Wind Rider Pathfinder Mission to Trappist-1 Solar Gravitational Lens Focal Region in 8 Years

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Abstract

A key benefit to the scientific community of a pathfinder to 542 AU is calibration data for an array of instruments on a flagship probe to interstellar space. There are fundamental processes and parameters of the near interstellar medium, whose estimated range of values could be greatly narrowed by in-situ sampling from a fast and small mission. By selecting an angle relative to the sun, plane of the ecliptic and a scientifically interesting target (such as Trappist-1), it is possible to perform initial optical measurements from the Solar Gravitational Lens (SGL) focal region on the same pathfinder. Doing so provides a basic set of data for larger follow-on missions to observe that (and other) solar systems in greater detail. By combining the datasets from 2 solar cycles (22 years) of space weather monitoring satellites, Voyager 1 and other deep space probes, the Practical Interplanetary Propulsion (PIP) Study constructed a radial profile for the solar wind ranging from 1 AU through the foreshock at 83 AU, to a notional heliopause at 123 AU, and the near interstellar medium out to 1,800 AU. The resulting matrix of plasma parameters was applied to a trajectory model "seed code," to test flight paths for future probes. This paper presents an example pathfinder, consisting of a cubesat bus equipped with a Wind Rider propulsion system and radioisotope power system (RPS). A brief description of those subsystems and how they interact with the solar wind or interstellar medium is included. Trajectory simulation results estimate the trip time from 1 to 542 AU near the plane of the ecliptic takes 6.9 years. Adding a compact imaging instrument enables the probe to sample data from the vantage point of the Trappist-1 SGL, as well as PickUp Ions (PUI) for a 1 year science campaign. Total pathfinder mission time after launch is less than 8 years. A set of policy-making recommendations for enabling such small precursor-type missions is provided in the conclusions, as well as ways to extend the mission to communicate from 1,000 AU to 1,800 AU. Alternatively, a method to gradually decelerate to a near stop at the end of the mission, using the Wind Rider to drag against the interstellar plasma, is also included.

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Fig. 3 Solar Wind Speed vs Distance

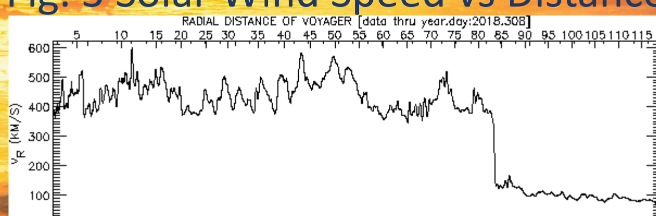
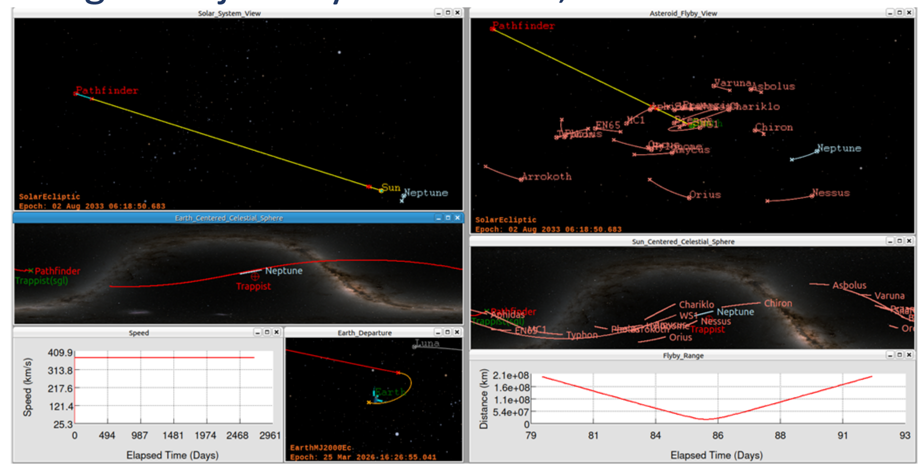


Fig. 1 Trajectory Simulation, Centaurs to SGL



Trajectory Design:

The trajectory to the Trappist-1 Solar Gravity Lens (SGL) was initially modeled in an internal seed code and then designed in Thinking Systems' Astrodynamics Workbench, as shown in Figure 1. The 6.9 year trajectory to the SGL, along with its projection on the celestial sphere, is shown on the left. Pathfinder reaches its 390 km/s cruising speed quickly. Once the trajectory model was complete, the PIP Group searched for targets of opportunity along its path. The right side of Figure 1 shows a collection of Trans-Neptunian Objects (along with Centaur asteroids) considered for flyby opportunities along the trajectory, and includes a modeled close approach to fly-by one of those objects.

Fig. 2 Photon-Conversion Radioisotope Battery