• Lucy is a Trojan asteroid tour
  ▪ Called for in Decadal Survey
  ▪ It will perform flybys of 6 Trojans.

• Its strengths are:
  ▪ High science return from never before encountered objects.
  ▪ Low risk mission – high heritage.
  ▪ Low cost mission – costs fit comfortably within AO constraints.
  ▪ Timely – unique opportunity in launch window gets multiple high-value Trojans.

• 2021 launch, encounters from 2025-2033.
Science Motivation

- To boldly go where no one has gone before.
  - We have never seen one close up.
- Trojans are remnants of giant planet formation.
- They are not a monolithic population, however.
  - Contain C-, D-, and P-type spectral types.
  - Have albedos from $\sim 4$ - $\sim 15\%$
  - Wide range of colors – also bimodal.
Trojans likely harbor objects that formed throughout the outer Solar System. It is only by sampling their diversity that their true scientific potential can be realized.
Trojans likely harbor objects that formed throughout the outer Solar System. It is only by sampling their diversity that their true scientific potential can be realized.
Lucy’s Orbit

With q~1AU and Q~6AU, Lucy will pass through the 2 swarms on back-to-back orbits.
Trojans likely harbor objects that formed throughout the outer Solar System. It is only by sampling their diversity that their true scientific potential can be realized.
- All known spectral types - Both the L₄ and L₅ swarms
Lucy’s Coverage

(Grav et al.)
Lucy’s Coverage

Lucy’s Targets

(W1 Albedo vs. Visible Albedo)

(Grav et al.)
- All known spectral types - Both the L₄ and L₅ swarms
(3548) Eurybates is the largest member of the only major disruptive collisional family.

- We have never visited such an object before.
- Will give unique insight into collisional processes
- Eurybates is a C-type?!?
- Rare in the Trojans.
- No D-type families in asteroid belt.
- Perhaps D’s disintegrate when hit.
- Perhaps D’s become C’s when hit.
- Lucy will help understand this.
- All known spectral types - Both the L₄ and L₅ swarms
- Disruptive collision remnant
The Perfect Couple

<table>
<thead>
<tr>
<th></th>
<th>(3548) Eurybates</th>
<th>(21900) 1999 VQ\textsubscript{10}</th>
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<tbody>
<tr>
<td>H</td>
<td>9.8</td>
<td>9.9</td>
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<tr>
<td>D</td>
<td>64 km</td>
<td>51 km</td>
</tr>
<tr>
<td>P rot</td>
<td>8.7 hr</td>
<td>13.5 hr</td>
</tr>
<tr>
<td>e</td>
<td>0.09</td>
<td>0.04</td>
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<tr>
<td>i</td>
<td>8.1 deg</td>
<td>8.5 deg</td>
</tr>
<tr>
<td>type</td>
<td>C</td>
<td>D (color)</td>
</tr>
<tr>
<td>p\textsubscript{v}</td>
<td>0.05</td>
<td>0.08</td>
</tr>
<tr>
<td>Color</td>
<td>gray</td>
<td>red</td>
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</table>
- All known spectral types
- Both the L₄ and L₅ swarms
- Disruptive collision remnant
We have been amazingly lucky and found multiple other targets that make this a much richer mission!

<table>
<thead>
<tr>
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<th>(617) Patroclus and Menoetius</th>
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<tbody>
<tr>
<td>H</td>
<td>8.2</td>
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<tr>
<td>Dia</td>
<td>141 km &amp; 112 km</td>
</tr>
<tr>
<td>P rot</td>
<td>4.3 days</td>
</tr>
<tr>
<td>e</td>
<td>0.14</td>
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<tr>
<td>i</td>
<td>22 deg</td>
</tr>
<tr>
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<td>P</td>
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The Mystery of Equal Mass Binaries

Many Cold Classical KBOs are equal mass binaries

- Most undisturbed population in the Solar System.
  - Most objects formed this way?
- Their formation is a mystery.
  - Classical ideas don’t work.
  - Most successful idea relies on pebble accretion.

- (617) Patroclus is very similar.
  - It will give insight into how these things came to be.
We will also be able to go to these Trojans.

<table>
<thead>
<tr>
<th></th>
<th>(15094) 1999 WB&lt;sub&gt;2&lt;/sub&gt;</th>
<th>(11351) 1997 TS&lt;sub&gt;25&lt;/sub&gt;</th>
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<tr>
<td></td>
<td>L&lt;sub&gt;4&lt;/sub&gt; Trojan</td>
<td>L&lt;sub&gt;4&lt;/sub&gt; Trojan</td>
</tr>
<tr>
<td>H</td>
<td>11.6</td>
<td>10.7</td>
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<tr>
<td>Dia</td>
<td>21 km</td>
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<tr>
<td>a</td>
<td>5.2 AU</td>
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<td>D (color)</td>
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<tr>
<td>p&lt;sub&gt;v&lt;/sub&gt;</td>
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<td>0.08</td>
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We cover diversity in the L<sub>4</sub> swarm alone.
TS$_{25}$ is a strange bird

**•** Extremely long period (514 hr).
**•** Huge amplitude (1 mag)! Also it is asymmetric (?).
  - Remember this object is 34 km.
**•** Potential second 53 hr period → Satellite?
We will also visit a main belt asteroid, 1981 EQ$_5$

- Intended simply to test our procedures.
- However, it is a member of the $\sim$100Myr Erigone family

- We will get to see a young surface.
- Fresh craters will help us understand collisional evolution of asteroid belt.
- It will constrain space weathering.
- Will help us understand the Yarkovsky forces.
LUCY
Surveying the Diversity of Trojans

Payload

L’LORRI
L’TES
L’Ralph
L’LORRI

- Heritage: New Horizons
- Provider: APL
- Average Power: 4.7 W
- Mass: 9 kg
- Volume: 65.0 x 42.2 x 42.5 cm
- IFOV: 5 μrad
- FOV: .29 x .29 deg
- Panchromatic 0.35 – 0.85μm
L’Ralph

- Visible: Multi-spectral Visible Imagining Camera (MVIC)
- NIR: Linear Etalon Imaging Spectral Array (LEISA)

Provider: GSFC
Heritage: NH, O’REX
Average power: 8.1 W
Mass: 15.6 kg
Volume: 37.3 x 48.5 x 30.5 cm
L’Ralph: MVIC

- IFOV: 29 μrad
- FOV: 8.3°
- Spectral Coverage:
  - 0.4-0.96 μm
  - 0.4-0.5 μm
  - 0.5-0.625 μm
  - 0.625-0.75 μm
  - 0.75-0.85 μm

New Horizons
L’Ralph: LEISA

- IFOV: 80 μrad
- FOV: LEISA 4.6°x3.2°
- Spectral Coverage: 1.0-3.6 μm

Surveying the Diversity of Trojans

New Horizons
L’TES

- Thermal Emission Spectrometer
  - Provider: ASU
  - Heritage: O’REX, MGS
  - Average Power: 11.9 W
  - Mass: 6.2 kg
  - Volume: 28.9 x 37.5 x 51.2 cm
  - Spectral Range: 6 – 100 um
  - FOV: 8 mrad (single channel)
Radio Science

- Radioscience EXperiment
- Measures target masses
- 2-way measurement (i.e. round trip)
- Onboard telecom system
- Ground antenna network
LUCY  Surveying the Diversity of Trojans

Spacecraft

- IPP Gimbal
- L’LORRI
- L’TES
- L’Ralph

- Z-axis
- X-axis
- HGA boresight
- 20°
- HGA (2 m)
- Solar Array (edge-on)
- Main Engine

SwRI  LOCKHEED MARTIN  NASA  GODDARD SPACE FLIGHT CENTER  APL  ASU
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 subsurface composition via crater windows, fractures, ejecta blankets, and exposed bedding.

We will also look for rings and satellites
- All known spectral types - Both the L₄ and L₅ swarms
- Near-equal mass binary - Disruptive collision remnant
- Very young MBA.
"I Love Lucy" logo – Courtesy of CBS Broadcasting Inc.
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We have found a trajectory that visits 6 Trojans and 1 MBA