Celestial and Spaceflight Mechanics Laboratory

Janus: A mission concept to explore two NEO Binary Asteroids

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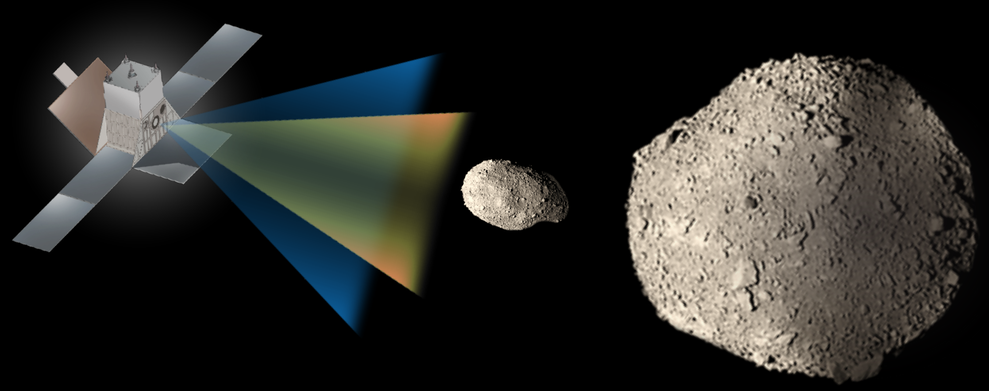
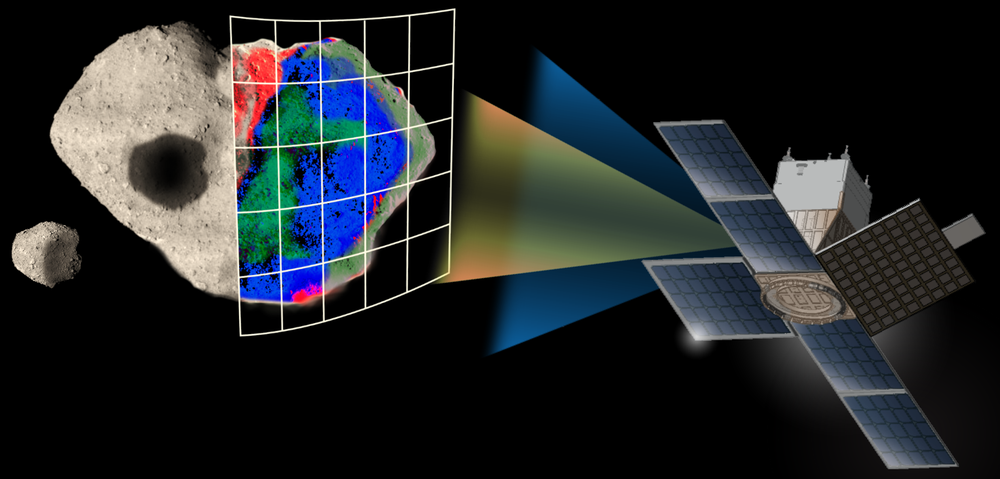
Janus

A dual spacecraft mission to open a gateway to understand the transitions and lifecycles of rubble pile asteroids

Janus observes two binary asteroid systems at a higher spatial resolution and greater phase angle coverage than any previous asteroid flyby mission

Named for the Roman god of duality, depicted with two faces looking to the past & future





University of Colorado Boulder

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Janus Mission Partnerships and Science Team

Institutional Partnerships

University of Colorado Boulder

PI Office
Mission Oversight

LOCKHEED MARTIN

Project Management
Spacecraft
Mission Operations

Malin SSS
Instrument Suite

Science Team

- **PI: Dan Scheeres** (CU) — OREX, NEAR, Hayabusa, Hayabusa2
- **Deputy-PI:** J. McMahon (CU) — OREX, Hayabusa2
- **Project Scientist:** E. Bierhaus (LM) — OREX
- **Instrument Scientist:** M. Ravine (MSSS) — OREX
- **Mission Scientist:** C. Hartzell (UMd) — OREX
- **Visible Imaging:** L. Le Corre (PSI) — OREX, Dawn, Hayabusa2
- **IR Imaging:** P. Hayne (CU-LASP) — DIVINER

- **Radar Astronomers:**
  - L. Benner (JPL)
  - S. Naidu (JPL)
- **Ground-based Observers:**
  - R. Jedicke (UH)
  - P. Pravec (CAS)

Janus Mission Science: A first close look at binary asteroids

Why Binaries?

- Binary Asteroids are…

  … ubiquitous in the asteroid population ~ 15%

  … thought to form when rubble pile asteroids fission due to high spin rates

  … just one of several “pathways” that small rubble asteroids piles travel down

  … the key to understanding the mechanical properties of rubble pile asteroids, and by extension the geophysics of microgravity aggregates.

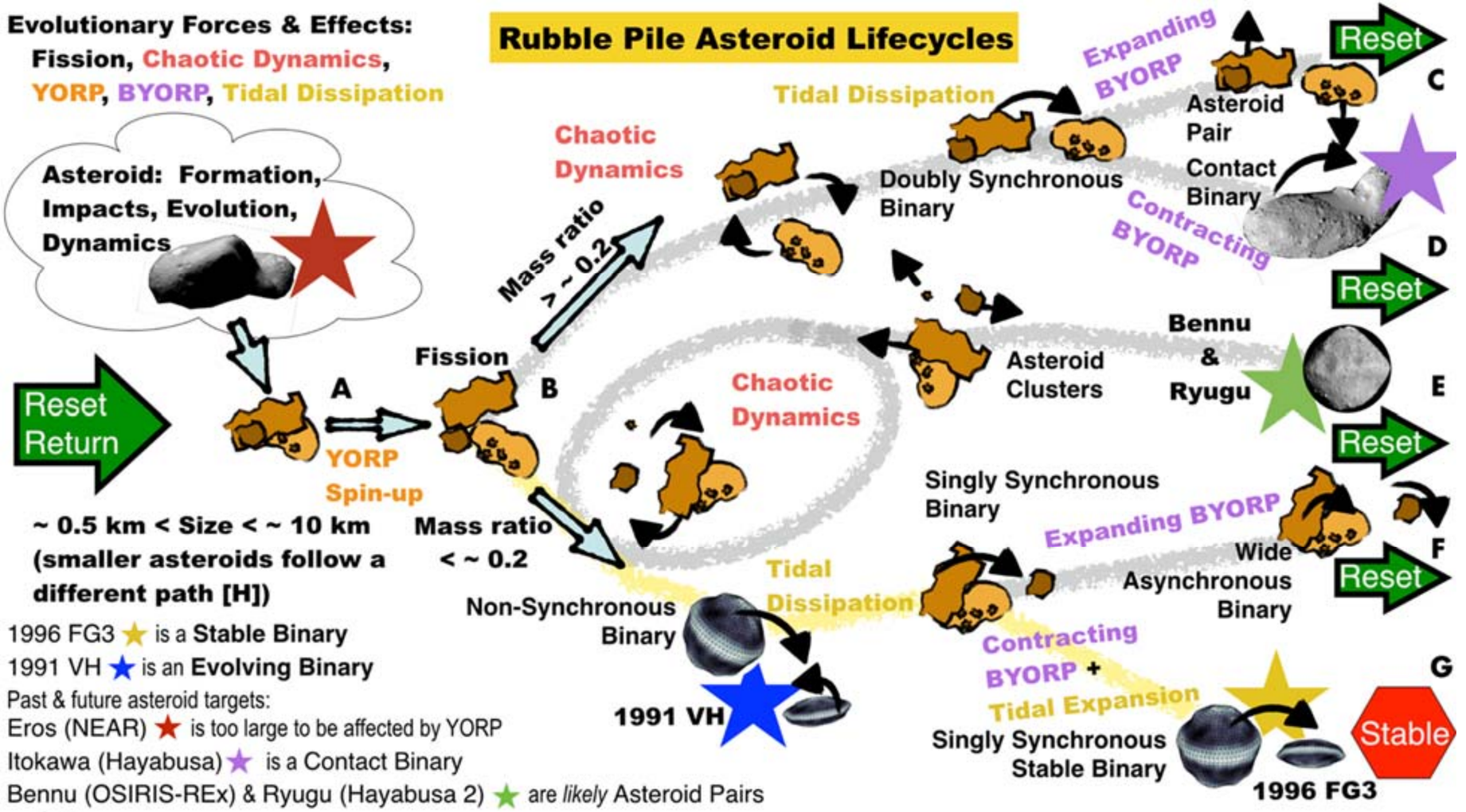
Janus targets are key to understanding the physical evolutionary pathways that drive rubble pile asteroids

Janus targets diverse binaries at key points along their evolutionary pathway:

1991 VH is in its chaotic orbital evolution phase and is an S Type.

1996 FG3 is in a stable end-state and is a C Type.

Observing a diversity of binary bodies with one mission will give fundamental insight into rubble pile bodies in the solar system.



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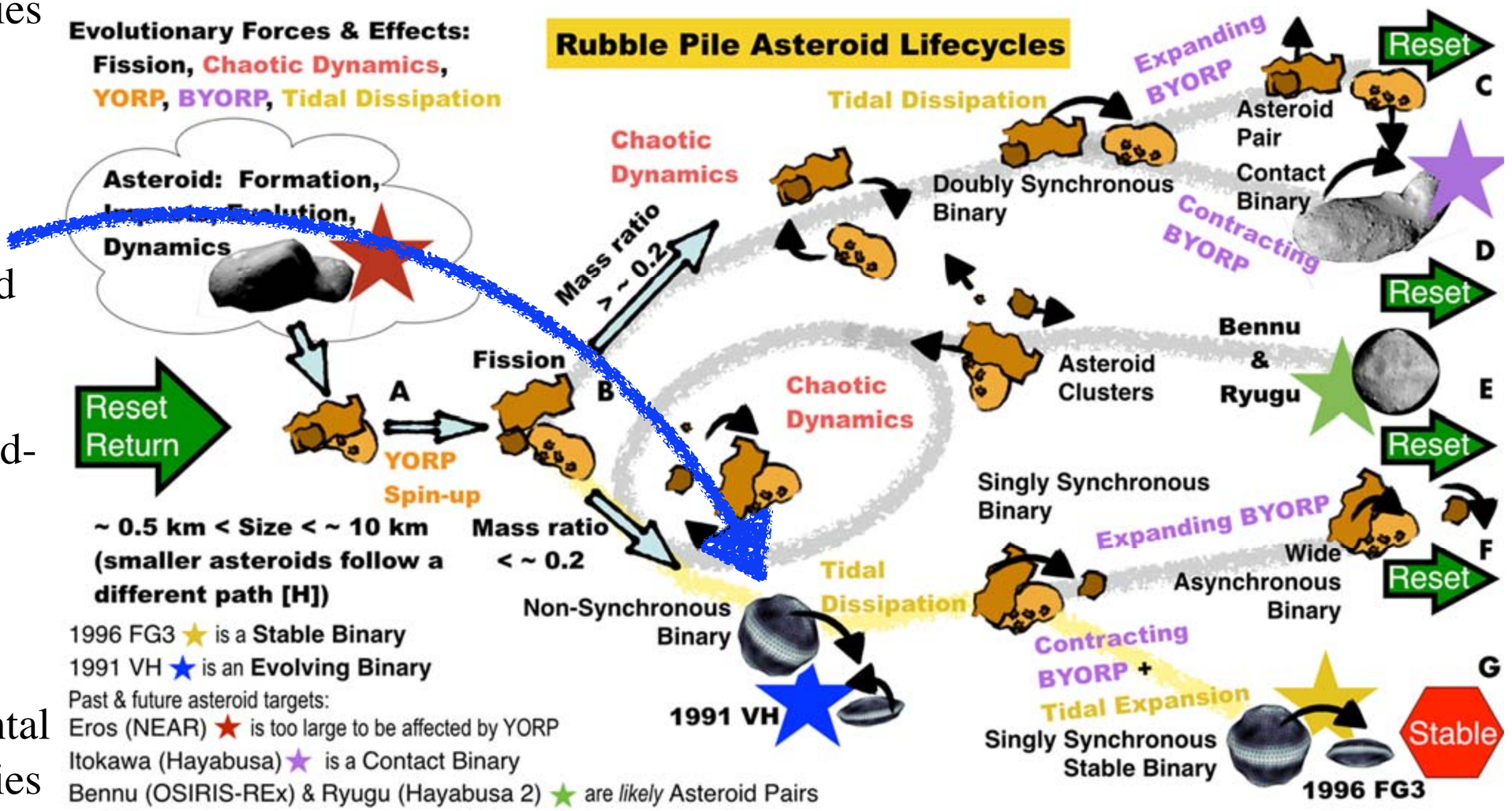

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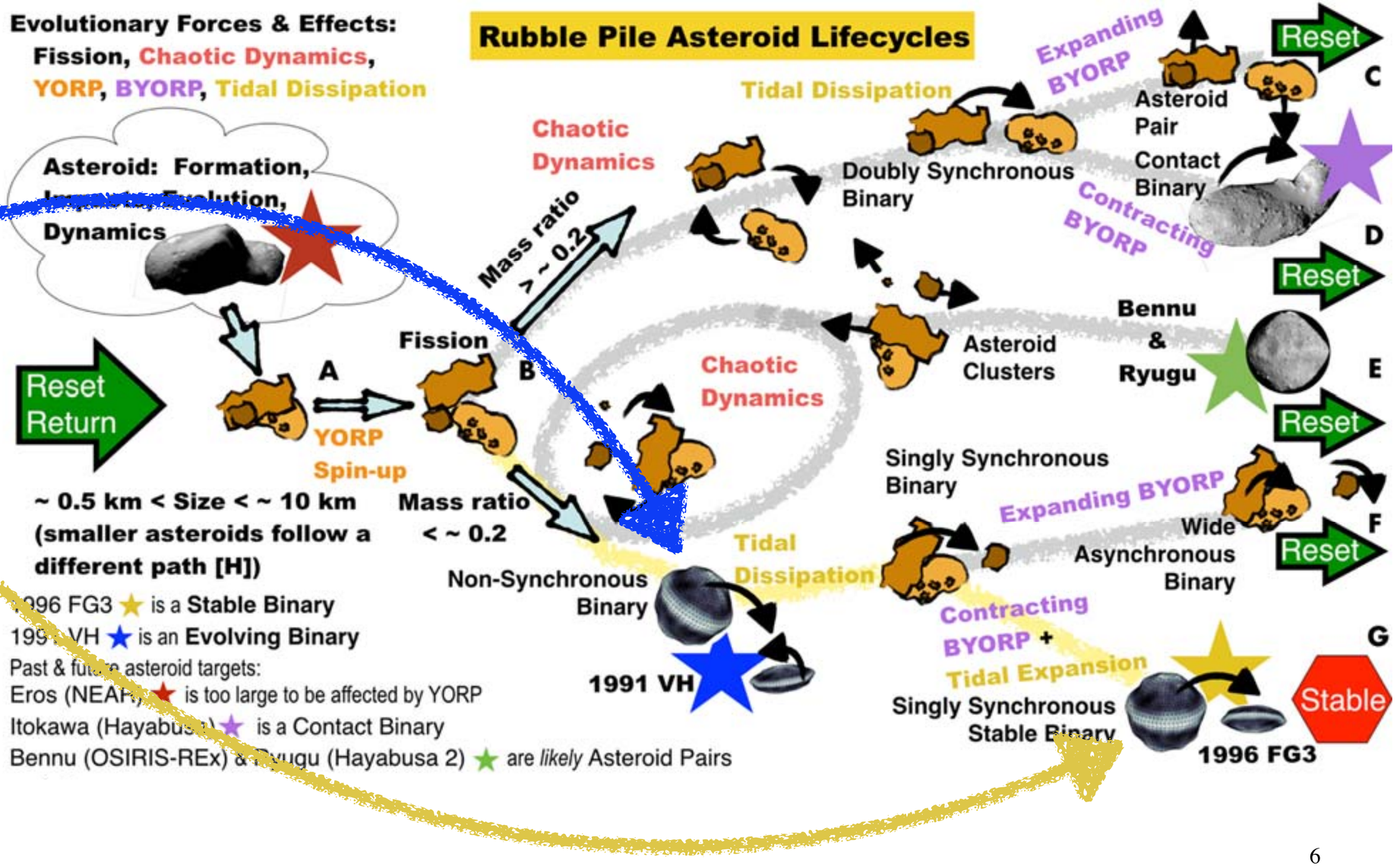
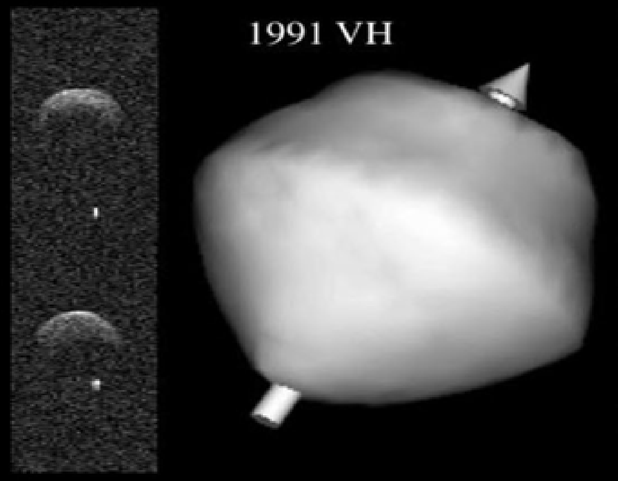


The ***Janus*** mission targets are well studied and diverse, enabling precision flybys and meaningful comparisons to expose the fundamental processes of binary asteroid formation

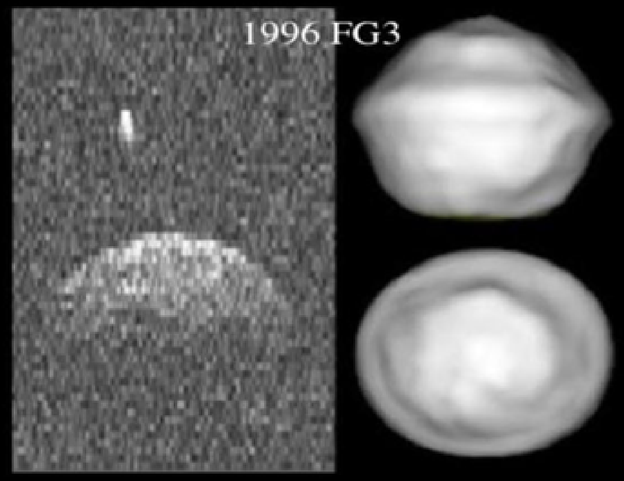
Target Binary Asteroids: (175706) 1996 FG3 and (35107) 1991 VH

Ideal Targets Enable Janus' Science Goals

- *Binary near-Earth asteroids that have been subject to multiple transitions and have similar shapes and morphologies*
- *Distinct systems that lie at different evolutionary stages and which have different compositional properties*
- *Both have been extensively characterized by ground-based observations providing known mass, shape, rotation and orbit*
- *Potentially Hazardous Asteroids*



A rocky S-Type in an excited state and a non-synchronous secondary rotation state



A primitive C-Type in a long-term stable state and a synchronous secondary

Janus targets reside in a Sweet Spot between science and mission implementation

- We know enough about our target asteroids to pose fundamental science questions, and architect a sound mission implementation
- Science knowledge
  - Spectral classes: sampling two binary systems of very different spectral classes
  - Binary states: stable vs. excited
  - Decameter shape models to enable computation of key geophysical parameters
- Mission implementation knowledge
  - The orbits of the binary pairs around the Sun are well-known to enable accurate encounter targeting
  - The orbits of the secondary around the primary enable targeting specific secondary orientation relative to the primary at the time of flyby
  - Decameter shape models to enable detailed planning

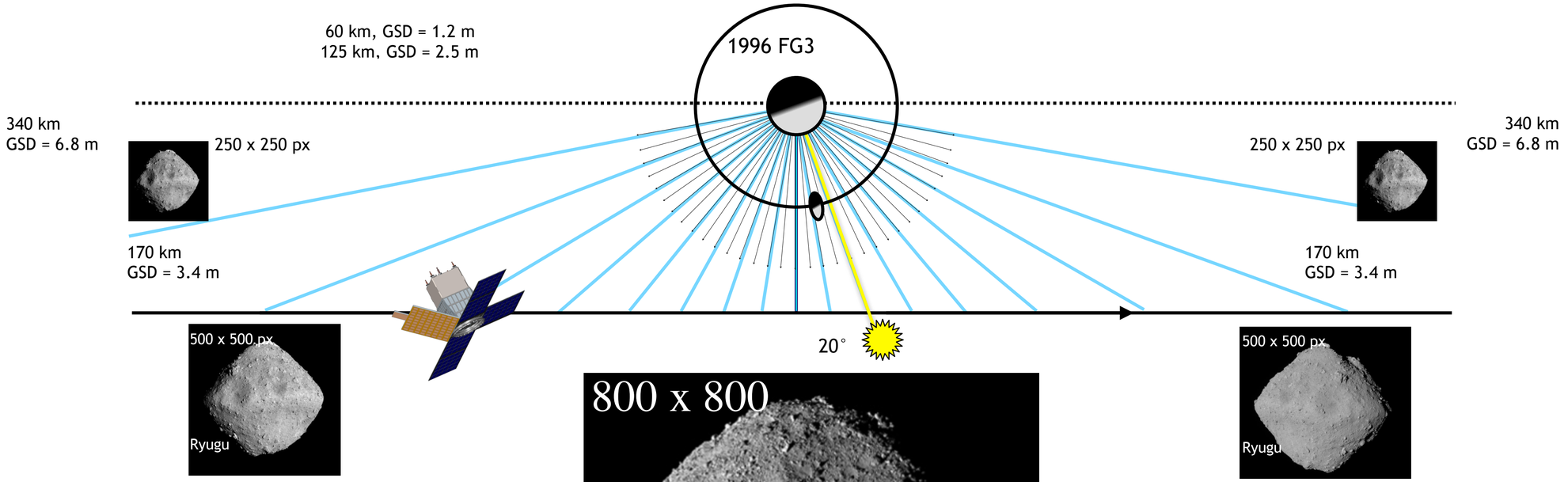
The *Janus* Science Objectives and corresponding Mission Implementation are focused and simple

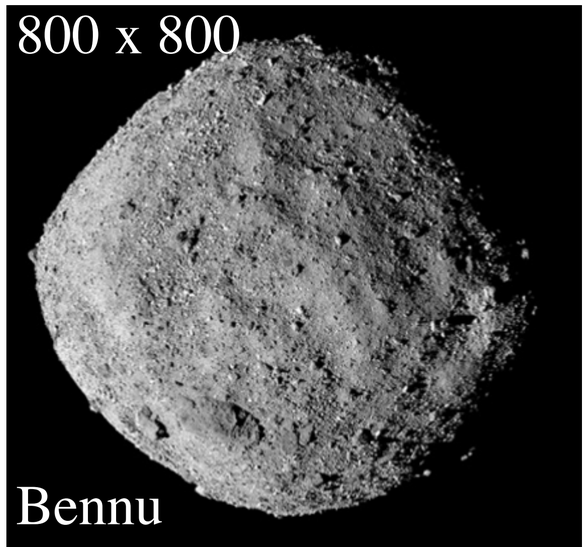
Science Objectives	Mission Overview

Janus science goals address key
Cross-Cutting NASA Themes
Solar System Workings:
How do rubble pile asteroids evolve over time?
Building New Worlds:
What properties do microgravity aggregates have?
 	
Goal I: Identify and understand the processes that lead to binary asteroid formation.
Goal II: Test and evaluate theories for binary asteroid evolution by studying the unique dynamical states of binary asteroid systems.
	Science Implementation Requirements
	• *Fly by two binary asteroids at low speed with favorable illumination conditions*
	• *Image the system components at high resolution across a diversity of phase angles*
	
	Mission Design & Implementation
	• *Launch: Psyche Rideshare August 2022*
	• *Earth Gravity Assist: August 2025*
	• *Binary Asteroid Flybys:*
	  • *1991 VH: March 3, 2026*
	  • *1996 FG3: April 20,2026*
	• *End of flight operations May 31, 2026 (45 months)*
	• *Science evaluation through December 31, 2026*

Janus Provides Data to Advance Planetary Science

- Flyby data provide the needed resolutions and coverage to address fundamental science objectives for size, shape, bulk properties, and surface processes





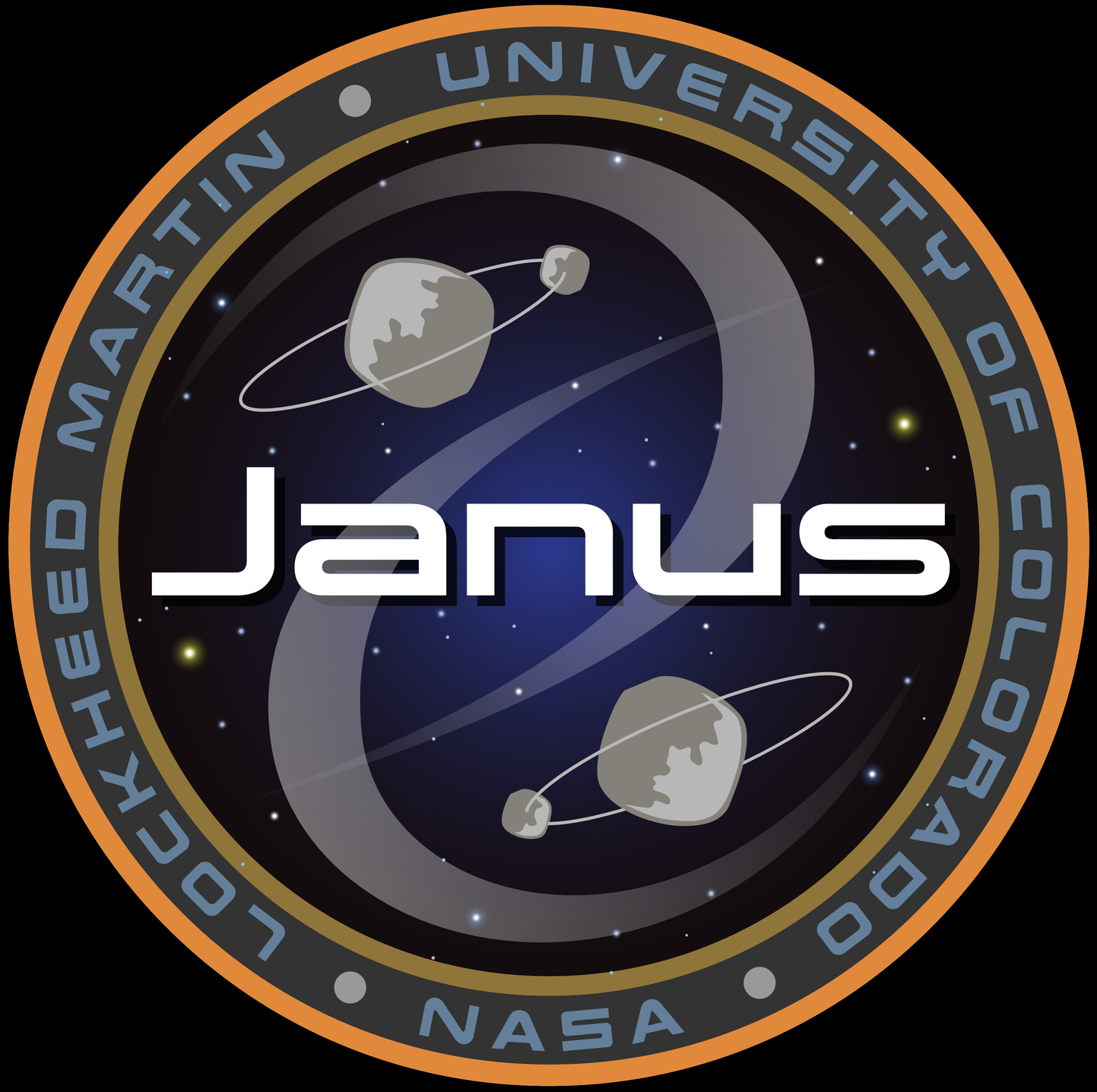
Approximate equivalent pixel scales of images

Janus and Planetary Defense

- *Janus* supports key planetary defense objectives, and will:
  - Enable the DART impactor mission observations and results to be placed into a wider context, helping to
    - Interpret topographic features that DART sees on approach to Didymos
    - Provide a wider context for interpreting the surfaces of binary asteroid components
    - Create precise models of binary system dynamics to constrain the DART impulse effects
  - Provide key insight into the evolutionary mechanisms and geophysical properties of rubble pile asteroids, both of which are key to the design and implementation of hazardous asteroid characterization and mitigation strategies.
  - Enable the properties of binary asteroid systems to be more realistically characterized, enabling the development of more credible hazardous binary asteroid deflection scenarios and responses.
  - Develop a low cost mission and spacecraft concept that can be rapidly deployed to characterize hazardous asteroids.

Summary

- ***Janus*** is a University of Colorado / Lockheed Martin mission concept selected by NASA for Phase A/B development
- ***Janus*** will provide the first high resolution, scientific observations of NEO binary asteroid systems that span mineralogical and dynamical diversity
- ***Janus*** can provide insight into the mechanics of rubble pile bodies, and into microgravity geophysical processes in general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