



# **Main-belt Asteroid and NEO Tour with Imaging and Spectroscopy**

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APPLIED PHYSICS LABORATORY



# What is MANTIS?

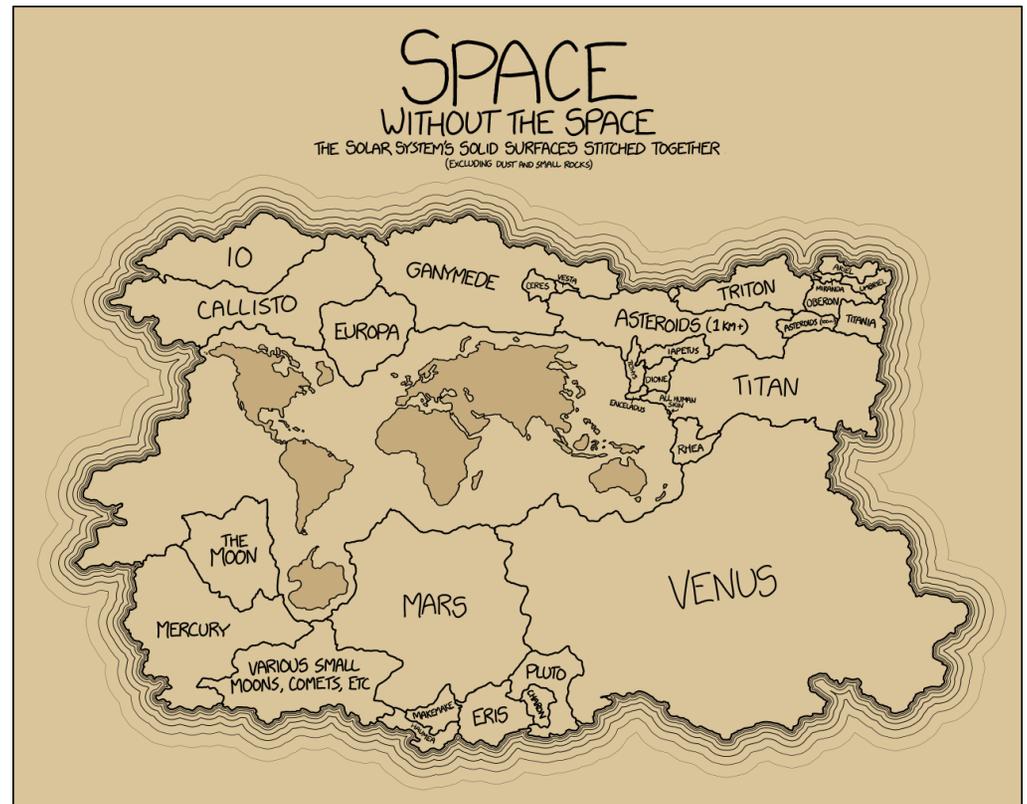


- **MANTIS** is the **Main-belt Asteroid and NEO Tour with Imaging and Spectroscopy**
- MANTIS is an **asteroid diversity tour mission** visiting the planetary building blocks from our solar system's past, exploring the dynamically active asteroid population of the present, and informing our knowledge for mitigation and exploration of asteroids in the future.
- MANTIS **firsts** include:
  - encountering an NEO binary asteroid
  - exploring a metallic asteroid
  - visiting asteroids that span a factor of 200 in size, including the smallest object ever visited
  - more than doubling the number of asteroids explored by humankind
- MANTIS revolutionizes our understanding of asteroids through its state of the art payload of complementary instruments:
  - A powerful **infrared imaging spectrometer** and **narrow angle camera**, both with flight heritage and both being used at small bodies for the first time
  - The first-ever **multispectral mid-IR imager** brought to a small body
  - A **dust instrument** to provide important data to the micrometeorite and exploration communities
  - Datasets taken at each target with a **common instrument suite** that can be readily intercompared with one another

# Asteroids are important

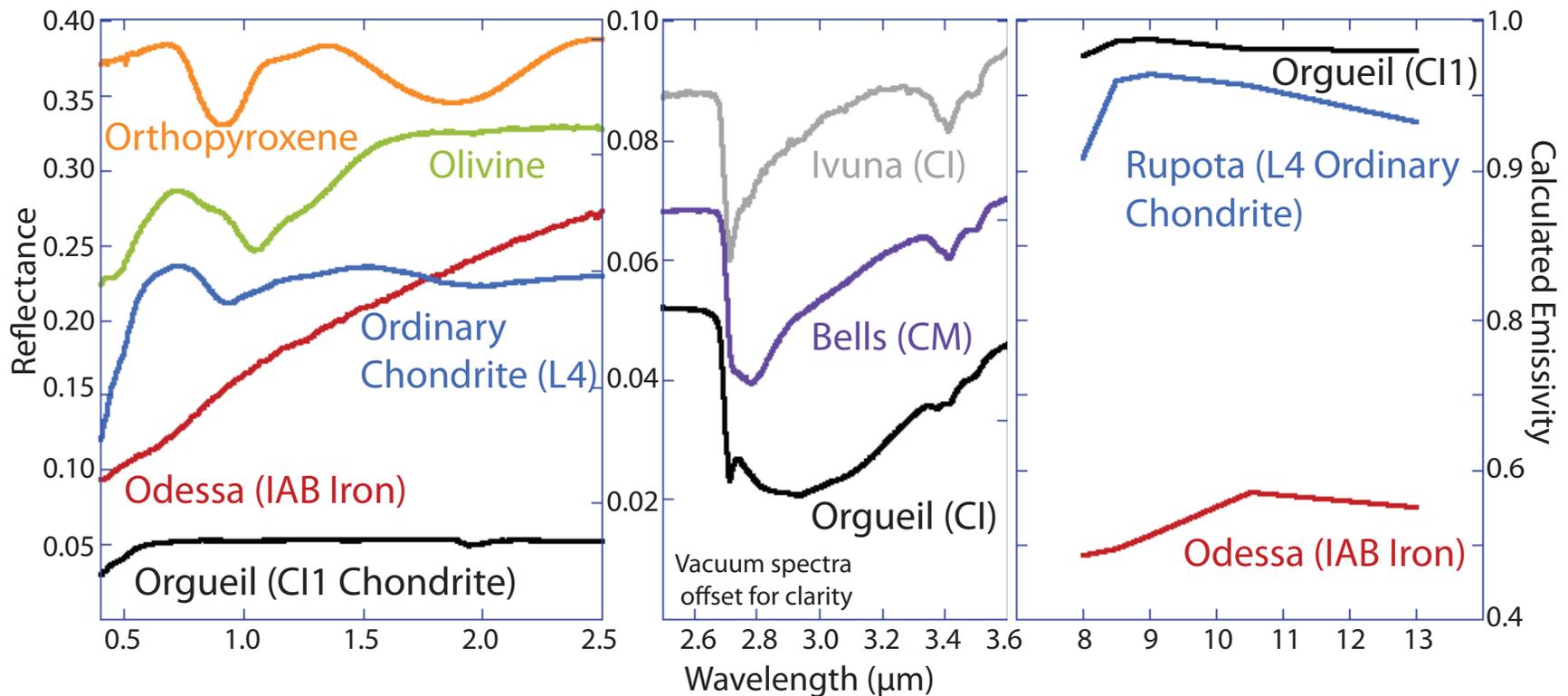


- Dominate the inner solar system by number
- Experienced and record a wide range of processes
- Offer hazards and opportunities to civilization

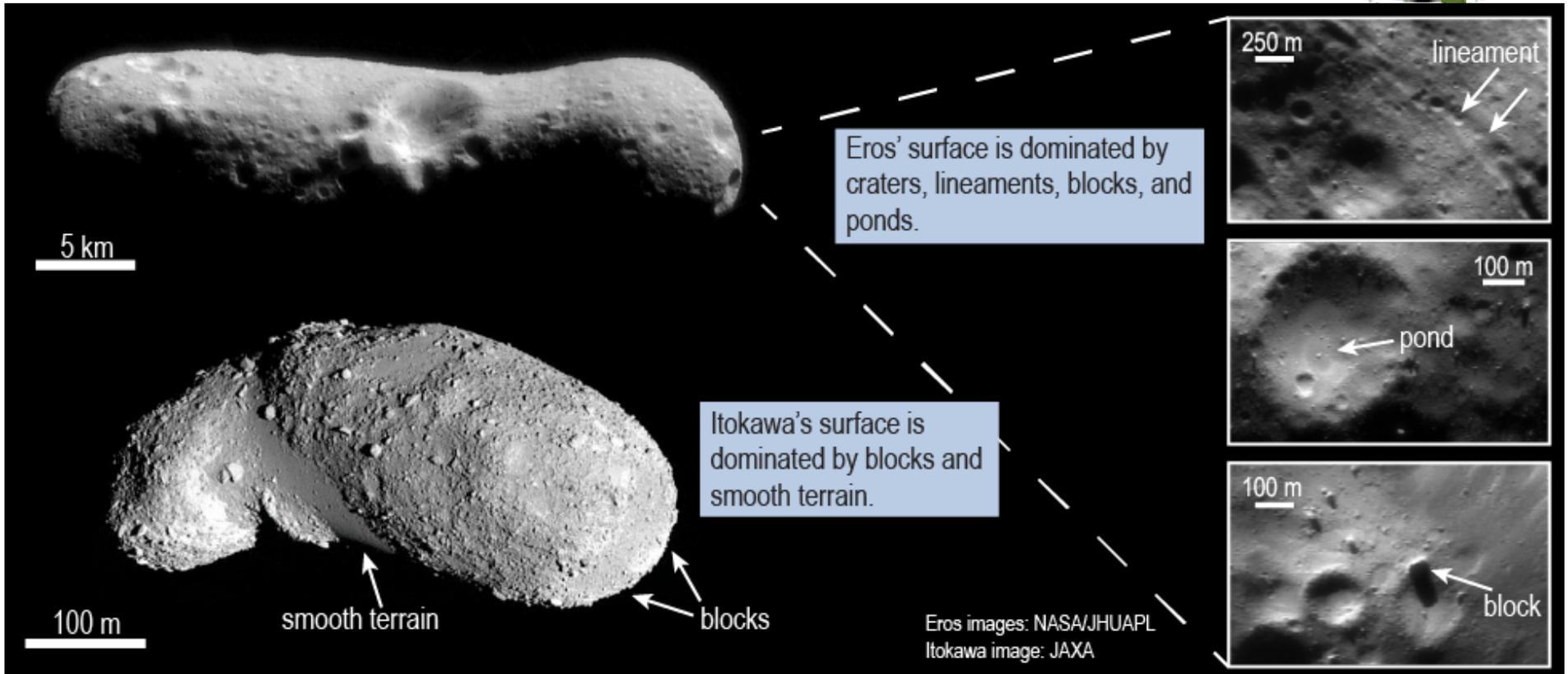


From xkcd, by Randall Munroe

# Asteroids have a variety of compositions



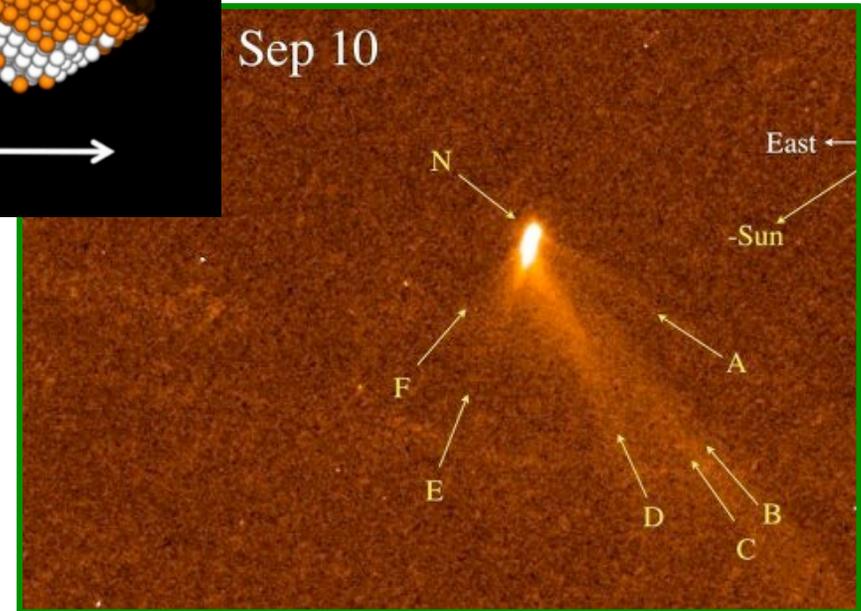
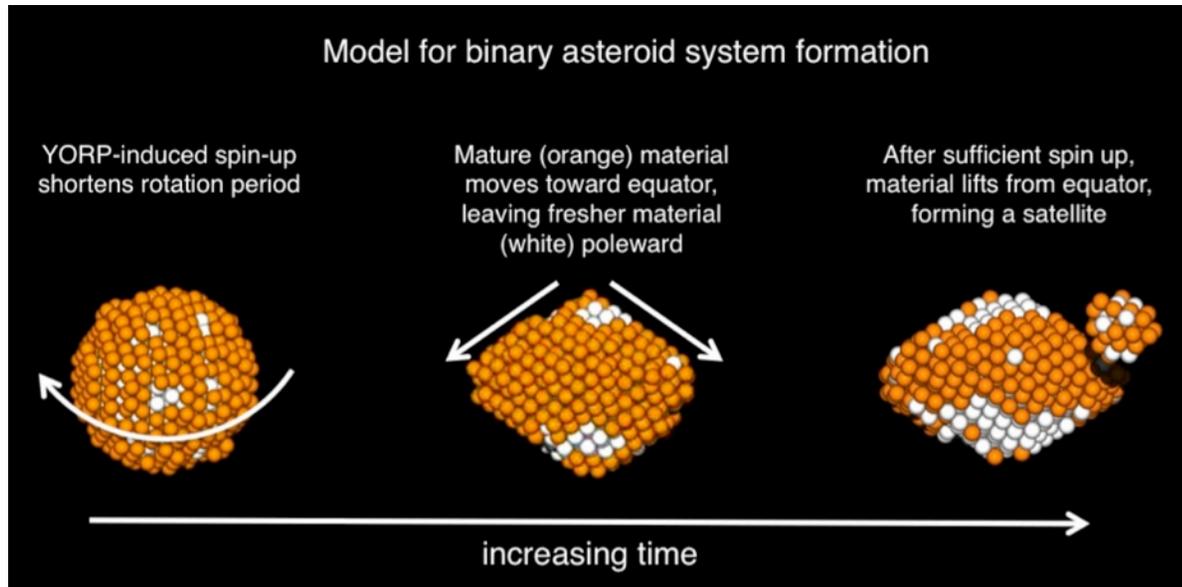
# Asteroids show geological variety



# Asteroids experience a variety of “unusual” processes



Model for binary asteroid system formation

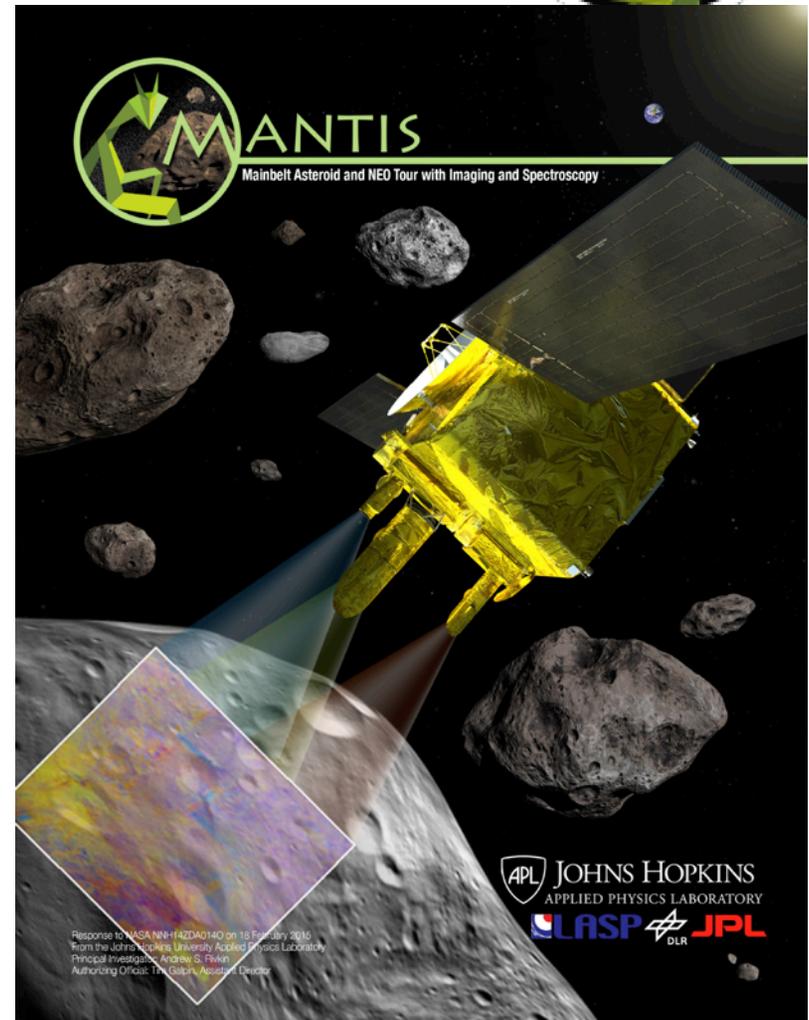


Main-belt asteroid P/2013 P5 episodically sheds dust (Jewitt et al. 2014)

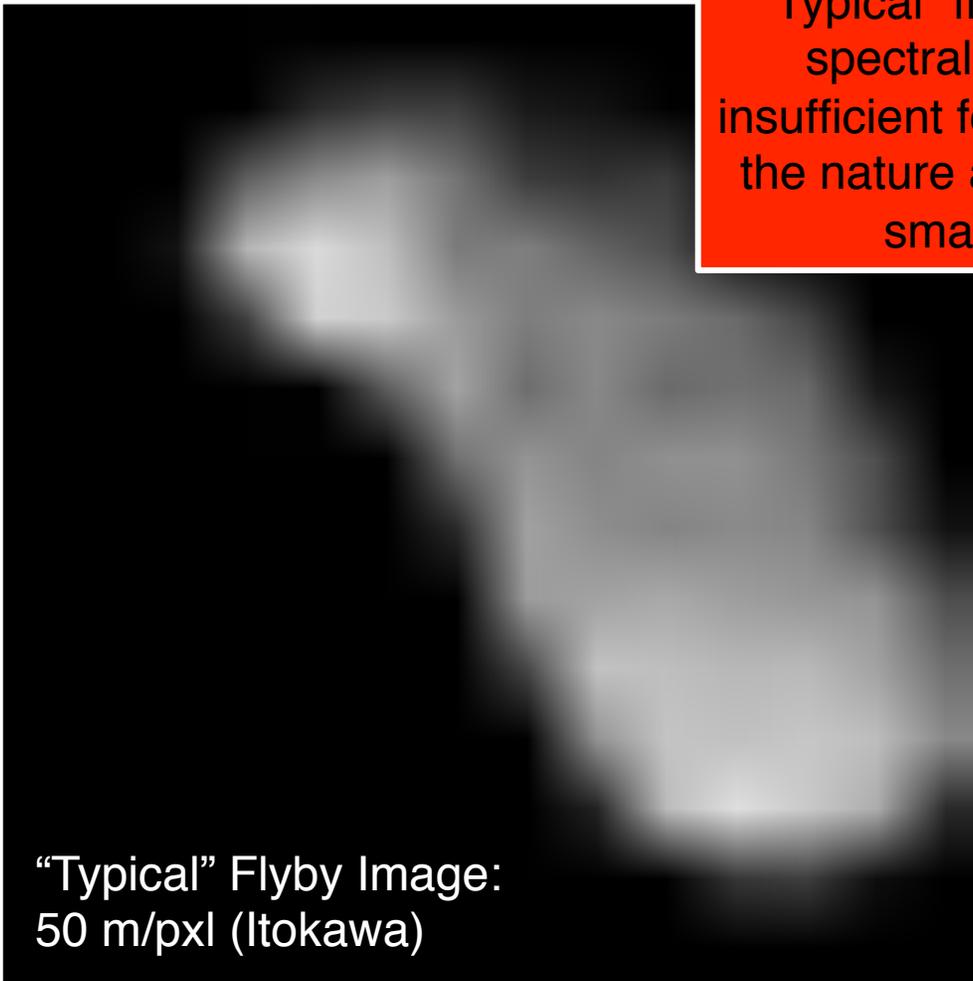
# MANTIS Science Goals



- Investigating the compositional relationship between asteroids, meteorites, and interplanetary dust particles to understand the origin of life and the evolution of solar system objects
- Investigating how the geochemical and physical properties of asteroids affect surface geology and regolith processes to understand the operation, interaction, and evolution of processes in our solar system
- Investigating the interior structure, formation, and evolution of asteroids to understand how our solar system evolves
- Characterizing potentially hazardous asteroids in Earth's neighborhood to identify and characterize objects that pose threats to Earth or offer resources for human exploration

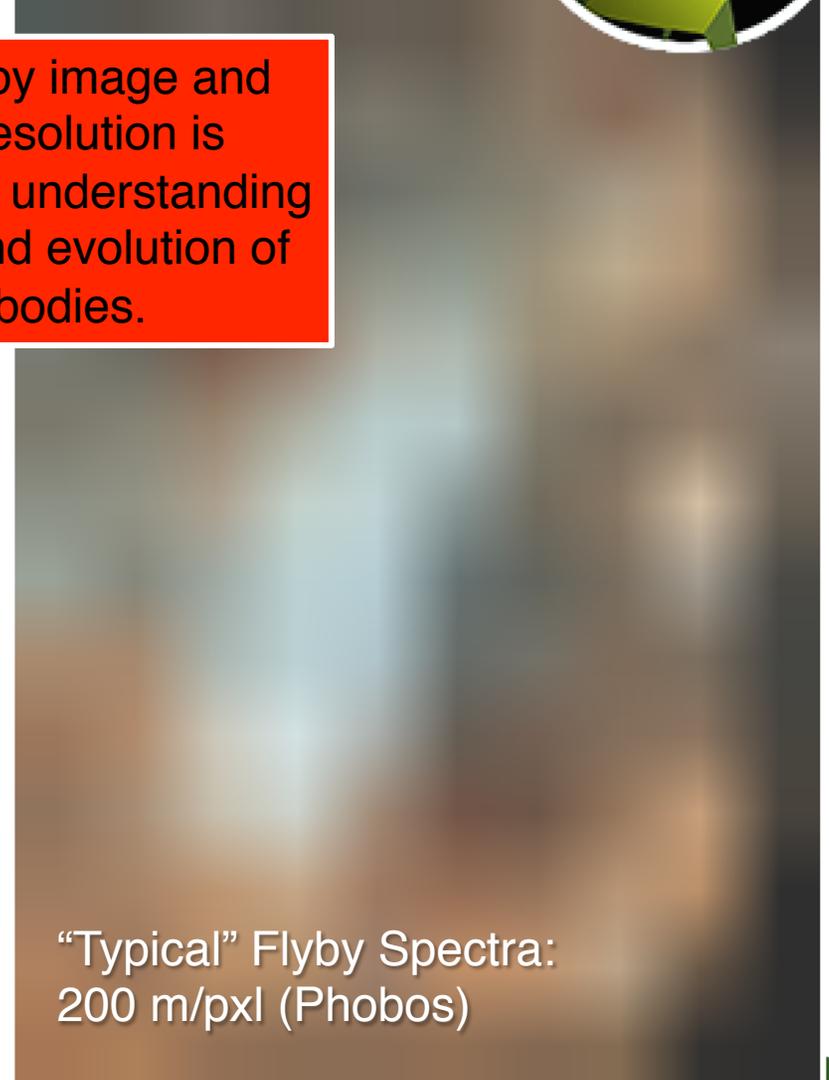


# What resolution is needed?



“Typical” Flyby Image:  
50 m/pxl (Itokawa)

“Typical” flyby image and spectral resolution is insufficient for understanding the nature and evolution of small bodies.

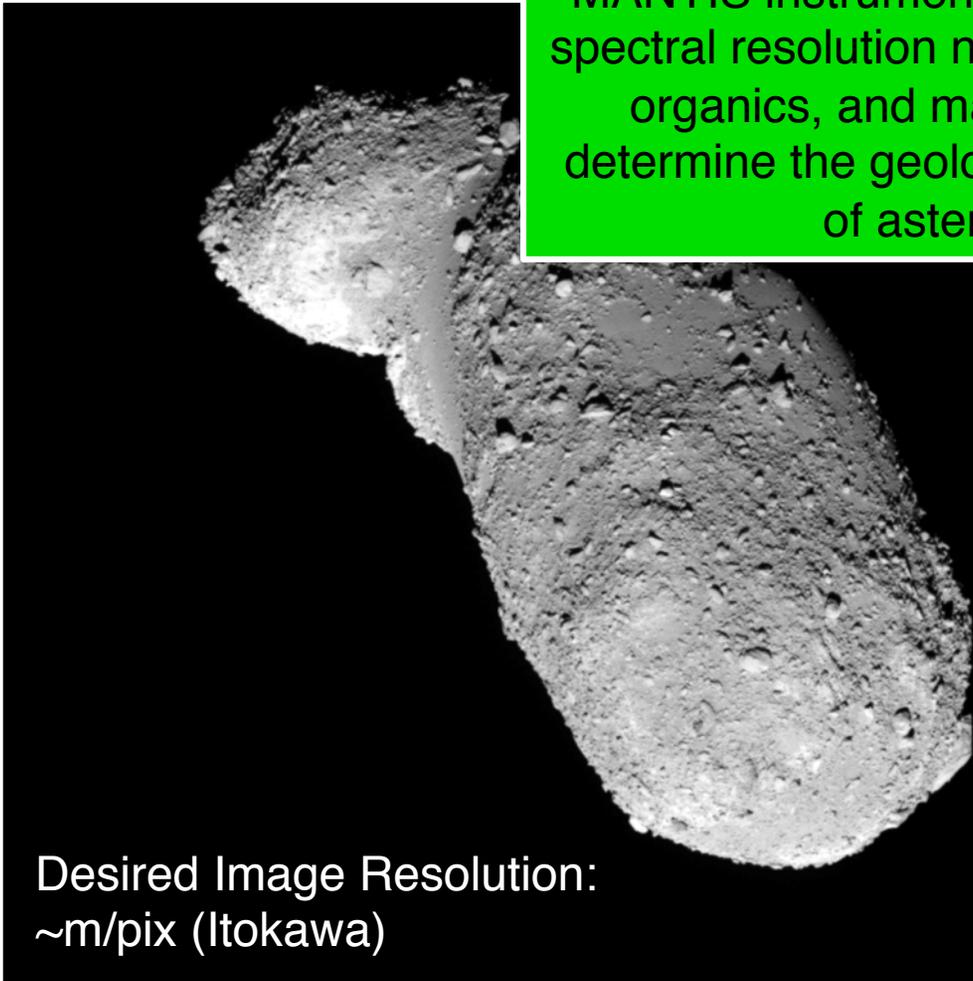


“Typical” Flyby Spectra:  
200 m/pxl (Phobos)

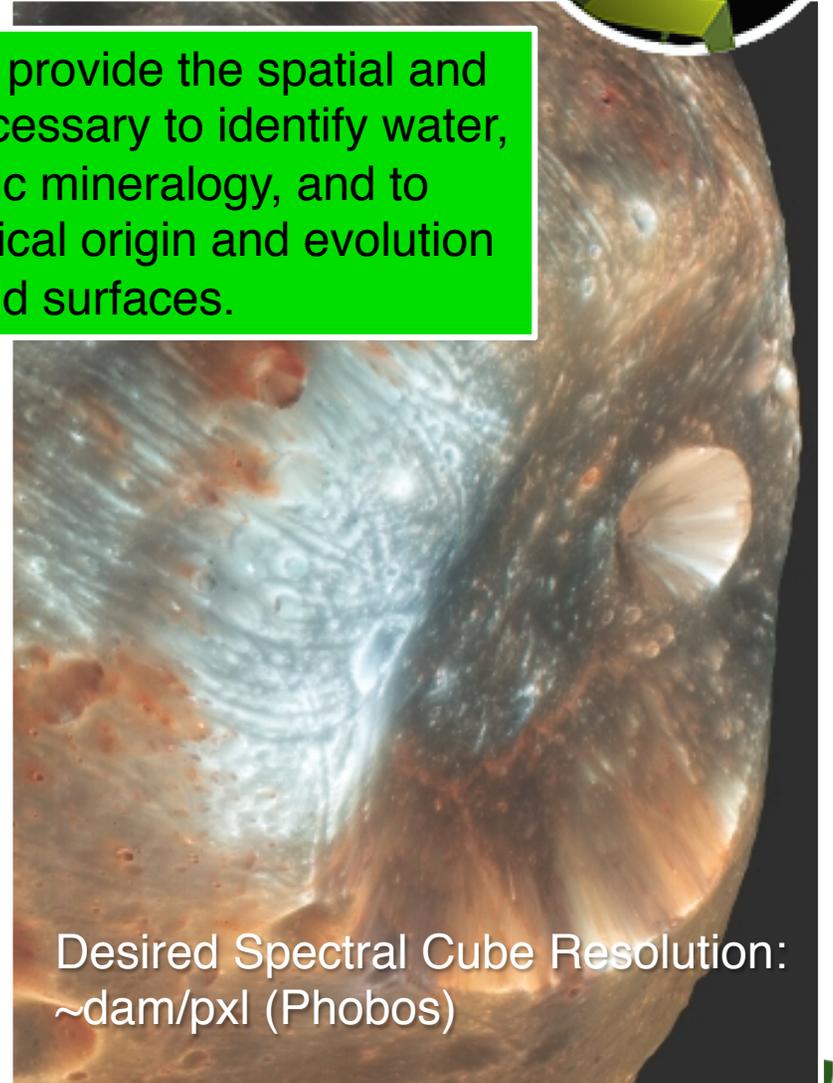
# What resolution is needed?



MANTIS instruments provide the spatial and spectral resolution necessary to identify water, organics, and mafic mineralogy, and to determine the geological origin and evolution of asteroid surfaces.



Desired Image Resolution:  
~m/pix (Itokawa)



Desired Spectral Cube Resolution:  
~dam/pxl (Phobos)



253 Mathilde -  $66 \times 48 \times 44$  km  
NEAR, 1997



433 Eros -  $33 \times 13$  km  
NEAR, 2000



951 Gaspra  
 $18.2 \times 10.5 \times 8.9$  km  
Galileo, 1991



5535 Annefrank  
 $6.6 \times 5.0 \times 3.4$  km  
Stardust, 2002



2867 Steins  
 $5.9 \times 4.0$  km  
Rosetta, 2008



Dactyl  
[(243) Ida I]  
 $1.6 \times 1.2$  km  
Galileo, 1993



4179 Toutatis  
 $4.5 \times 2.4 \times 1.9$  km  
Chang'e 2, 2012

25143 Itokawa  
 $0.5 \times 0.3 \times 0.2$  km  
Hayabusa, 2005

9969 Braille  
 $2.1 \times 1 \times 1$  km  
Deep Space 1, 1999



243 Ida -  $58.8 \times 25.4 \times 18.6$  km  
Galileo, 1993

Asteroids < 100 km in diameter for  
which we have:

-Resolved imaging data



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Asteroids < 100 km in diameter for which we have:

-Resolved imaging data

-Resolved NIR spectral data



433 Eros -  $33 \times 13$  km  
NEAR, 2000

25143 Itokawa  
 $0.5 \times 0.3 \times 0.2$  km  
Hayabusa, 2005

Asteroids  $< 100$  km in diameter for  
which we have:

- Resolved imaging data  
at  $\sim$ few m scale
- Resolved NIR spectral data

Asteroids < 100 km in diameter for  
which we have:

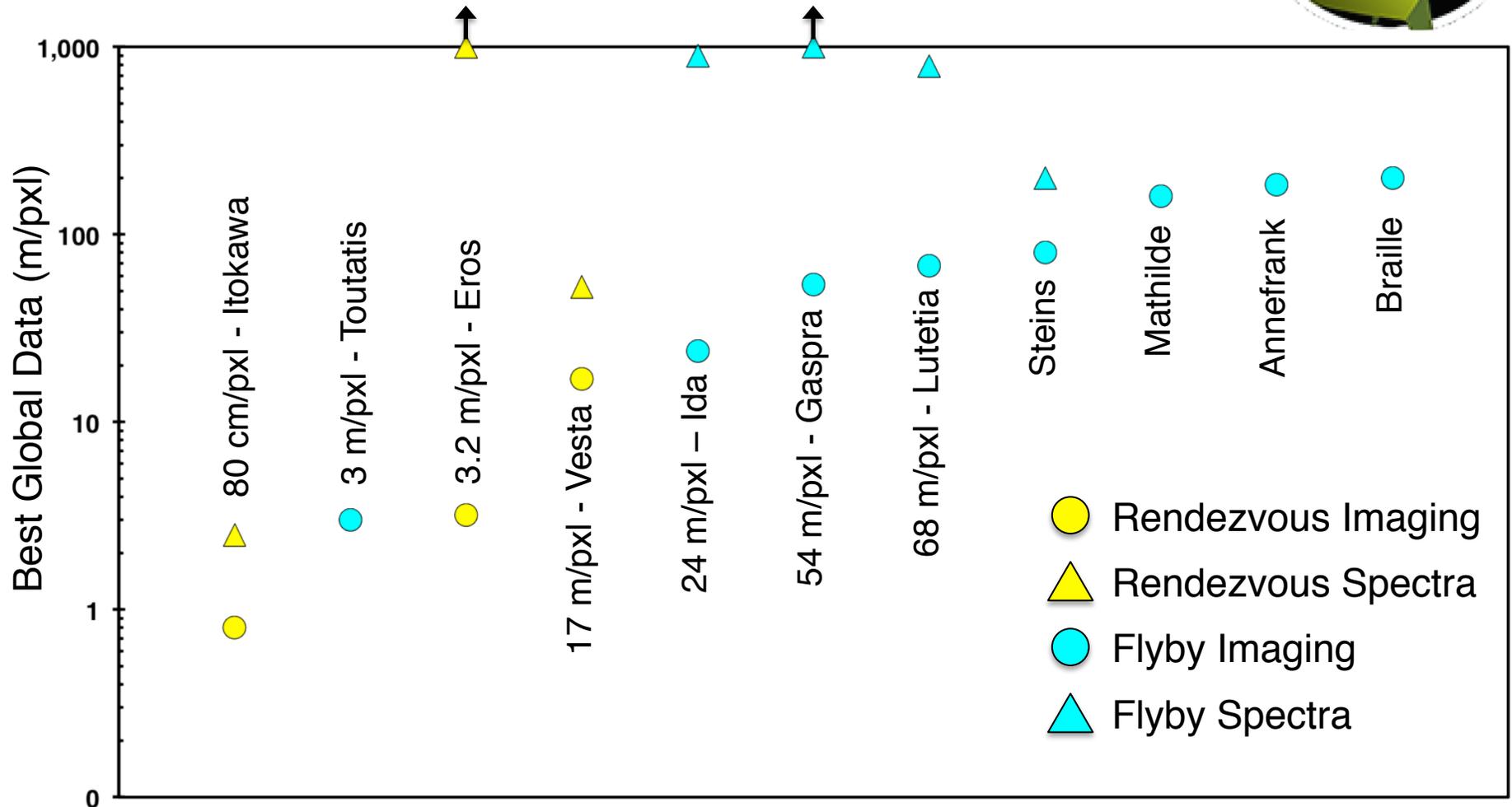
- Resolved imaging data  
at ~few m scale

- Resolved NIR spectral data  
at ~few km scale

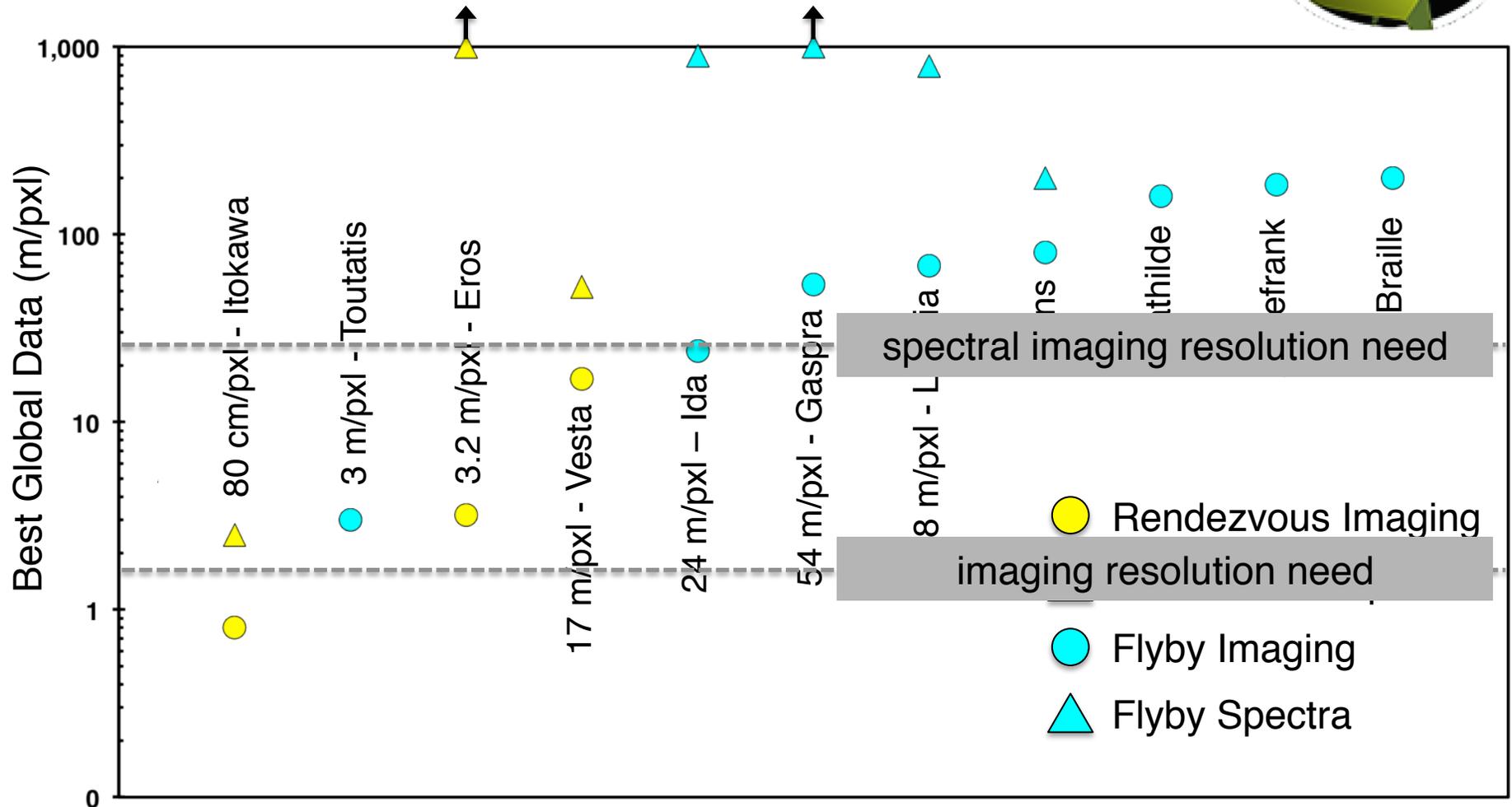
Asteroids < 100 km in diameter for  
which we have:

-Resolved thermal IR

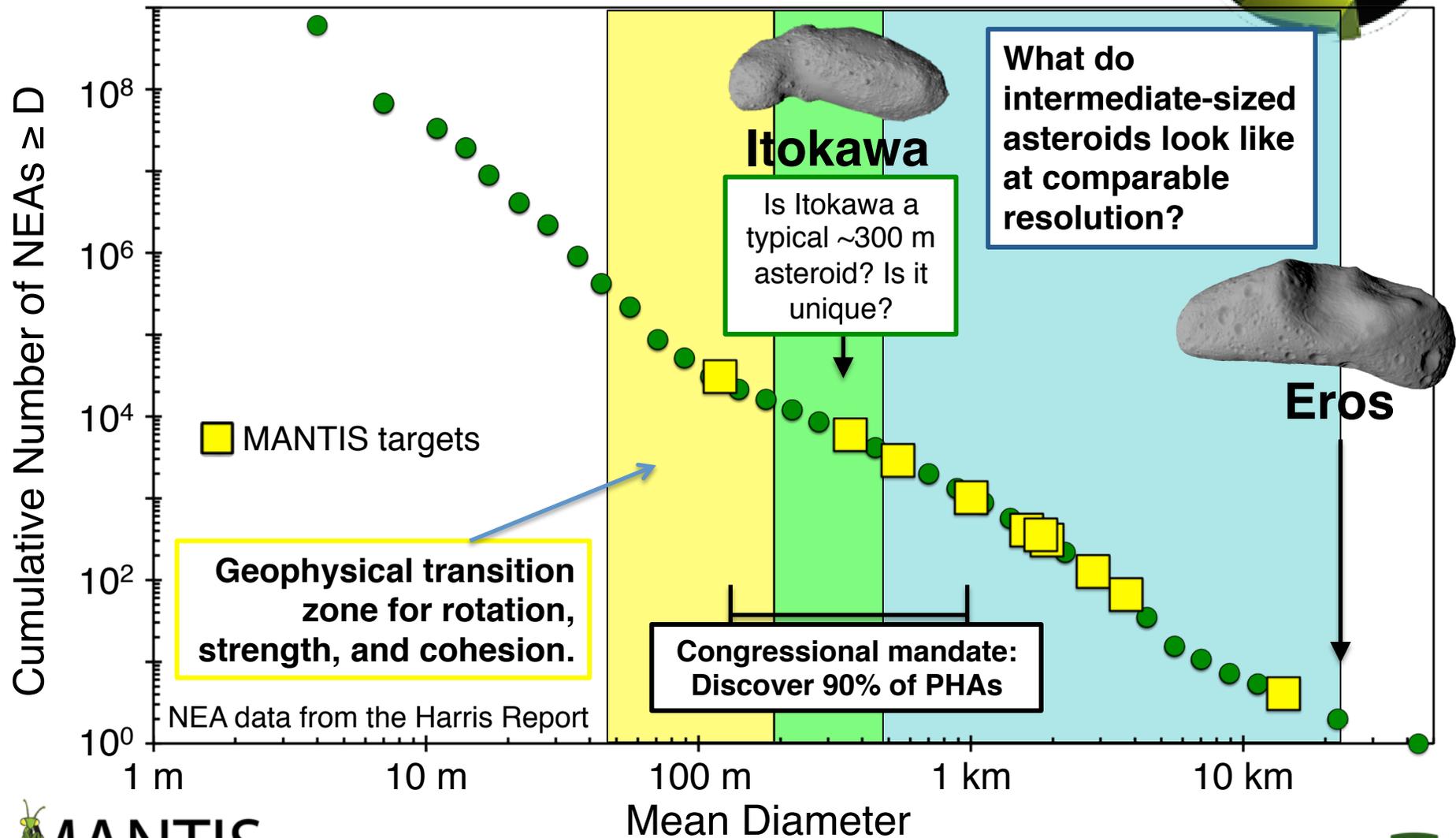
# MANTIS High-Resolution Observations Enable Rendezvous-Quality Science



# MANTIS High-Resolution Observations Enable Rendezvous-Quality Science



# MANTIS Explores the Diverse Asteroid Population

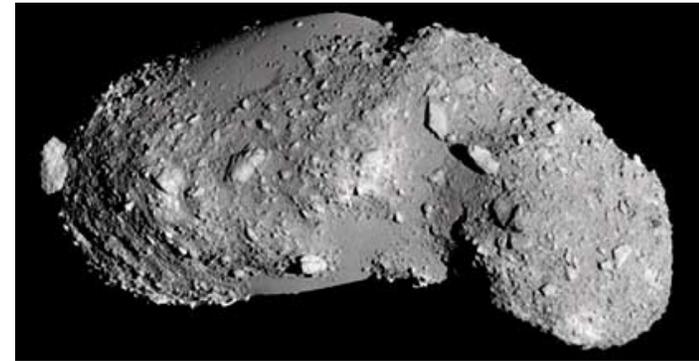
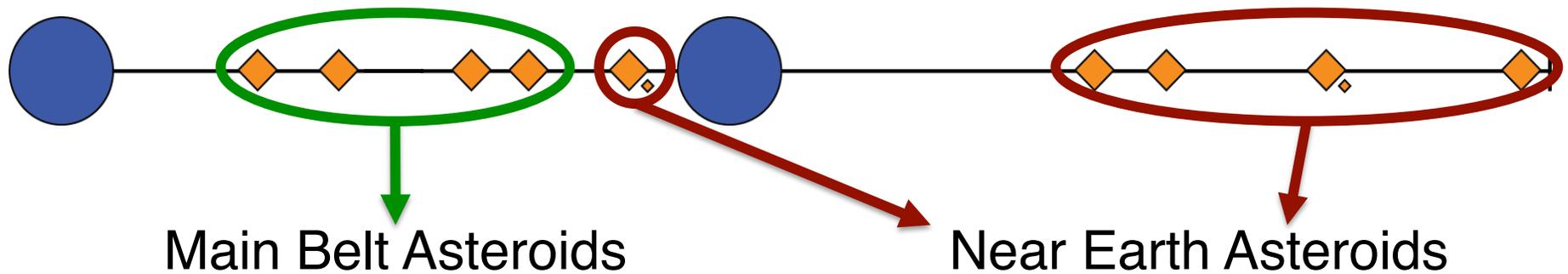


# MANTIS has a flexible set of target requirements



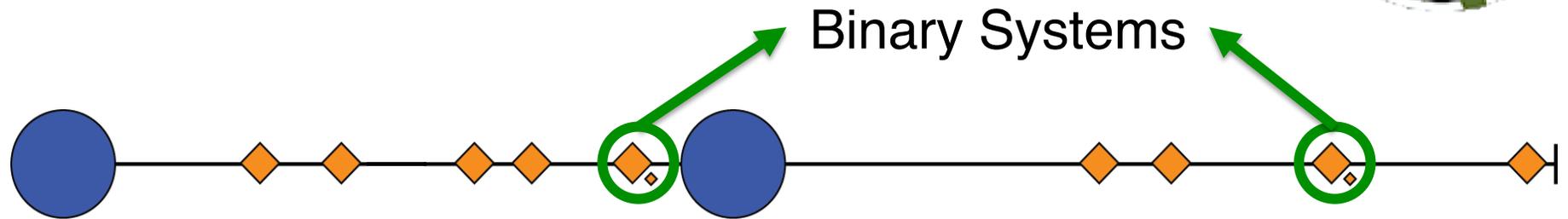
- Diverse set of targets required to answer science questions
- Physical properties databases enable identification of many targets to fulfill needs
- Many trajectories exist that provide required diversity
- Can accommodate changes in launch date, specific targets of NASA interest, etc.

# MANTIS Explores Asteroid Diversity: Location

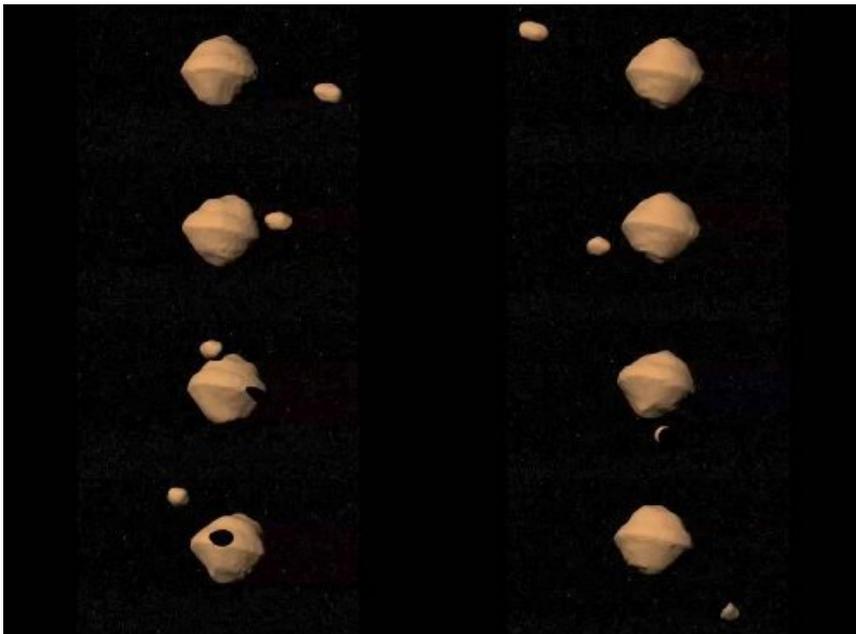


**MANTIS visits both Main Belt and Near Earth Asteroids**

# MANTIS Explores Asteroid Diversity: Multiple Asteroid Systems

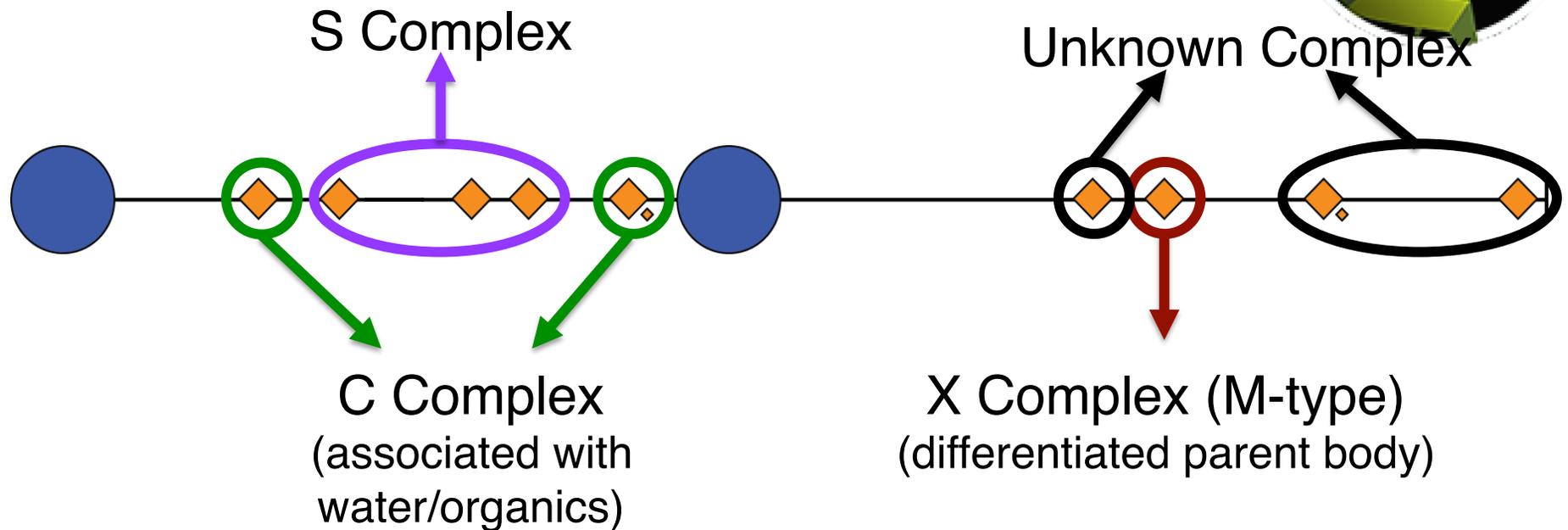


Binary Systems



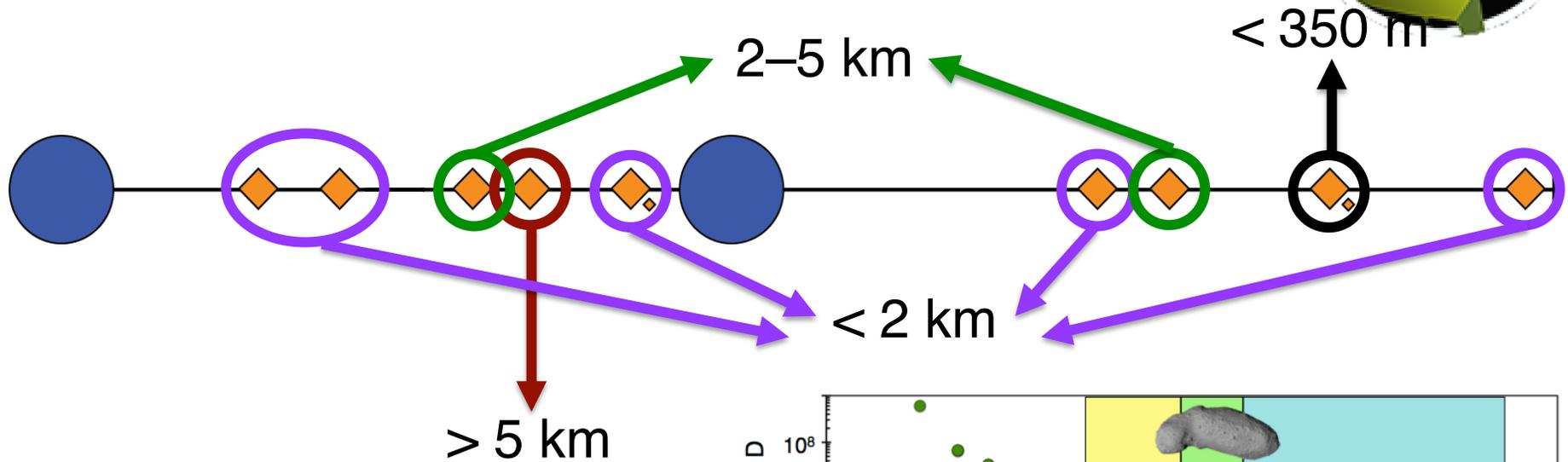
**MANTIS is the first mission  
to visit a known binary  
asteroid system**

# MANTIS Explores Asteroid Diversity: Composition

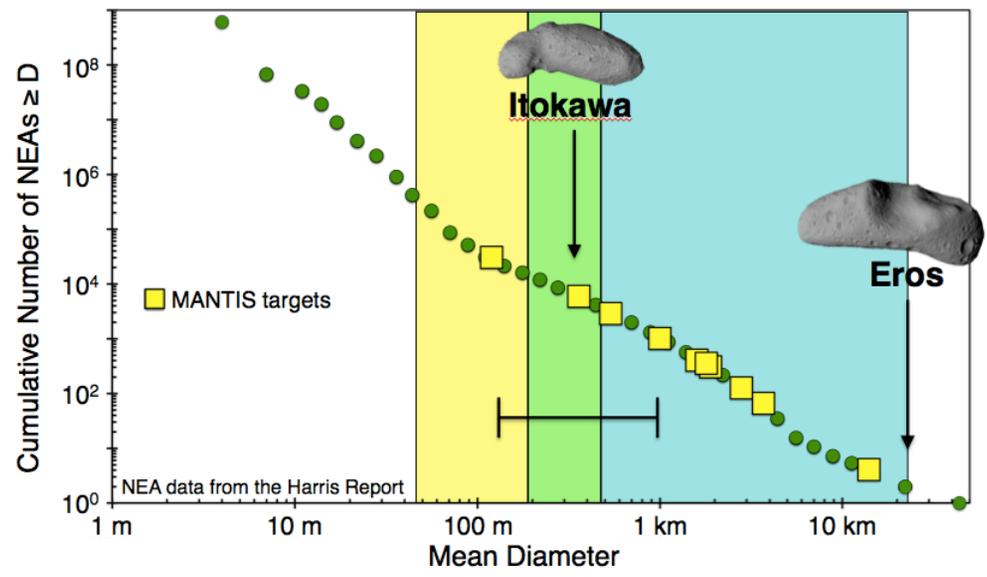


**MANTIS visits all three main spectral complexes, and is the first mission to visit an M-type asteroid**

# MANTIS Explores Asteroid Diversity: Size



**MANTIS visits a diverse size range of asteroids, including objects in four key size ranges.**



# Conclusions



- We have only begun to sample the diversity present in the asteroid population
- MANTIS visits important representatives of unsampled groups
- MANTIS delivers consistent, intercomparable datasets at all of its targets
- MANTIS augments existing asteroid data by a large multiplier
- The MANTIS concept is flexible, supporting a myriad of trajectories as priorities evolve

