propulsion for launch vehicle upper stages to deliver payloads to a variety of destinations of interest to the space systems community, including lunar orbit, Earth-moon and Earth-Sun Lagrange points, and Earth-escape trajectories. Of particular interest are:

1. evaluation of a new launch system, designed from the “ground up” to utilize electric propulsion.
2. determination of how much additional payload current and planned launch systems (e.g. SLS) can deliver to a notional deep-space gateway in cis-lunar space with an electric propulsion upper stage.
3. identification of areas for technology investment that may improve performance of an electric propulsion upper stage.

These areas will be investigated using numerical simulation of the equations of motion, optimization, and a review of literature to identify current state-of-the-art technology performance.

Applicants should have scientific/technical programming experience (Matlab or Python preferred); be comfortable with numerical methods for integrating the equations of motion, root-finding, and optimization; and possess some knowledge of orbital mechanics. Knowledge of launch vehicles, electric propulsion systems, or optimal control is also desirable. Depending on results, this project may lead to a technical conference paper and/or a longer-term research position.