

LUCY



Surveying
the Diversity
of Trojans



Lucy Mission and Trojan Asteroid Planetary Protection Measures

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Southwest Research Institute*



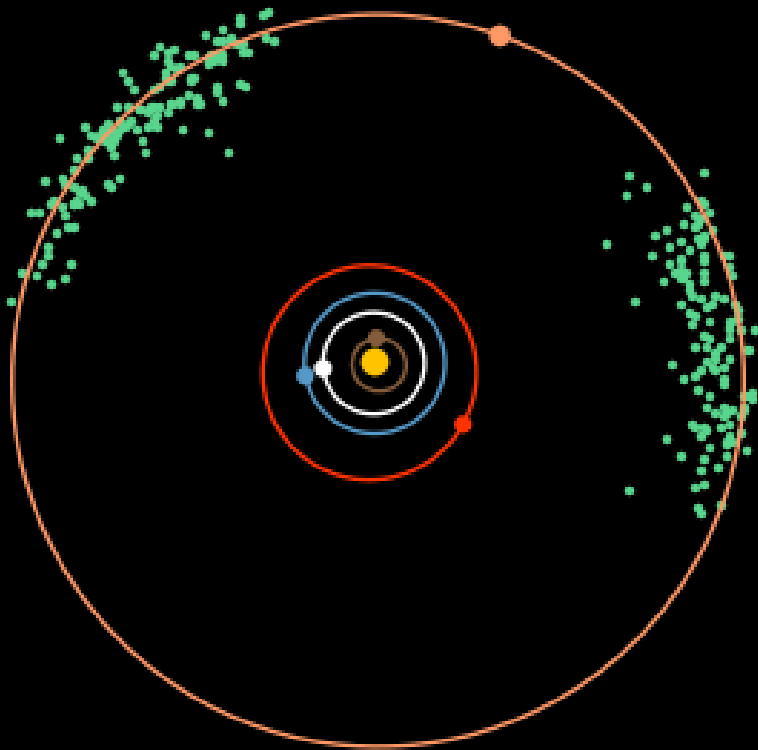
Goddard
SPACE FLIGHT CENTER

LOCKHEED MARTIN

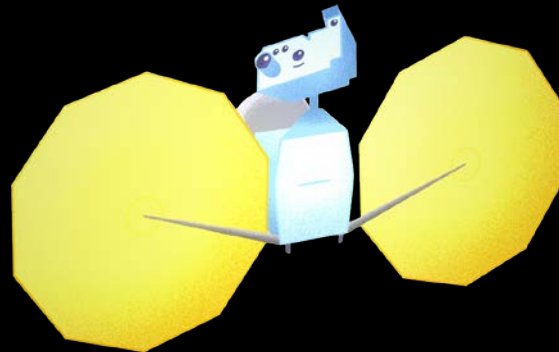




Lucy is a Trojan tour

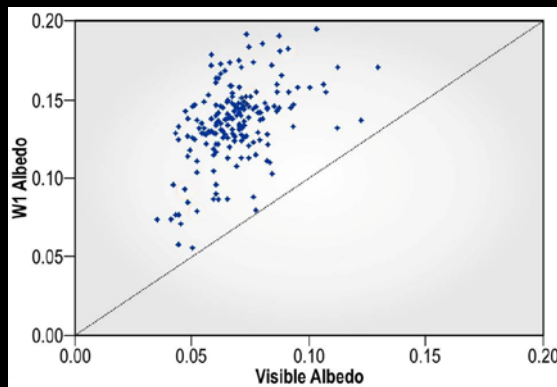


- Main Belt Asteroid rehearsal in 2025
- 5 Trojan encounters from 2027-2033
 - Total of 7 Trojans
- Visiting the most asteroids of any mission

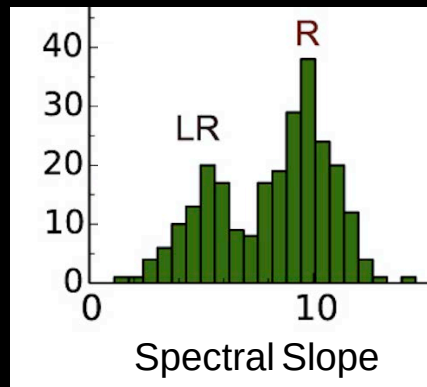


Lucy Our current knowledge of the Trojan asteroids is limited

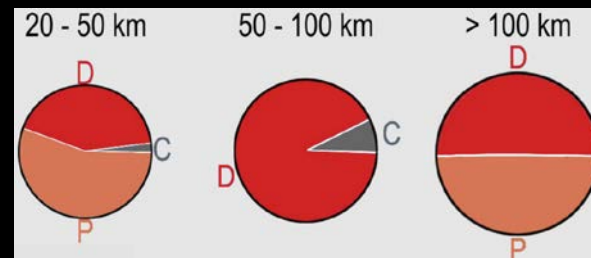
- We don't have high spatial resolution imaging or spectra
 - We have never seen one close up
- We have orbital elements and global information such as size, color, albedo and spectra.



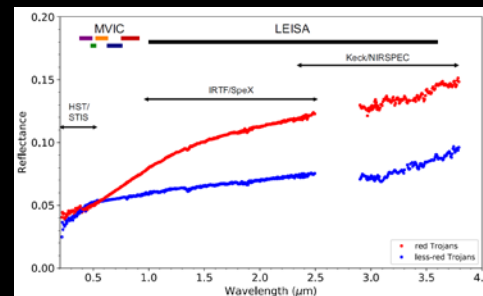
Visible albedos from ~4 - ~15%
Grav et al. 2012



Wong et al. 2015

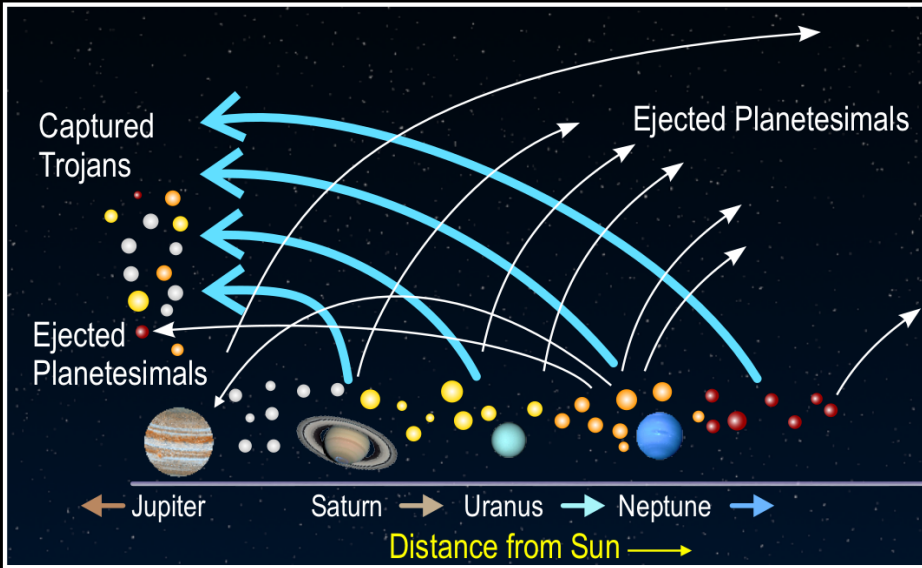


DeMeo et al. 2009, DeMeo et al. 2013



Levison et al. 2021





Objects from the same source populations could have delivered organics and volatiles to the Earth.

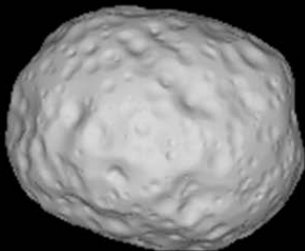
This diversity is the result of the accretion and dynamical evolution of the outer planets. Thus, Trojans present us with a **UNIQUE** opportunity to constrain planet formation and evolution models. **It is only by examining their diversity that their true scientific potential can be realized.**



L₄:

Eurybates + Queta

Gray
Aug. 2027



Polymele

Red
Sept. 2027



Leucus

Very Red
Apr. 2028



Orus

Very Red
Nov. 2028

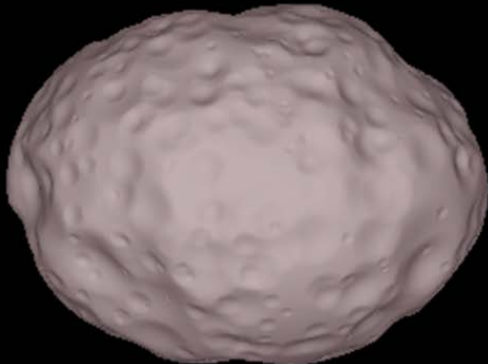


Only 15 months!

L₅:

Patroclus

Binary & Red



Menoetius

Binary & Red

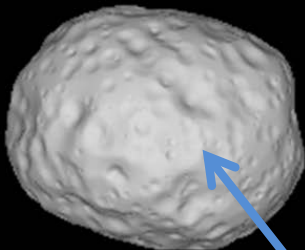


Mar. 2033



Eurybates + Queta

Gray
Aug. 2027



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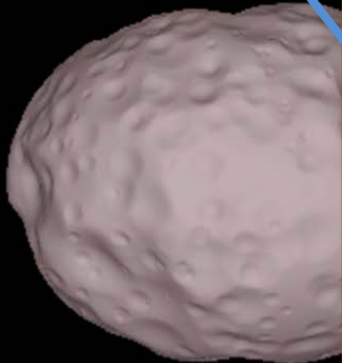
Very Red
Nov. 2028

(3548) Eurybates is the largest remnant of the only disruptive collisional family in the Trojans.

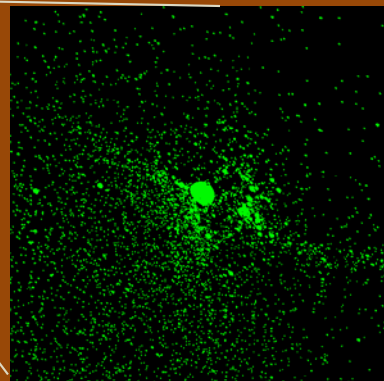
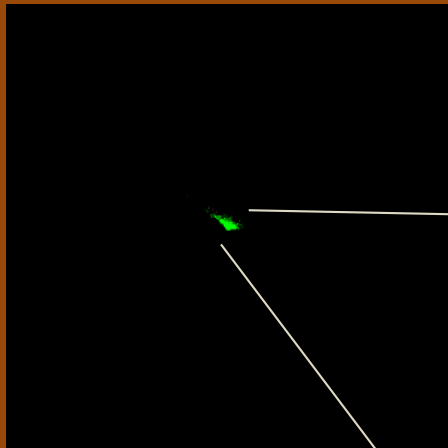
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Patroclus

Binary & Re



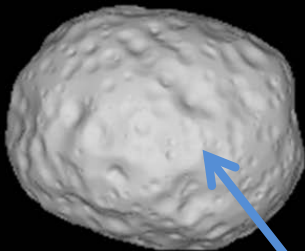
L₅:





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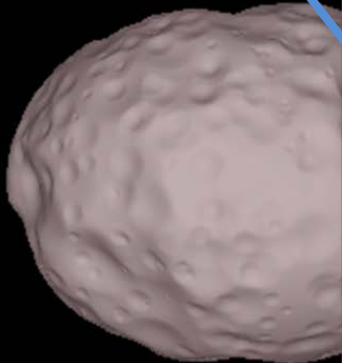
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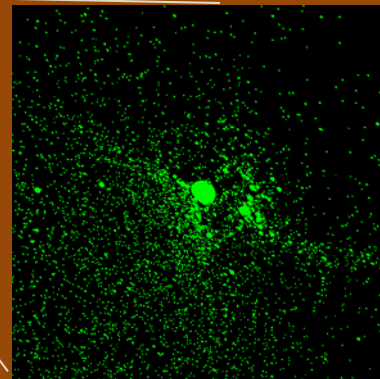
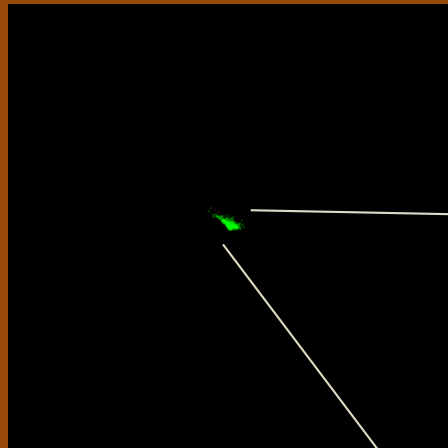
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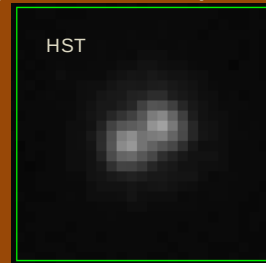


Lucy's Rich Trojan Targets



A near-equal size binary probes the earliest times of solar system history.

L₄:

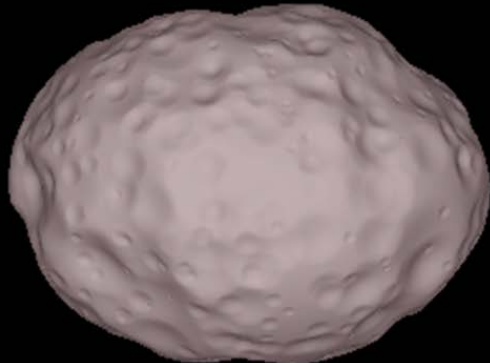


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Patroclus
Binary & Red

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Binary & Red

L₅:



Mar. 2033



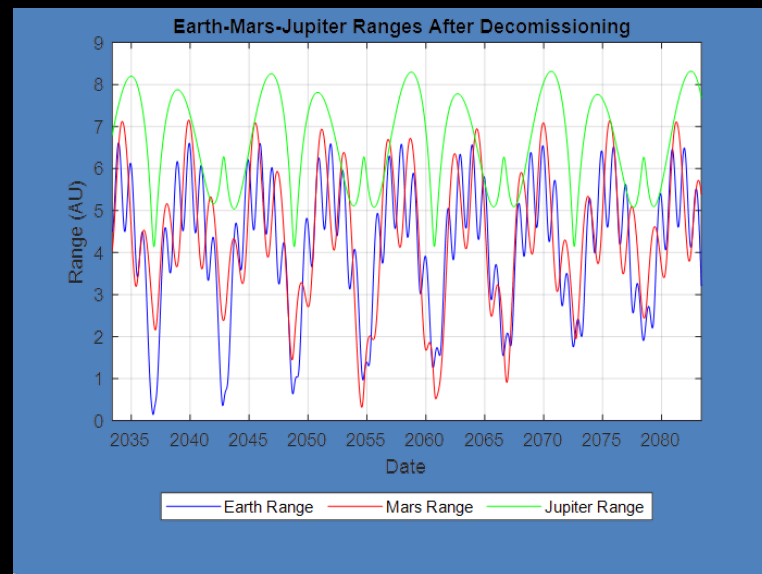
Artist conception based on Earth-based observations







- Lucy is a Discovery-class mission
 - Flyby mission
 - Flyby targets include 1 main belt asteroid and 7
- **Category II** under NPR 8020.12
 - From our categorization letter of Nov 24, 2017: *Requirements for Category II missions include the provision that all hardware launched in support of your mission shall avoid objects for which there is greater concern (e.g., Mars; Europa) at the appropriate probabilities: impact probabilities at Mars are $<1 \times 10^{-4}$ for the launch vehicle, and $<1 \times 10^{-2}$ for the spacecraft, over a period of 50 years after launch, and $<1 \times 10^{-4}$ for Europa.*
- Effort to meet the planetary protection criteria was not significant.
 - This is in part because we are Cat II
 - And also because we have a team experienced in addressing planetary protection requirements.
 - And finally because we had time given our categorization was early in development.





➤ Would the contamination of a subset of these small bodies do irreparable harm to the study of these objects?

- Given the large population (~1M+ objects over 1 km; ~10,000 known), it would be hard to establish that contamination of a very small number would irreparably harm scientific advancement.
- Our knowledge is currently very limited so we should reassess on regular cadence (maybe ~5 years) or after significant increase of information (such as initial reconnaissance by Lucy).
- Extra protections could be afforded certain Trojan asteroid such as:
 - Asteroid families: to maintain the record for understanding the formation and evolution of collision processes and surface modifications (space weathering).
 - Ended members in colors and spectral types: to understand potential extremes
 - Large Trojan asteroids as they are more primitive than the collisionally evolved small size population. They could have organics and volatiles which could inform our understanding of the delivery of these elements to Earth.

