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TRAJECTORY DESIGN OF THE LUCY MISSION TO EXPLORE THE DIVERSITY OF THE JUPITER TROJANS

Abstract

Lucy, NASA's next Discovery-class mission, will explore the diversity of the Jupiter Trojan asteroids. The Jupiter Trojans are thought to be remnants of the early solar system that were scattered inward when the gas giants migrated to their current positions as described in the Nice model. There are two stable subpopulations, or "swarms," captured at the Sun-Jupiter L4 and L5 regions. These objects are the most accessible samples of what the outer solar system may have originally looked like. Lucy will launch in 2021 and will visit five Trojans, including one binary system.

The Lucy trajectory was designed to maximize the diversity, in both spectral class and size, of Trojans visited while also maximizing dry mass margin. This paper will discuss the target selection process, including a description of "alternate Lucys" that were ultimately passed over in favor of the final design.

We will also discuss both the mathematics and the workflow of the trajectory optimization process, which was designed to be fast, automated, and adaptable. The Lucy trajectory is first optimized via a two-point shooting direct transcription with two-body physics and patched-conic flybys in NASA Goddard Space Flight Center's Evolutionary Mission Trajectory Generator (EMTG) software. The solution is then automatically re-optimized using n-body gravity, solar radiation pressure, and detailed flybys that include non-spherical gravity in EMTG's higher-fidelity mode. A stochastic global search algorithm built into both the lower- and higher-fidelity EMTG modes helps alleviate the need to provide accurate initial guesses to the optimizer and allows for significant automated exploration of the search space. The solution

produced by EMTG is then used as an accurate starting point for re-targeting in a flight-fidelity tool – either KinetX's MIRAGE, Goddard's General Mission Analysis Toolkit (GMAT), or Analytical Graphics' Systems Toolkit. The use of multiple tools in this manner has proven to facilitate rapid and reliable re-optimization as mission requirements have evolved.