

# LUCY

## SURVEYING THE DIVERSITY OF TROJAN ASTEROIDS:

*the Fossils of  
Planet Formation*



IN RESPONSE TO:

NASA AO NNH14ZDA0140

PRINCIPAL INVESTIGATOR:

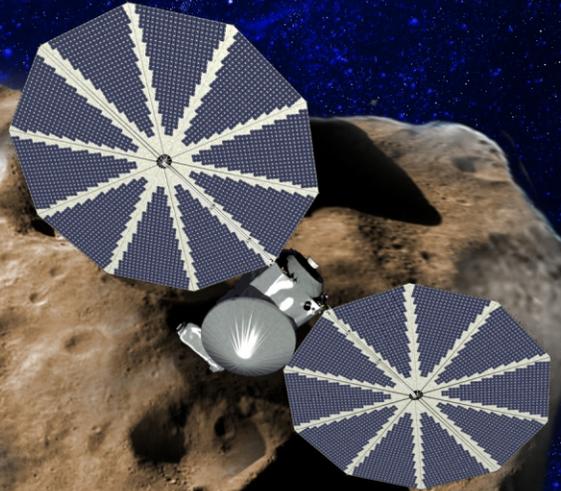
*Harold F. Levison*

HAROLD F. LEVISON, PH.D.

AUTHORIZING OFFICER:

*Ron Kalmbach*

MR. RON KALMBACH



Southwest Research Institute®



Goddard  
SPACE FLIGHT CENTER

LOCKHEED MARTIN



JOHNS HOPKINS  
APPLIED PHYSICS LABORATORY



# LUCY SURVEYING THE DIVERSITY OF TROJAN ASTEROIDS: *the Fossils of Planet Formation*

## MISSION OVERVIEW

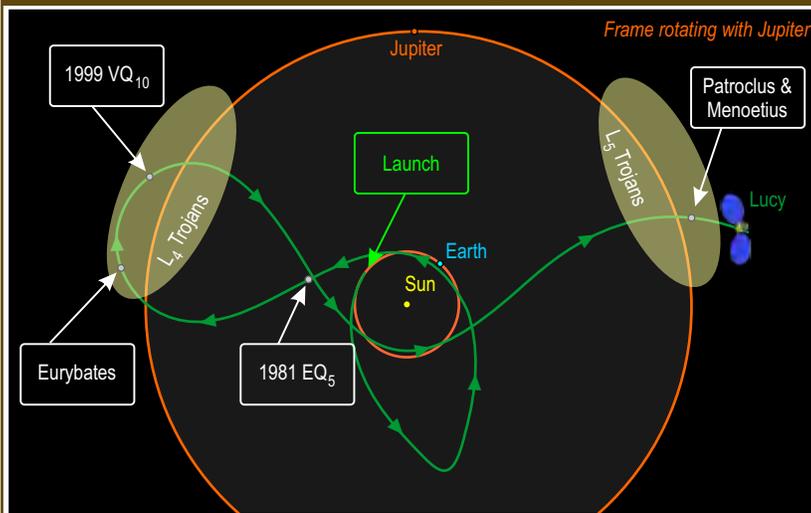
Lucy is the first reconnaissance of the Jupiter Trojan asteroids - objects that hold vital clues to deciphering the history of the Solar System. Due to an unusual and fortuitous orbital configuration, Lucy will perform an exhaustive landmark investigation that visits four of these primitive asteroids, covering both the L<sub>4</sub> and L<sub>5</sub> swarms, all the known taxonomic types, and a nearly equal mass binary. It will use a suite of high-heritage remote sensing instruments to map the geology, surface color and composition, thermal and other physical properties of our targets at close range - all this within constraints of the Discovery Program. Thus, Lucy, like the human fossil for which it is named, will revolutionize the understanding of our origins.

## High Impact Science

Through its unique tour, Lucy will provide crucial input to four of the ten Priority Questions for Planetary Science as expressed by DS13:

- What were the initial stages, conditions and processes of Solar System formation ...?
- How did the giant planets ... accrete, and is there evidence that they migrated to new orbital positions?
- What governed the accretion ..., and what roles did bombardment by large projectiles play?
- What were the sources of primordial organic matter?

## BASELINE MISSION TRAJECTORY

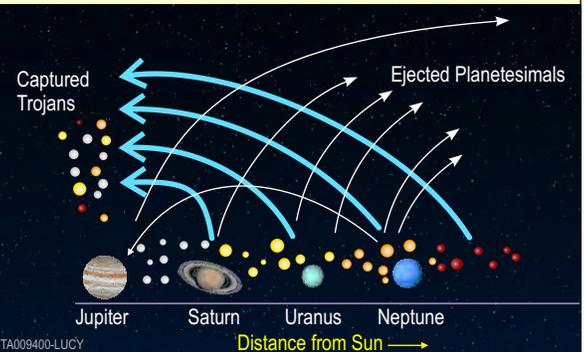


Launch: October 2021  
 Flyby 1 - 1981 EQ<sub>5</sub> C-Type Main-Belt: April 2025  
 Flyby 2 - Eurybates C-Type Trojan: August 2027  
 Flyby 3 - 1999 VQ<sub>10</sub> D-Type Trojan: October 2028  
 Flyby 4 - Patroclus & Menoetius P-Type Trojan Binary: March 2032

## LUCY'S COMPREHENSIVE TOUR

Lucy will study:

- All Trojan Classes: C-, D-, and P-types.
- Both the L<sub>4</sub> and L<sub>5</sub> swarms.



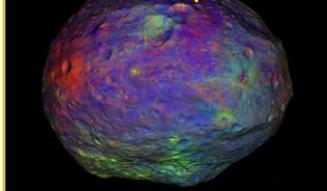
Trojans likely harbor objects that formed throughout the outer Solar System. **It is only by sampling their complete diversity that their true scientific potential can be realized.**

## IMPORTANCE TO NASA OBJECTIVES - DECADAL SURVEY RECOMMENDATION

"Study of these objects [Trojans] is important because they may contain key information about the parent materials that accreted in the inner Solar System. *An important science goal for this decade is to begin the scientific exploration of the trojan asteroids.*" - Planetary Decadal Survey 2013 (DS13)

## SCIENCE OBJECTIVES

### Surface Composition



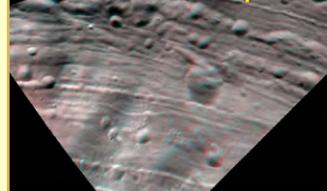
Lucy will map the color, composition and regolith properties of the surface and determine the distribution of minerals, ices and organics species.

### Surface Geology



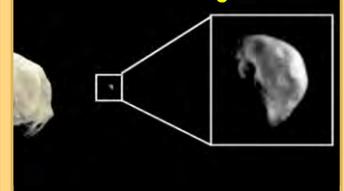
Lucy will map albedo, shape, crater spatial and size-frequency distributions, determine the nature of crustal structure and layering, and determine the relative ages of surface units.

### Interior and Bulk Properties

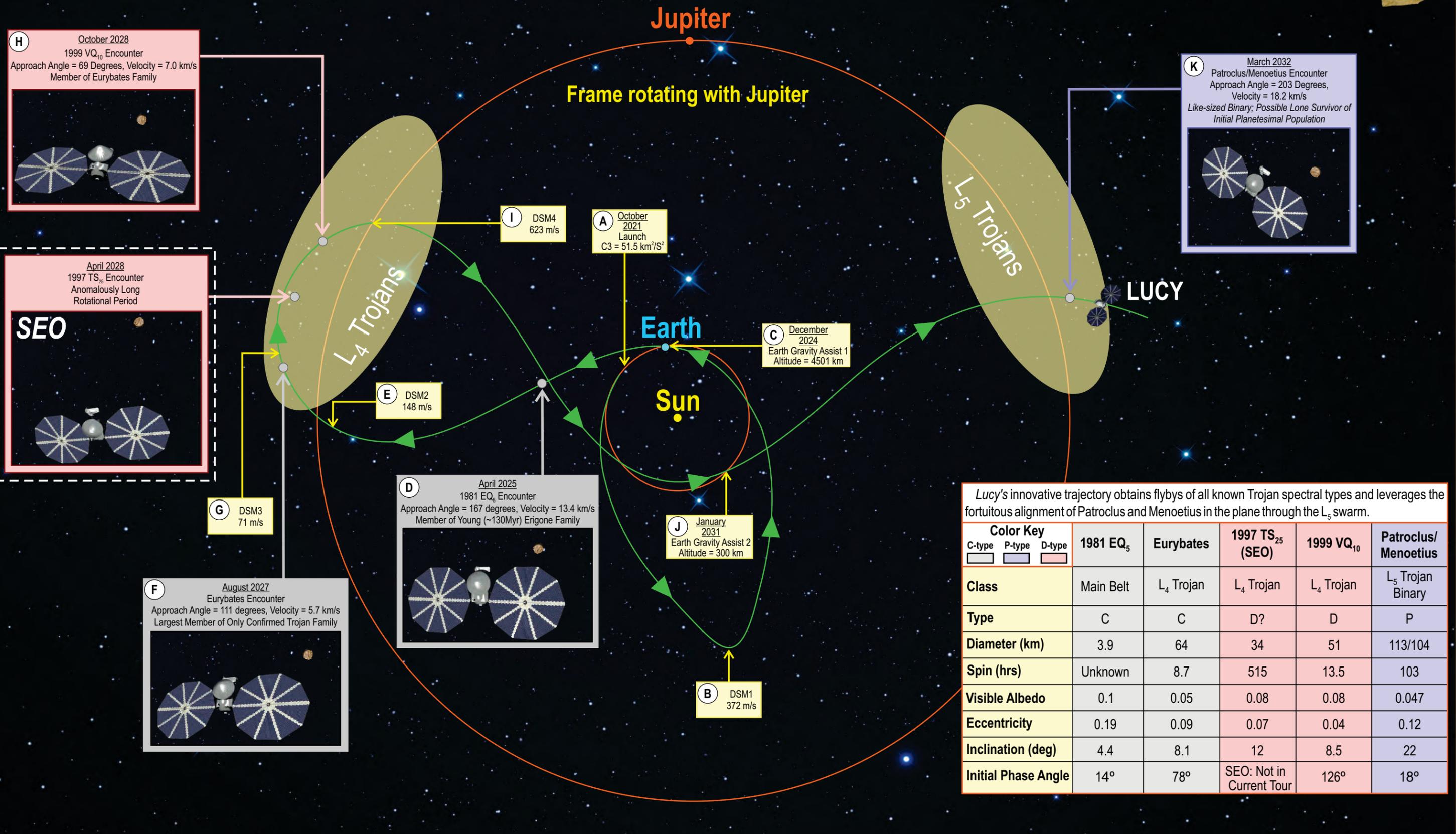


Lucy will determine the masses and densities, and study sub-surface composition via crater windows, fractures, ejecta blankets, and exposed bedding.

### Satellite and Ring Search



Lucy will determine the number, size-frequency distribution and location of km-scale satellites and dense rings.



Lucy's innovative trajectory obtains flybys of all known Trojan spectral types and leverages the fortuitous alignment of Patroclus and Menoetius in the plane through the L<sub>5</sub> swarm.

| Color Key                  | 1981 EQ <sub>5</sub> | Eurybates             | 1997 TS <sub>25</sub> (SEO) | 1999 VQ <sub>10</sub> | Patroclus/Menoetius          |
|----------------------------|----------------------|-----------------------|-----------------------------|-----------------------|------------------------------|
|                            |                      |                       |                             |                       |                              |
| <b>Class</b>               | Main Belt            | L <sub>4</sub> Trojan | L <sub>4</sub> Trojan       | L <sub>4</sub> Trojan | L <sub>5</sub> Trojan Binary |
| <b>Type</b>                | C                    | C                     | D?                          | D                     | P                            |
| <b>Diameter (km)</b>       | 3.9                  | 64                    | 34                          | 51                    | 113/104                      |
| <b>Spin (hrs)</b>          | Unknown              | 8.7                   | 515                         | 13.5                  | 103                          |
| <b>Visible Albedo</b>      | 0.1                  | 0.05                  | 0.08                        | 0.08                  | 0.047                        |
| <b>Eccentricity</b>        | 0.19                 | 0.09                  | 0.07                        | 0.04                  | 0.12                         |
| <b>Inclination (deg)</b>   | 4.4                  | 8.1                   | 12                          | 8.5                   | 22                           |
| <b>Initial Phase Angle</b> | 14°                  | 78°                   | SEO: Not in Current Tour    | 126°                  | 18°                          |