Celestial and Spaceflight Mechanics Laboratory

2019-o-3-07

Janus: A mission concept to explore two NEO Binary Asteroids

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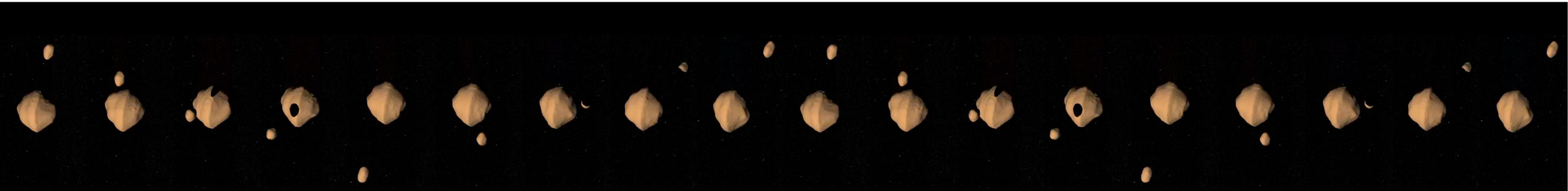


Janus Mission Selected for Phase A/B!

- ***Janus*** was submitted to the inaugural SIMPLEx call for proposals
  - Launch provided on an upcoming mission, e.g., Lucy or Psyche, for interplanetary missions
  - Up to $55M for a given mission
- Proposals were submitted July 2018 (12 total submissions)
- Announcement made last Thursday… ***Janus*** is selected for Phase A/B! (1/3)

Institutional Partnerships

University of Colorado Boulder

PI Office
Mission Oversight

LOCKHEED MARTIN

Project Management
Spacecraft
Mission Operations

Malin SSS

Instrument Suite

Science Team

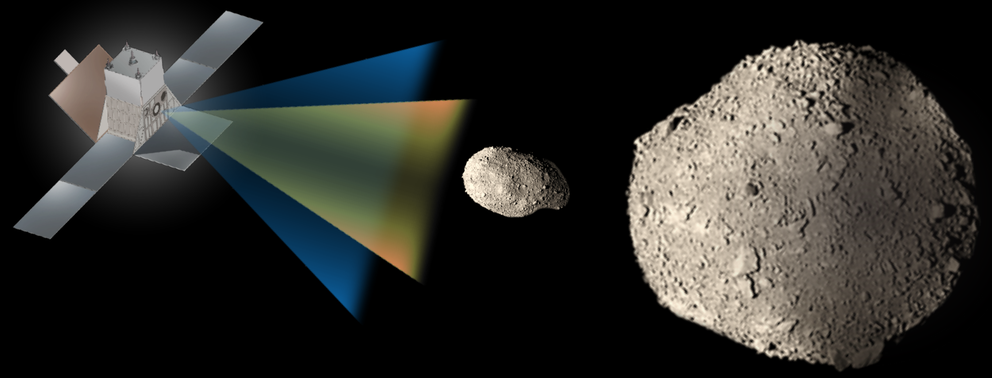
- **PI: Dan Scheeres** (CU)
- **Deputy-PI:** J. McMahon (CU)
- **Project Scientist:** E. Bierhaus (LM)
- **Co-Is:**
  - Mission Scientist: C. Hartzell (UMd)
  - Instrument Scientist: M. Ravine (MSSS)
  - Visible Imaging: L. Le Corre (PSI)
  - IR Imaging: P. Hayne (CU-LASP)
- **Radar Astronomers:**
  - L. Benner (JPL)
  - S. Naidu (JPL)
- **Ground-based Observers:**
  - R. Jedicke (UH)
  - P. Pravec (CAS)

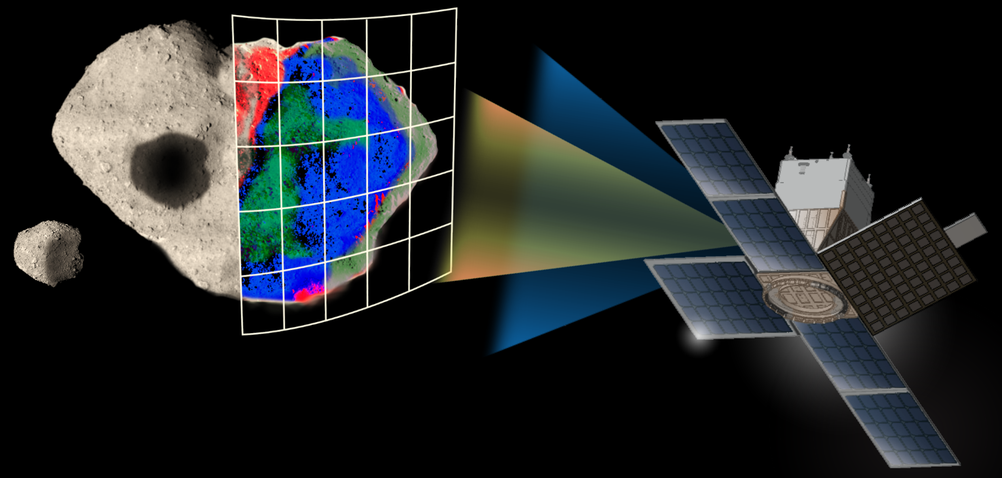
Janus

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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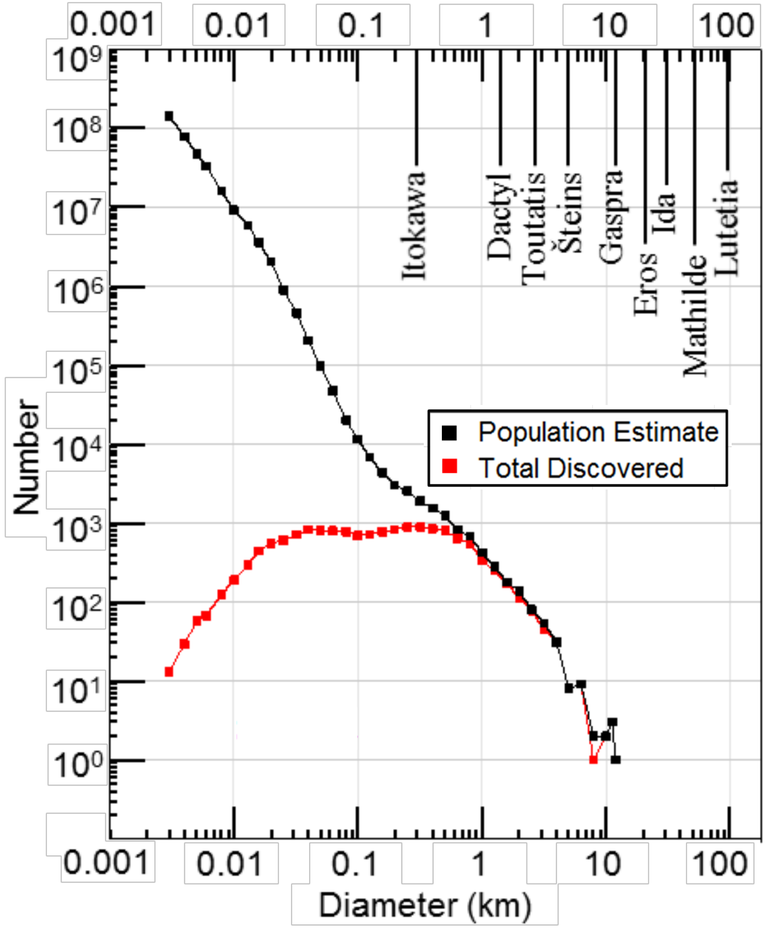
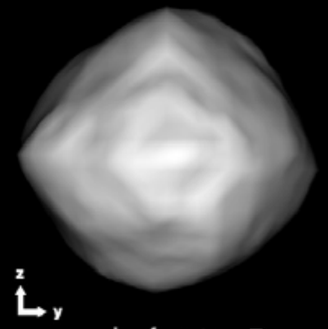
For Small Bodies… Numbers & Processes Matter

- *Most objects in the solar system belong to a physical scale that has never been visited by spacecraft*
- Small (< a few km) objects are ubiquitous in the solar system, yet are poorly understood
- Some motivations to study them include . . .
  - They comprise the vast majority of planetary bodies (NEOs, MBAs, KBOs)
  - They provide a window into early stages of planet formation
  - They are the greatest remaining unknown risk for Earth impact
  - They are candidate targets for ISRU and / or human exploration

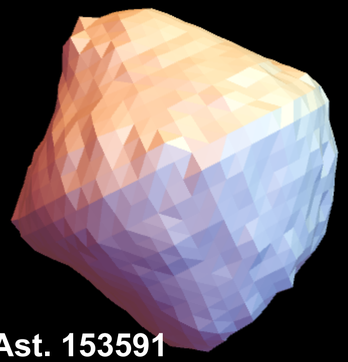


Small asteroids are among the most numerous objects in the solar system

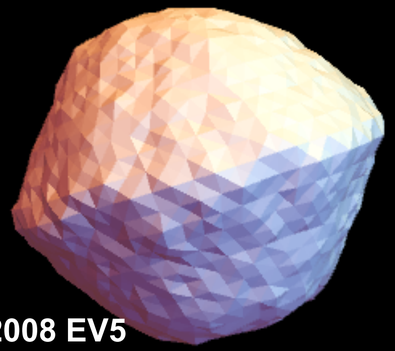
NEOs Encode a Diversity of Processes



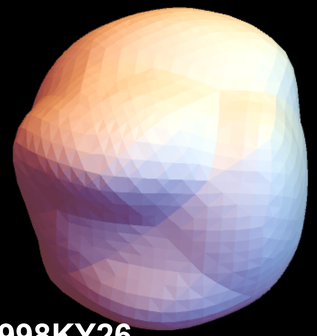
Bennu



Ast. 153591

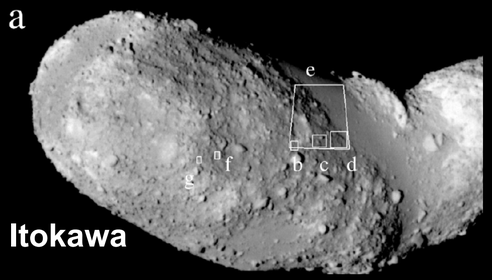


2008 EV5

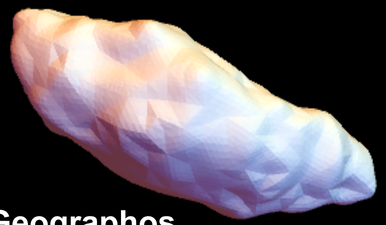


1998KY26

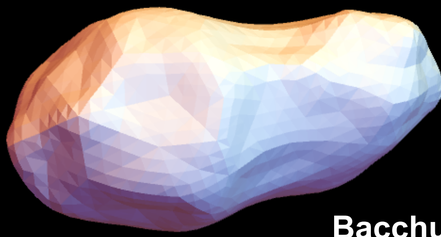
Ra-Shalom



Itokawa

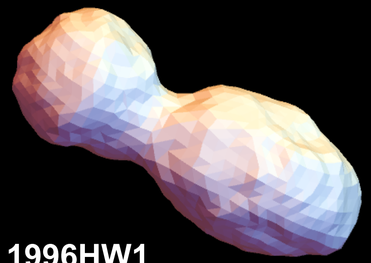


Geographos

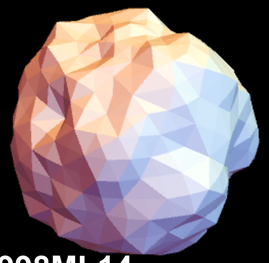


Bacchus

Castalia



1996HW1



1998ML14

YORP

Golevka

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

Science Objectives	Mission Overview

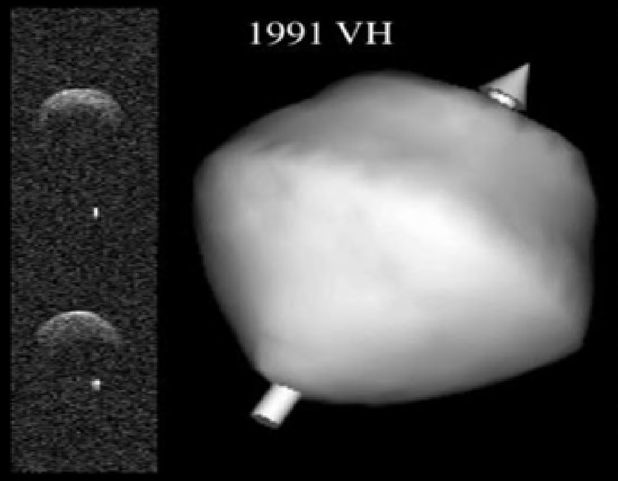
Janus science goals address key
Cross-Cutting NASA Themes
Solar System Workings:
How do rubble pile asteroids evolve over time?
Building New Worlds:
What properties do microgravity aggregates have?
 	
Goal I: Identify and understand the processes that lead to binary asteroid formation.
Goal II: Test 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*

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

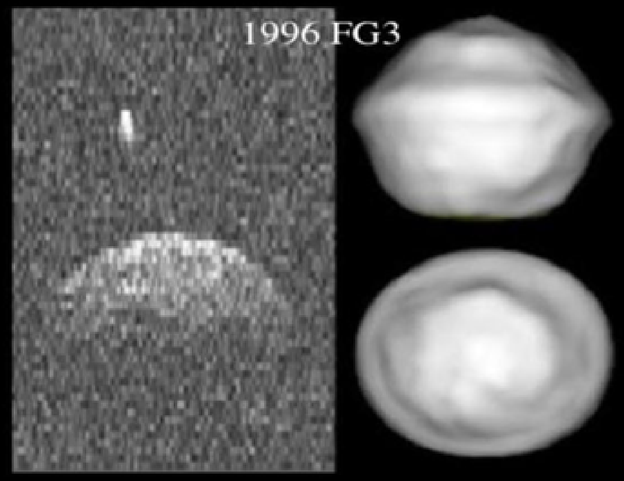
Target Binary Asteroids: (175706) 1996 FG3 and (35107) 1991 VH

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

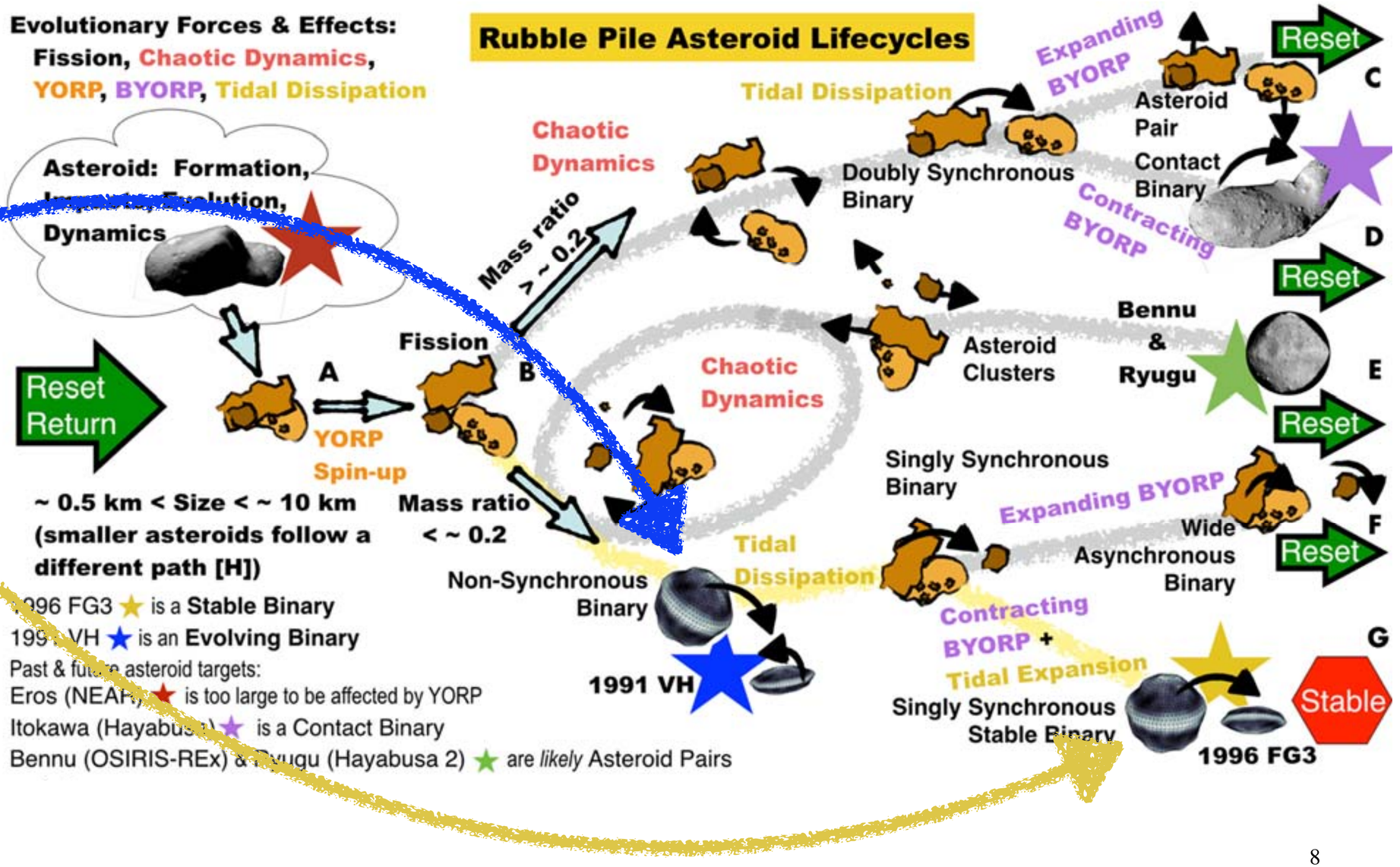
Current understanding of the physical evolutionary pathways that drive binary rubble pile asteroids

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



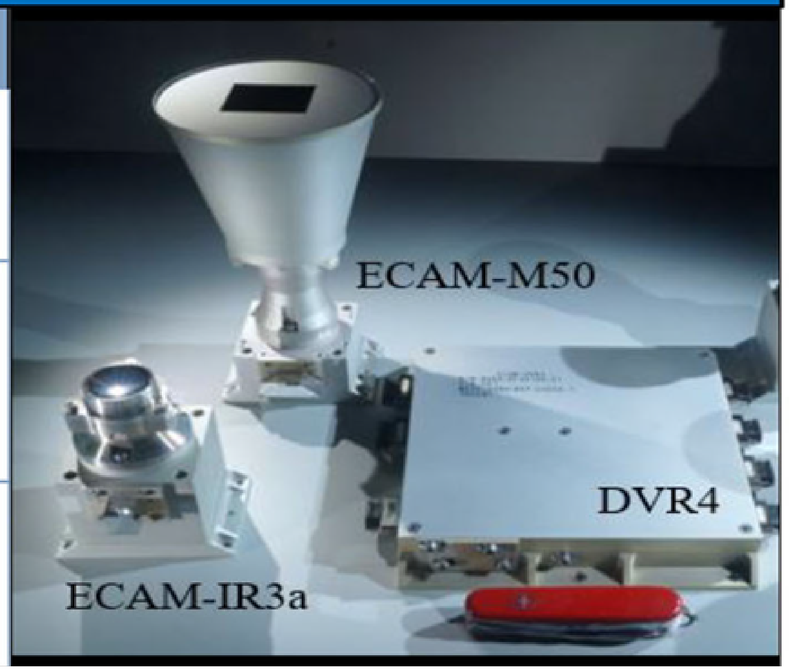
The ***Janus*** instrument suite has high-heritage and proven performance

The ***Janus*** instrument suite is provided by Malin SSS and supports visible and near-IR imaging of our target binaries.

The DVR allows for flexibility in imaging, on-board data compression and selective downloading of images taken through the flyby.

Science Instruments

Instrument	Description	Heritage
Visible Imager	ECAM-M50, 2592 x 1944 pixel CMOS sensor with 2.2 µm pixels, 420-680 nm bandpass, and an electronic rolling shutter	OSIRIS-REx, Undisclosed Mission
Infrared Imager	ECAM-IR3a, 640 x 480 pixel uncooled Long-Wave Infrared (LWIR) microbolometer sensor array with 8-12 µm bandpass, integral Read-Out Integrated Circuit (ROIC) and 17µm pixels.	Undisclosed Mission
DVR	ECAM-DVR4, power conditioning, camera control, image processing, compression, subset windowing, and storage.	OSIRIS-REx, Undisclosed Mission



Janus Science Goals and Objectives

- **Goal I**: Identify and understand the processes that lead to binary asteroid formation
  - **SO1**: Identify evidence in support of and constrain specific models of binary asteroid formation.
  - **SO2**: Estimate and constrain binary system parameters and mass models.
- **Goal II**: Test and evaluate theories for binary asteroid evolution by studying the unique dynamical states of the binary asteroid systems.
  - **SO3**: 1996 FG3 — Measure the secondary BYORP Coefficient and constrain the tidal dissipation rate of the system primary.
  - **SO4**: 1991 VH — Test hypotheses to explain the system's unsettled state.

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 fundamental surface processes
  - Significant contribution to small-body science, and planetary formation
- Flybys naturally provide a range of phase angles, incidence angles, and emission angles
  - High-phase angle imaging (typically approach and departure) provides shape and surface geomorphology
  - Low-phase angle imaging (typically near closest approach) provides information on albedo and shape
  - Existing radar shape models can be leveraged to provide decameter structure on which to hang our high-resolution flyby images

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
- 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

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