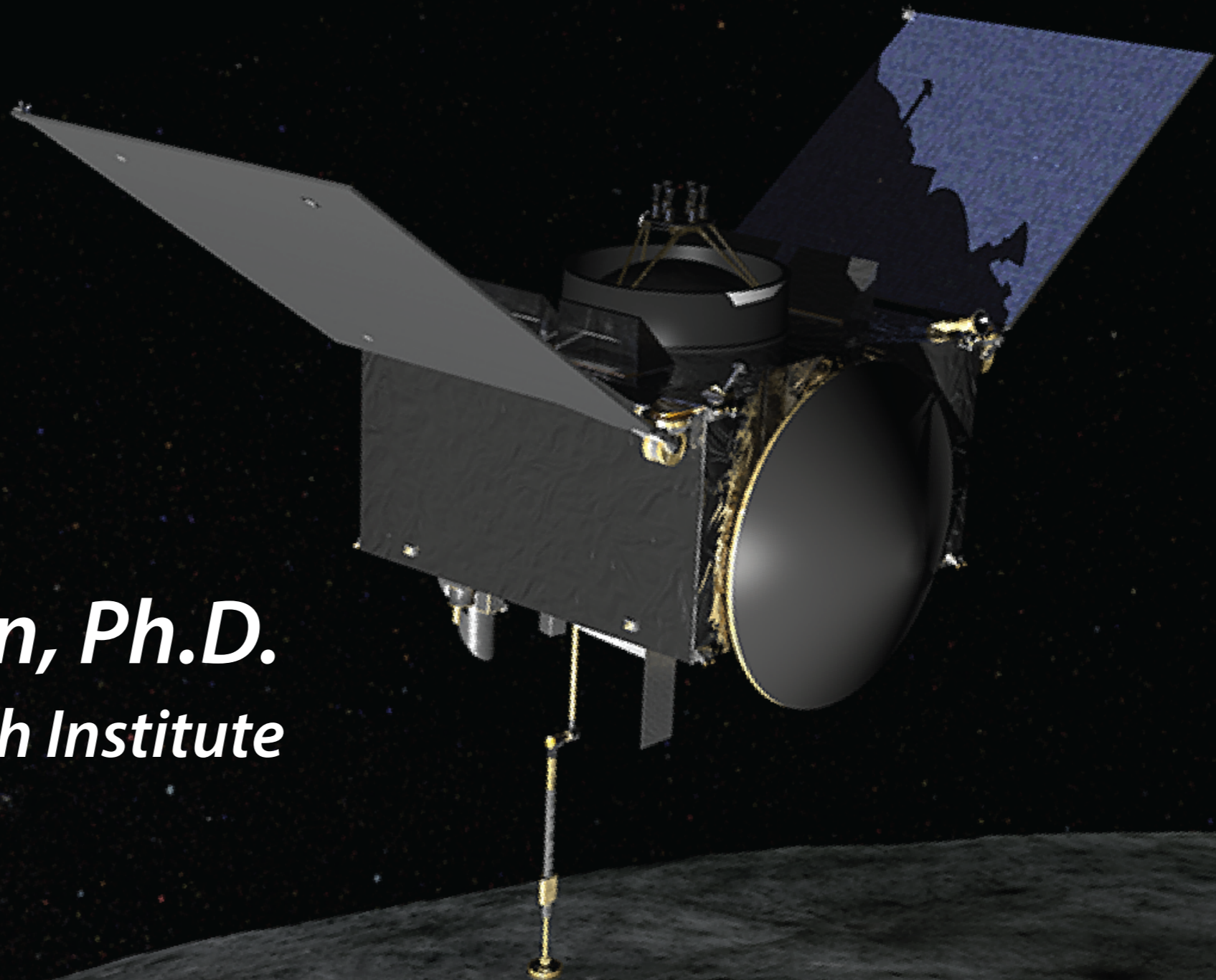




# OSIRIS-REX™

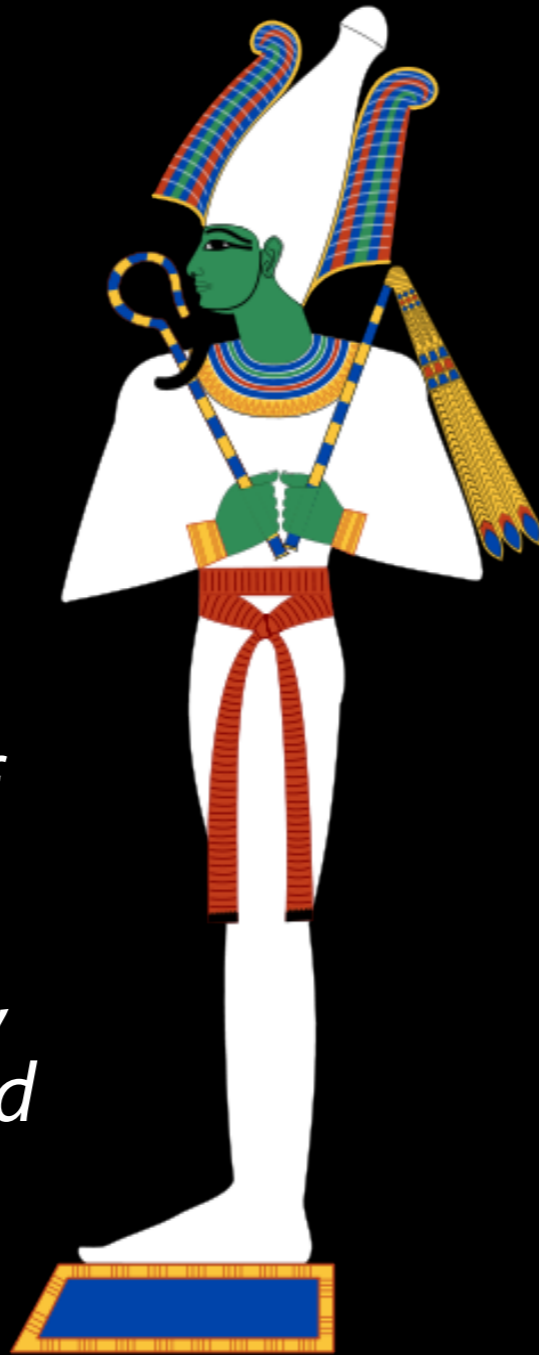
ASTEROID SAMPLE RETURN MISSION



***Vicky Hamilton, Ph.D.***  
***Southwest Research Institute***

# OSIRIS-REx Defined

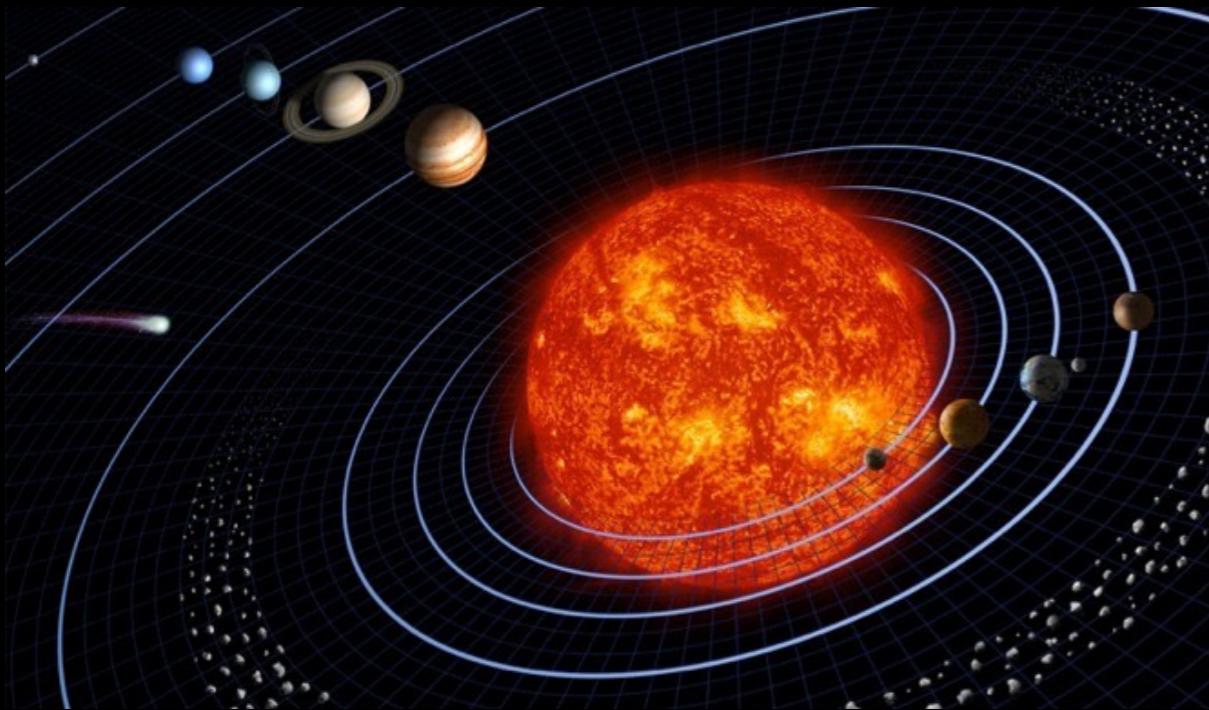
*Osiris is the Egyptian god of the afterlife, the dead, transition, resurrection, and regeneration*



- **O**rigins
  - Return and analyze a sample of pristine carbonaceous asteroid regolith
- **S**pectral **I**nterpretation
  - Provide ground truth for telescopic data of the entire asteroid population
- **R**esource **I**dentification
  - Map the chemistry and mineralogy of a primitive carbonaceous asteroid
- **S**ecurity
  - Measure the Yarkovsky effect on a potentially hazardous asteroid
- **R**egolith **E**xplorer
  - Document the regolith at the sampling site at scales down to the sub-cm

# *Exploring our Past, Securing our Future*

Revealing Solar System History



Mitigating Impact Hazards



Enabling Human Exploration

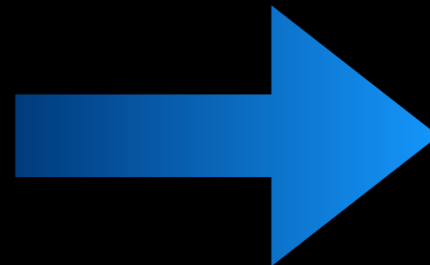


Developing a Space Economy



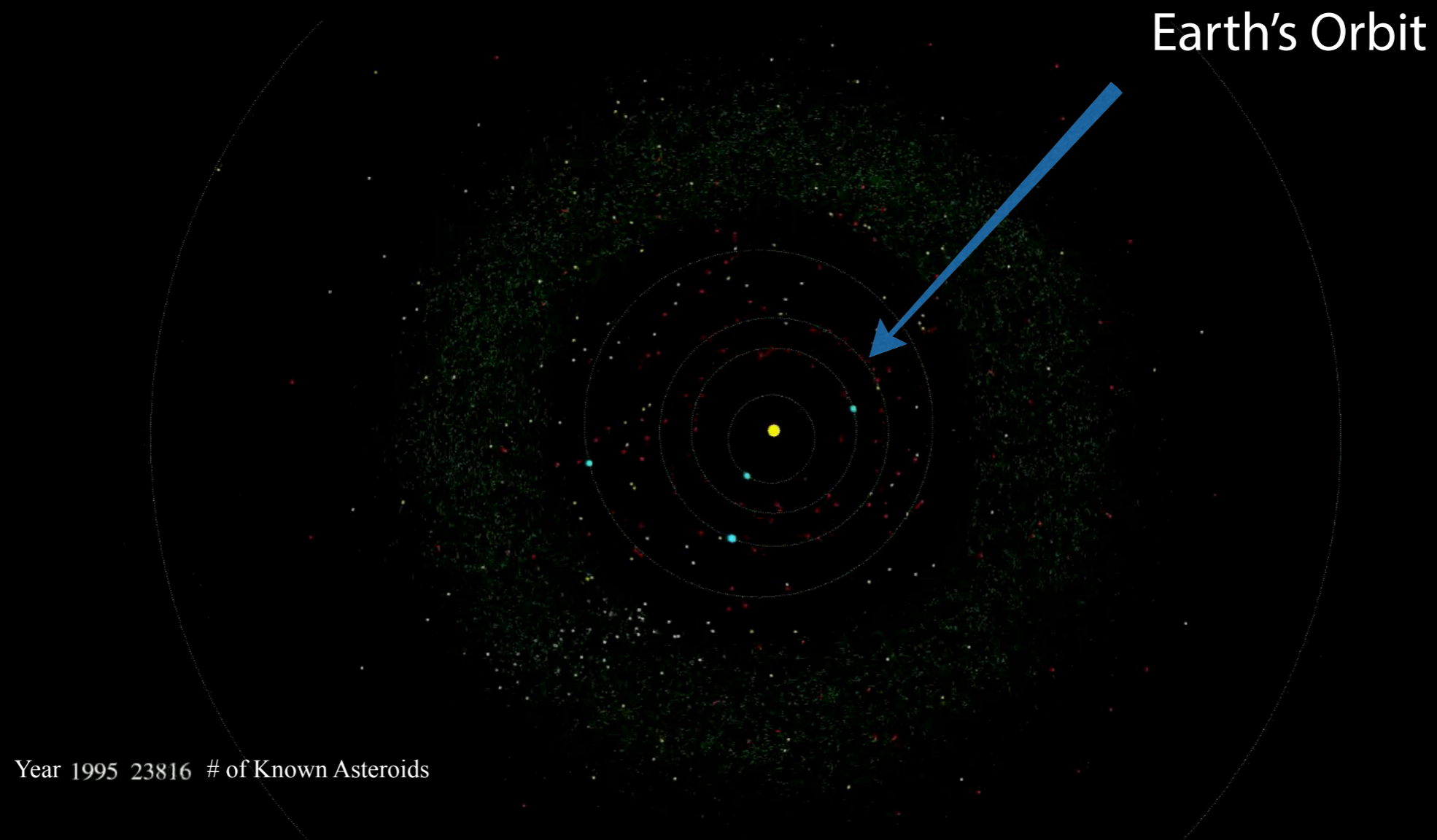
# *What is the Mission?*

OSIRIS-REx will return a sample from the early Solar System to help us understand where we came from



Dante Lauretta, Principal Investigator  
University of Arizona, Goddard Spaceflight Center, Lockheed Martin Space Systems

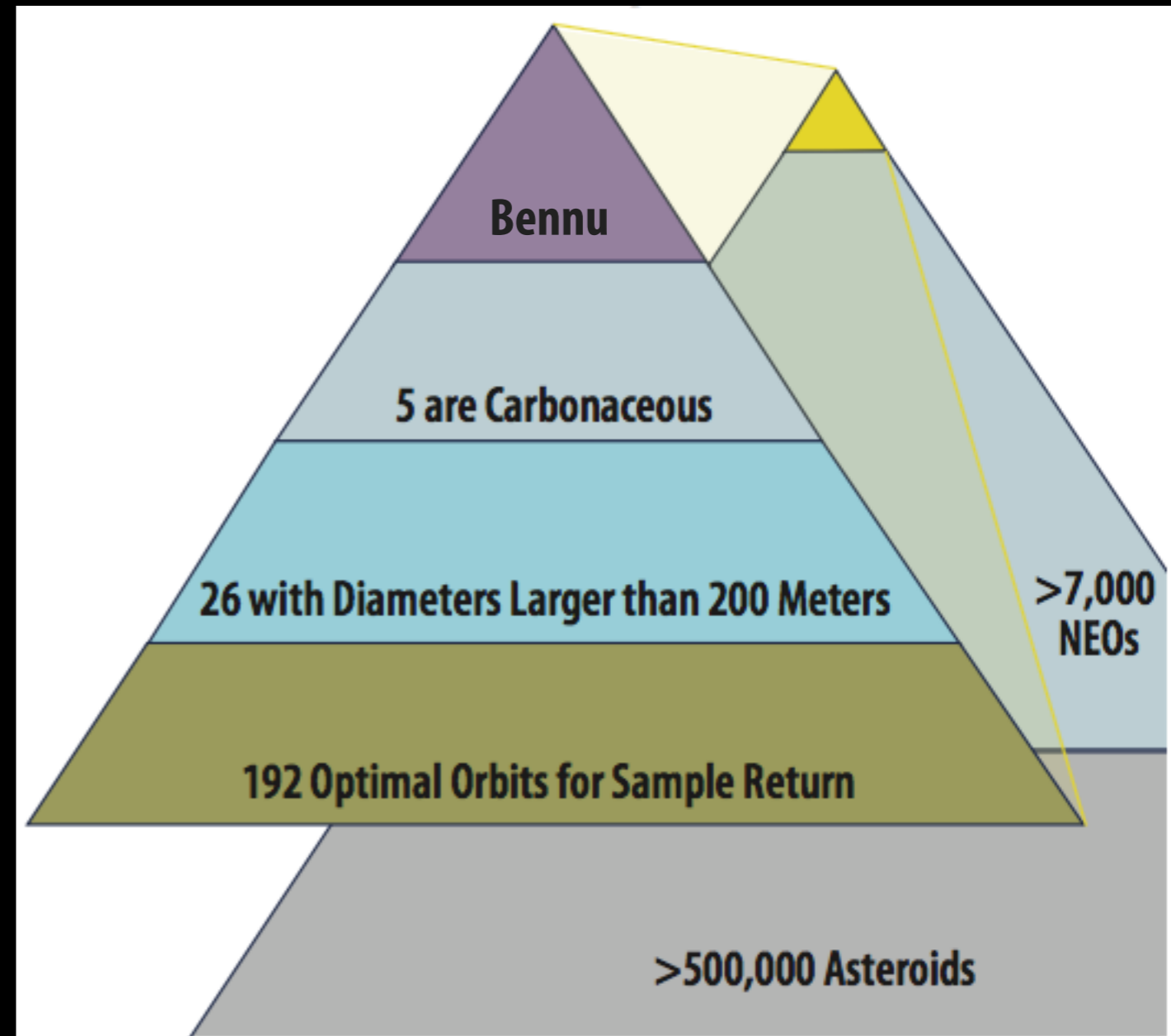
# *Which Asteroid? Lots of Choices...*



**White:** Discoveries  
**Red:** Earth-crossing asteroids  
**Yellow:** Earth-approaching asteroids  
**Green:** All others

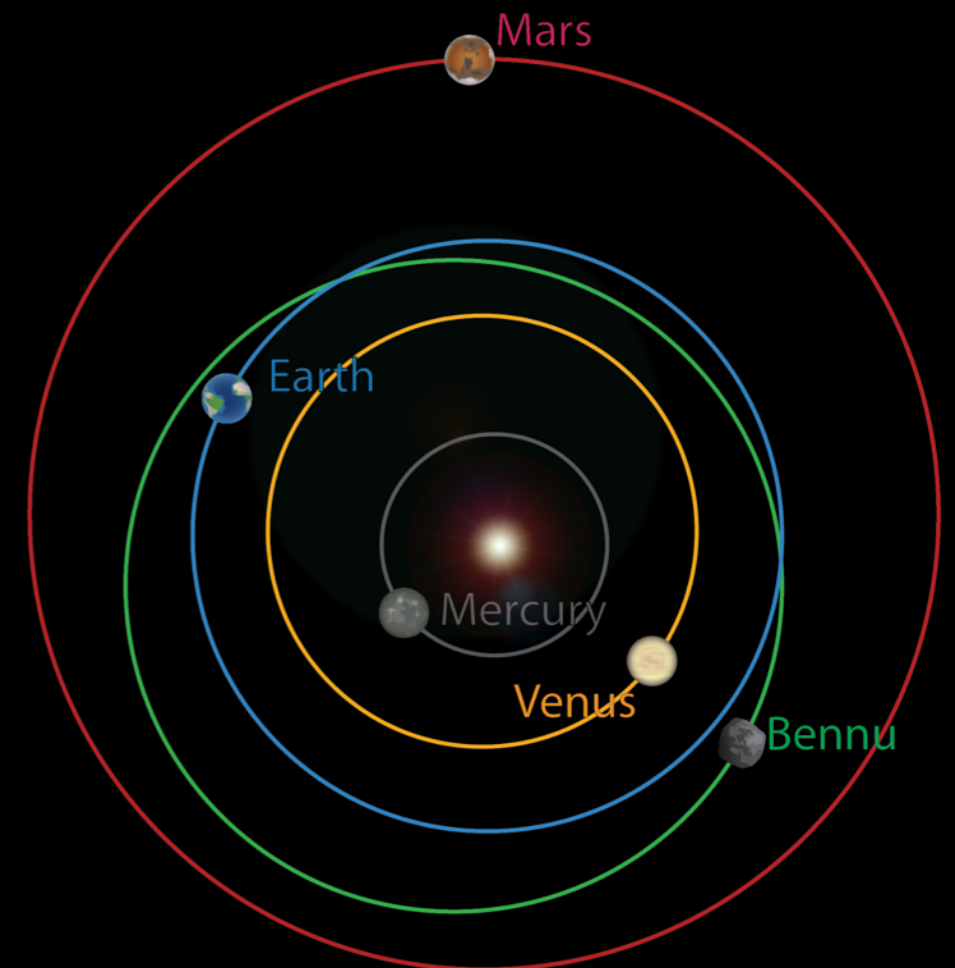
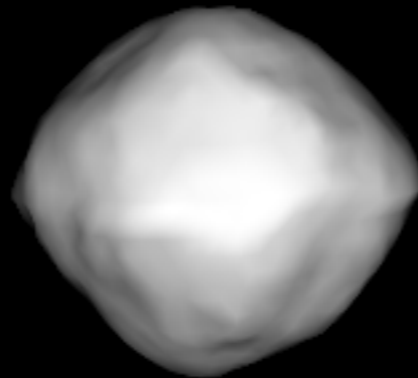
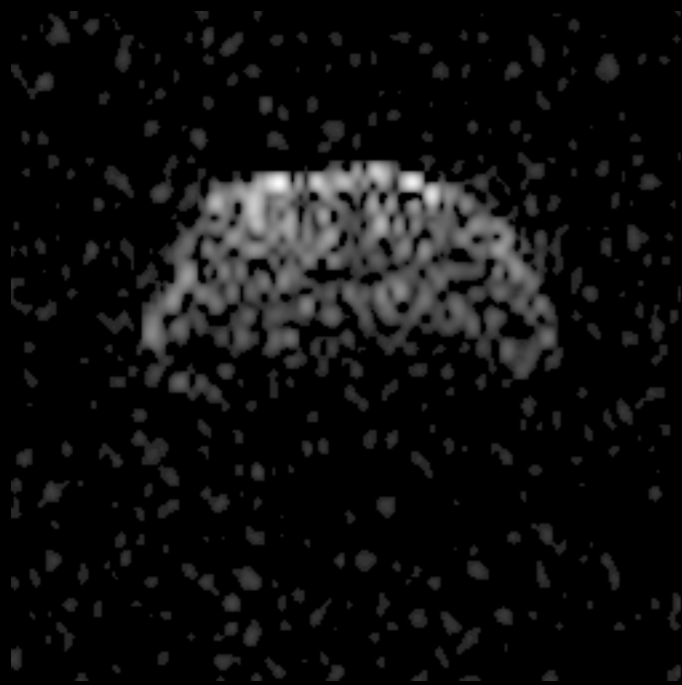
# ...*But Not Really*

- Want asteroid crossing Earth's orbit
- Distance to Sun is "just right" for return
- Big enough to rotate slowly and not eject all surface particles
- Want organics and water in minerals



# *Where Are We Going?*

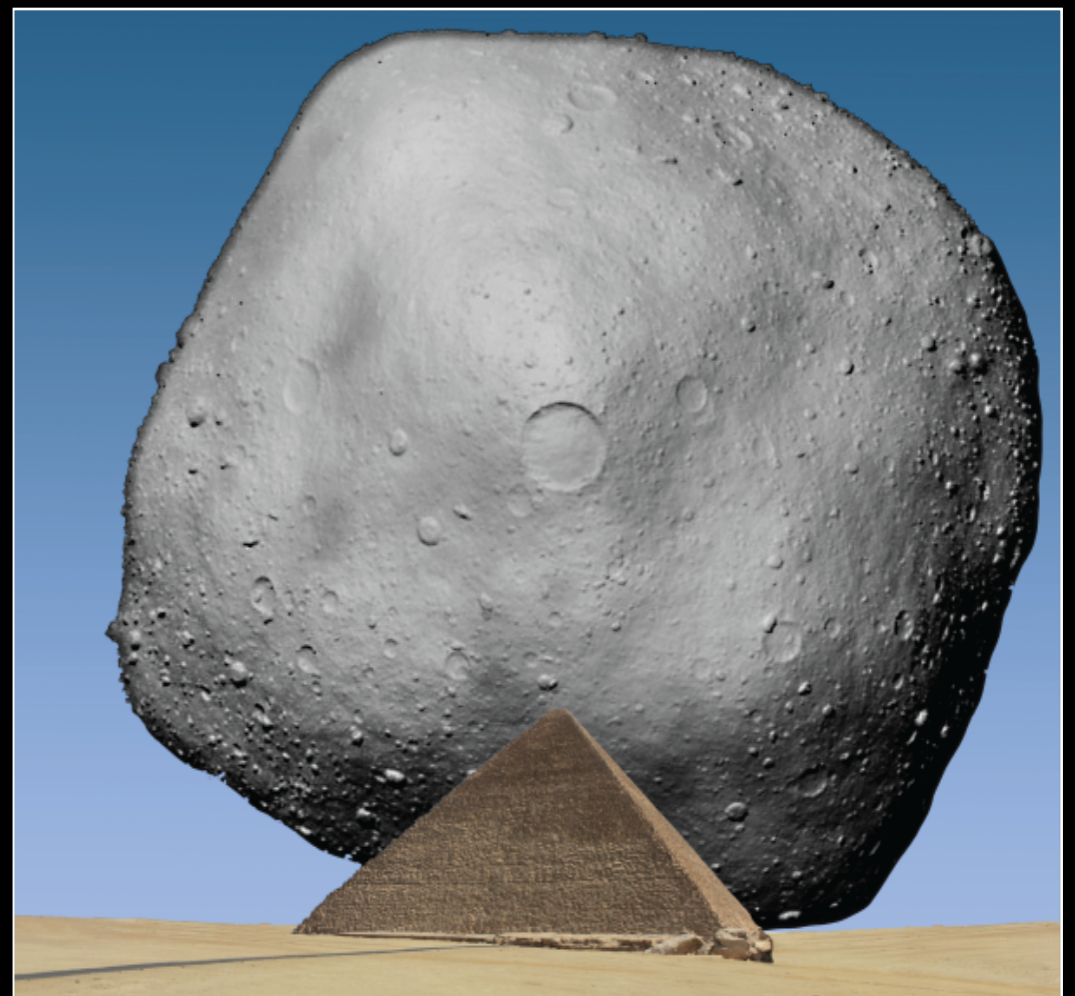
- Near-Earth Asteroid (101955) Bennu
- NC 3rd-grader Michael Puzio proposed the name in reference to the Egyptian mythological bird Bennu, a heron associated with rebirth & Osiris



# *Bennu Fast Facts*

- Near-Earth asteroid
- About 500 meters (1/3 mile) diameter
- 4.3-hour rotation period
- 436.6-day orbit of Sun
- Collection of materials into a rubble pile
- Ancient carbon and volatiles such as water
- Potential hazard to Earth (0.037% between 2175 - 2196)

*A time capsule from the early Solar System!*



*We will return at least 60 grams (2.1 ounces) and possibly as much as 2 kg (4.4 pounds)*



# *Defining the Mission*

## *Fundamental Questions*

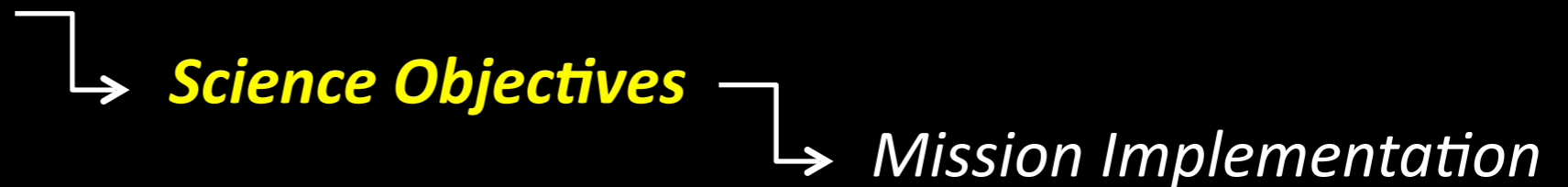
*Science Objectives*

*Mission Implementation*

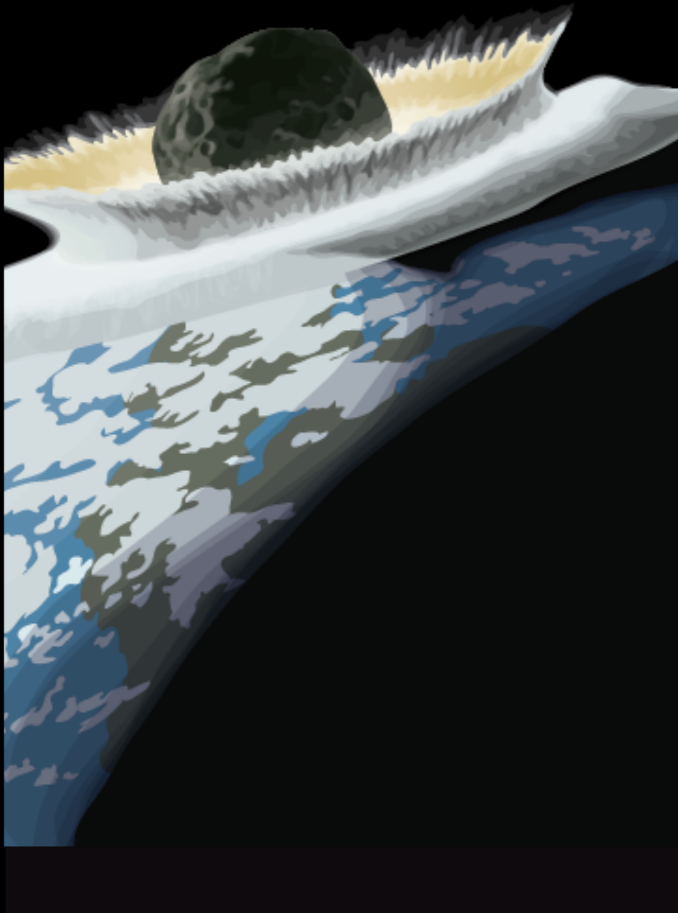
1. How did the Solar System form?
2. What kinds of materials exist in the Solar System?
3. How did life evolve in the Solar System?
4. Are asteroids bringers of life or death - *or both?*

# Defining the Mission

Fundamental Questions



- Map the asteroid & pick sample site
- Document the sample site and obtain the sample
- Return the sample and analyze
- Ground-truth observations
- Refine orbital deviations

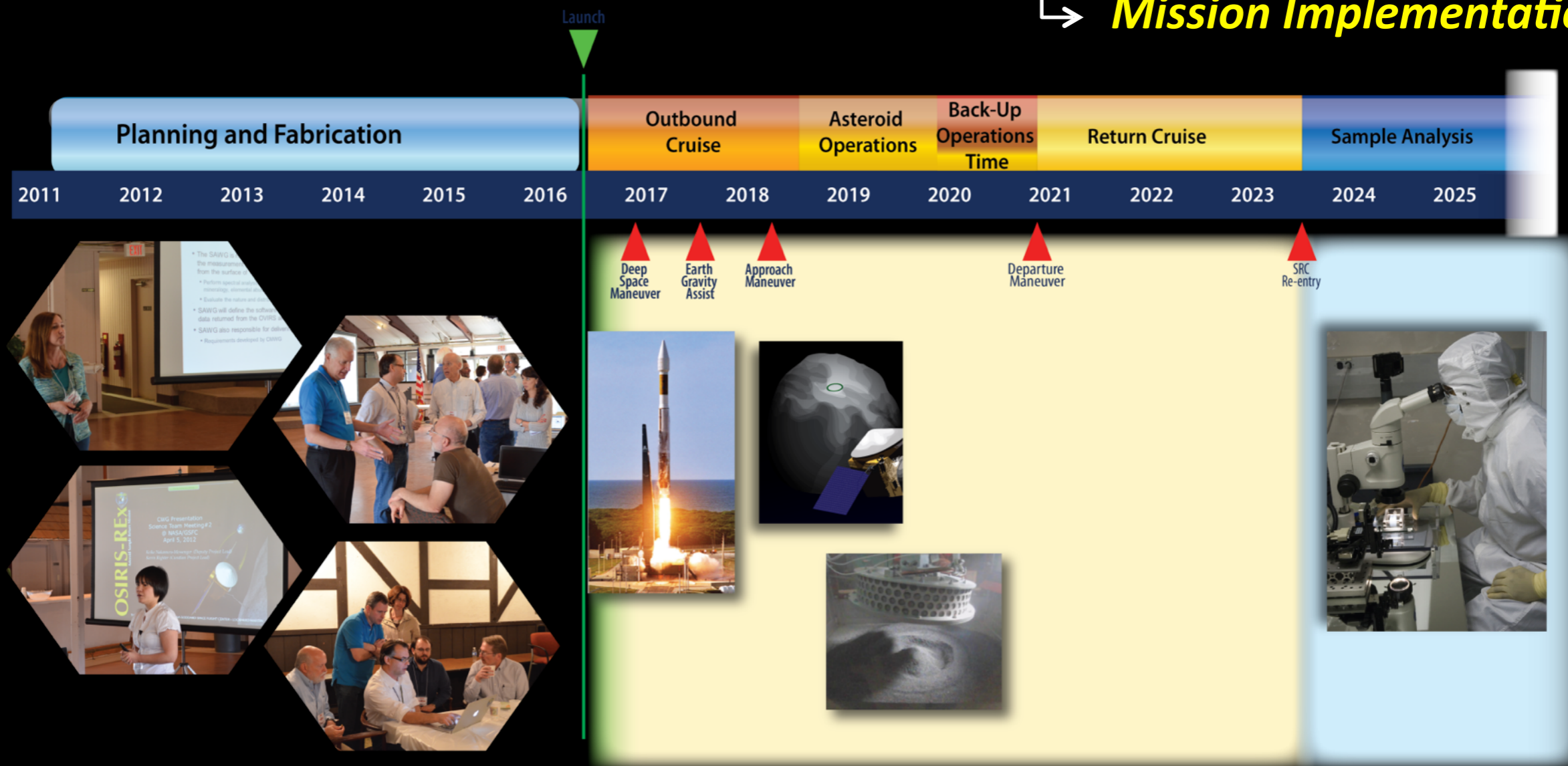


# Defining the Mission

Fundamental Questions

Science Objectives

Mission Implementation



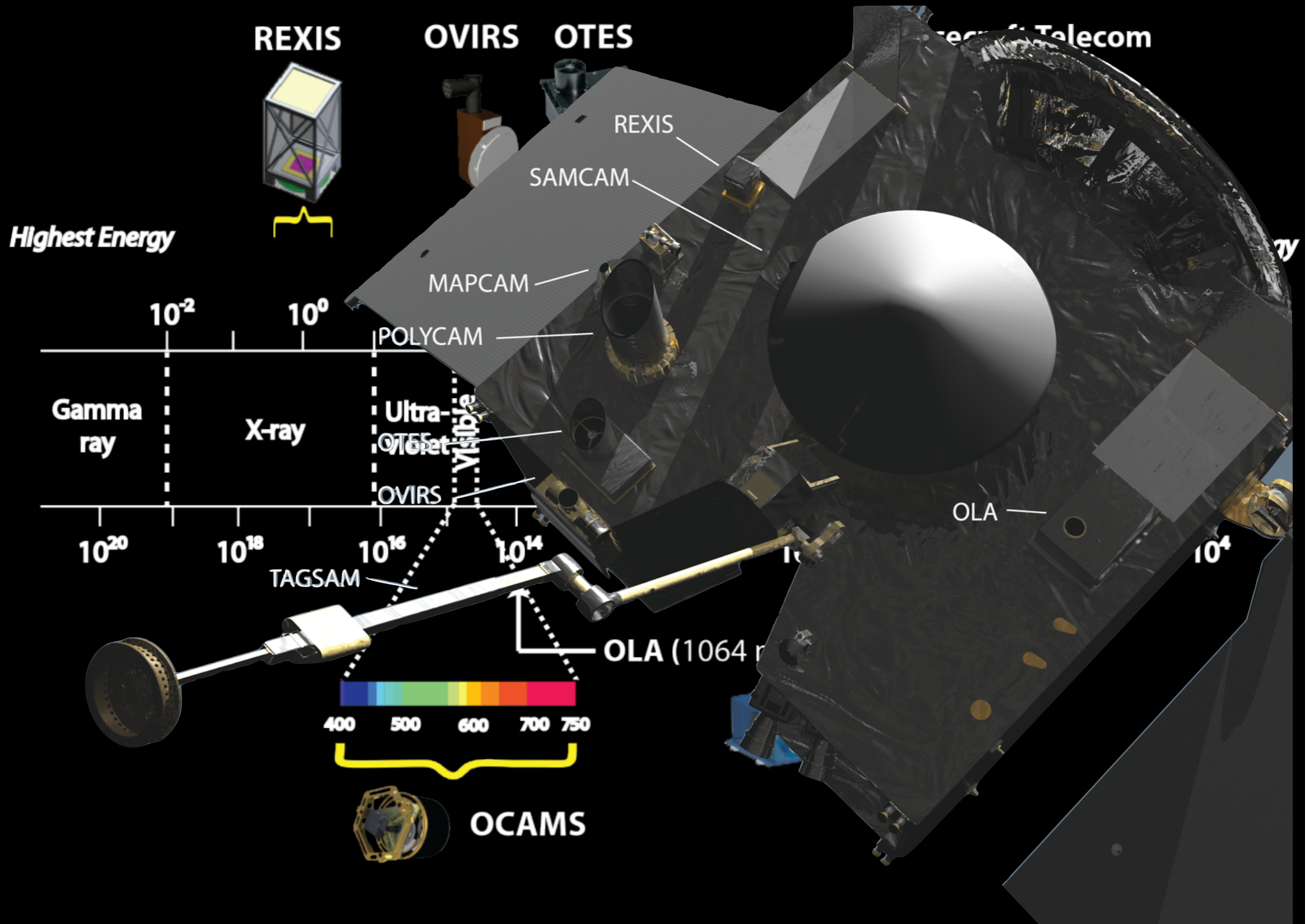
Students in this audience could be on teams analyzing OSIRIS-REx samples!

# *The Spacecraft*

- 2 meters (6.6 feet) per side
- 8.5 m<sup>2</sup> (91 sq. ft.) of solar panels
- 5 science instruments
- Touch-and-Go Sample Acquisition Mechanism (TAGSAM)
- Sample Return Capsule (SRC)

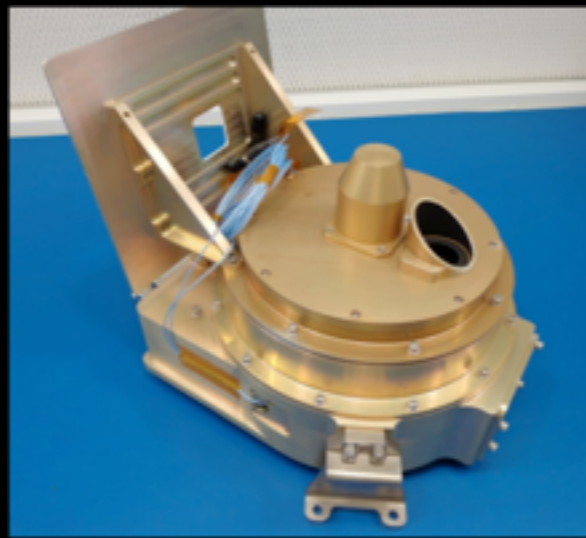
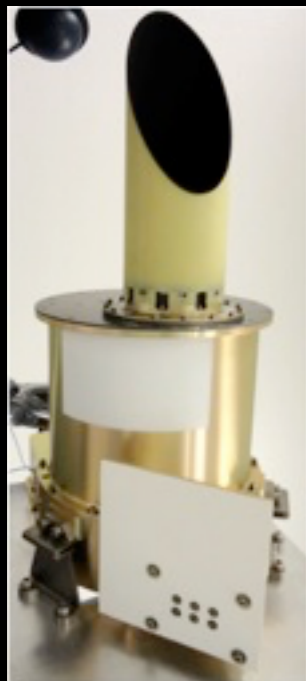
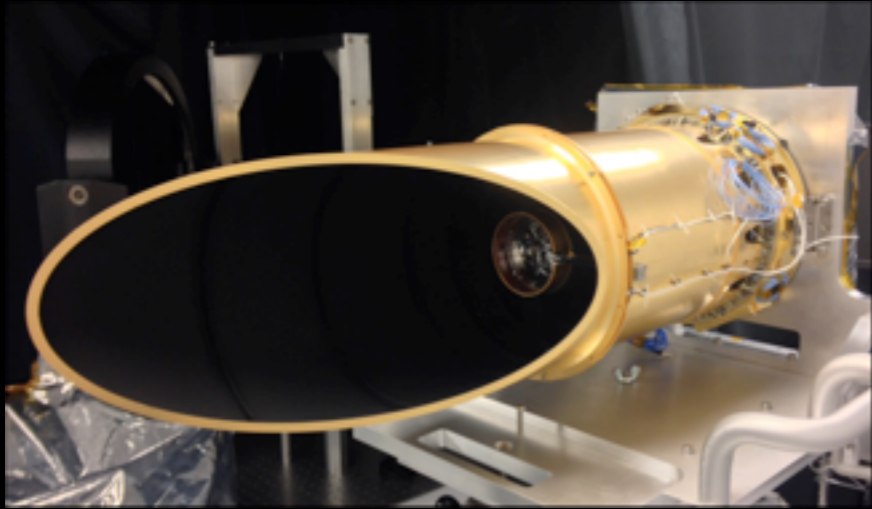


# How We Will Study Bennu



# *The Payload*

- OSIRIS-REx Camera Suite (OCAMS)
  - *PolyCam* is first to see Bennu from >500,000-km range, performs star-field OpNav, and performs high-resolution surface imaging
  - *MapCam* performs filter photometry, maps the surface, and images the sample site
  - *SamCam* images the sample site, documents sample acquisition, and images TAGSAM to evaluate sampling success



University of Arizona  
Bashar Rizk, Instrument Scientist

# *The Payload*



Contribution of the  
Canadian Space Agency  
Mike Daly, Instrument Scientist

- **OSIRIS-REx Laser Altimeter (OLA)**
- Provides ranging data out to 7 km and maps the asteroid shape & surface topography

# *The Payload*

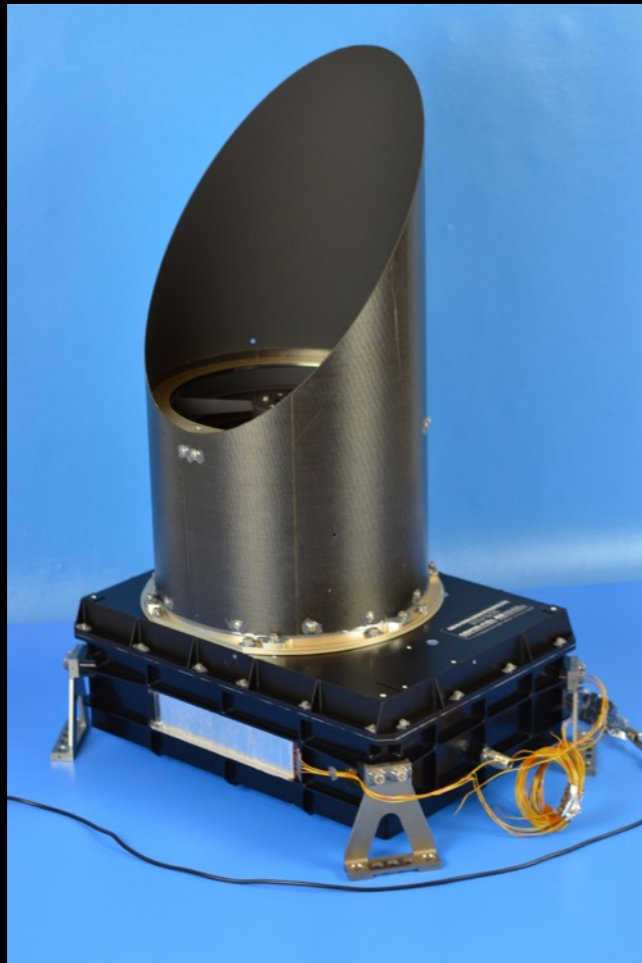


- **OSIRIS-REx Visible and Infrared Spectrometer (OVIRS)**
  - Maps spectral properties from 0.4 – 4.3  $\mu\text{m}$
  - Measures albedo

Goddard Space Flight Center  
Dennis Reuter, Instrument Scientist



# *The Payload*



- **OSIRIS-REx Thermal Emission Spectrometer (OTES)**
- Maps spectral properties from 5.5 – 50  $\mu\text{m}$
- Measures thermal flux

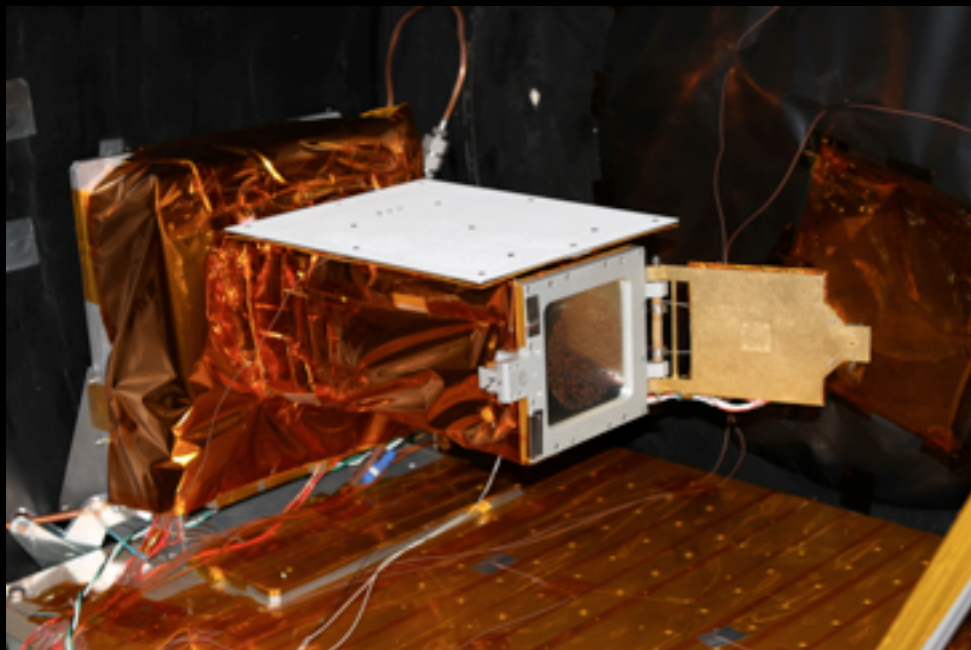
Arizona State University  
Phil Christensen, Instrument Scientist

# *The Payload*



University of Colorado, Boulder  
Dan Scheeres, Radio Science Lead

- **Radio Science** reveals the mass, gravity field, internal structure, and surface acceleration distribution
- **The Regolith X-ray Imaging Spectrometer (REXIS)** student experiment maps the elemental abundances of the asteroid surface

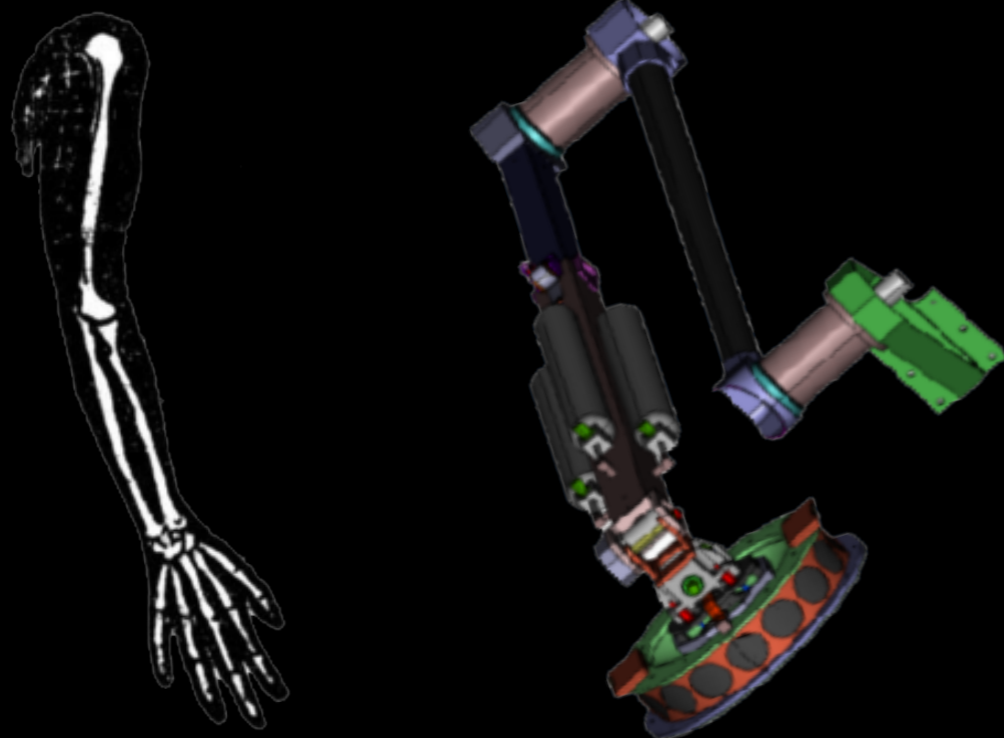


Massachusetts Institute of Technology  
Rick Binzel, Instrument Scientist

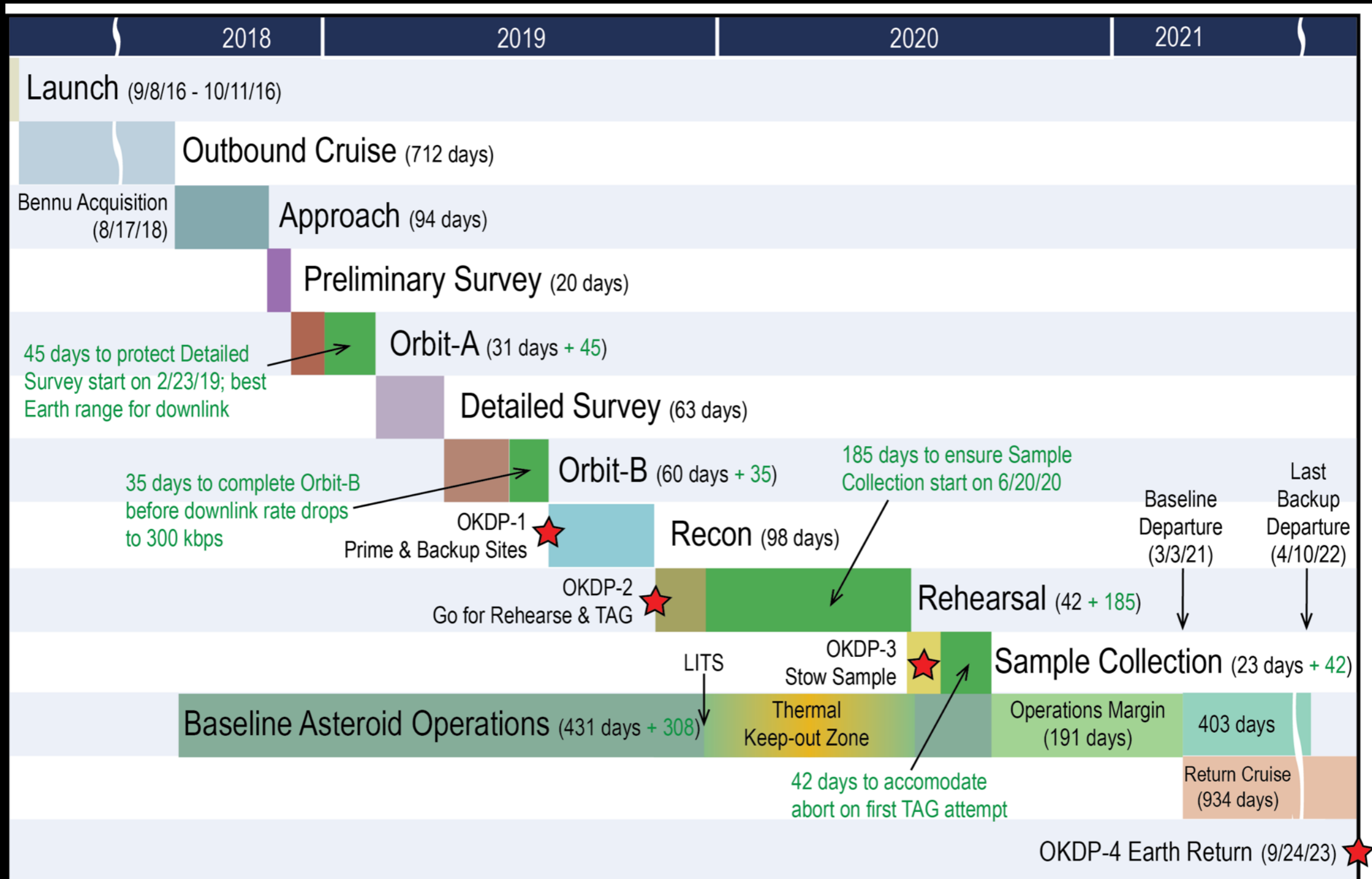
# *The Payload*



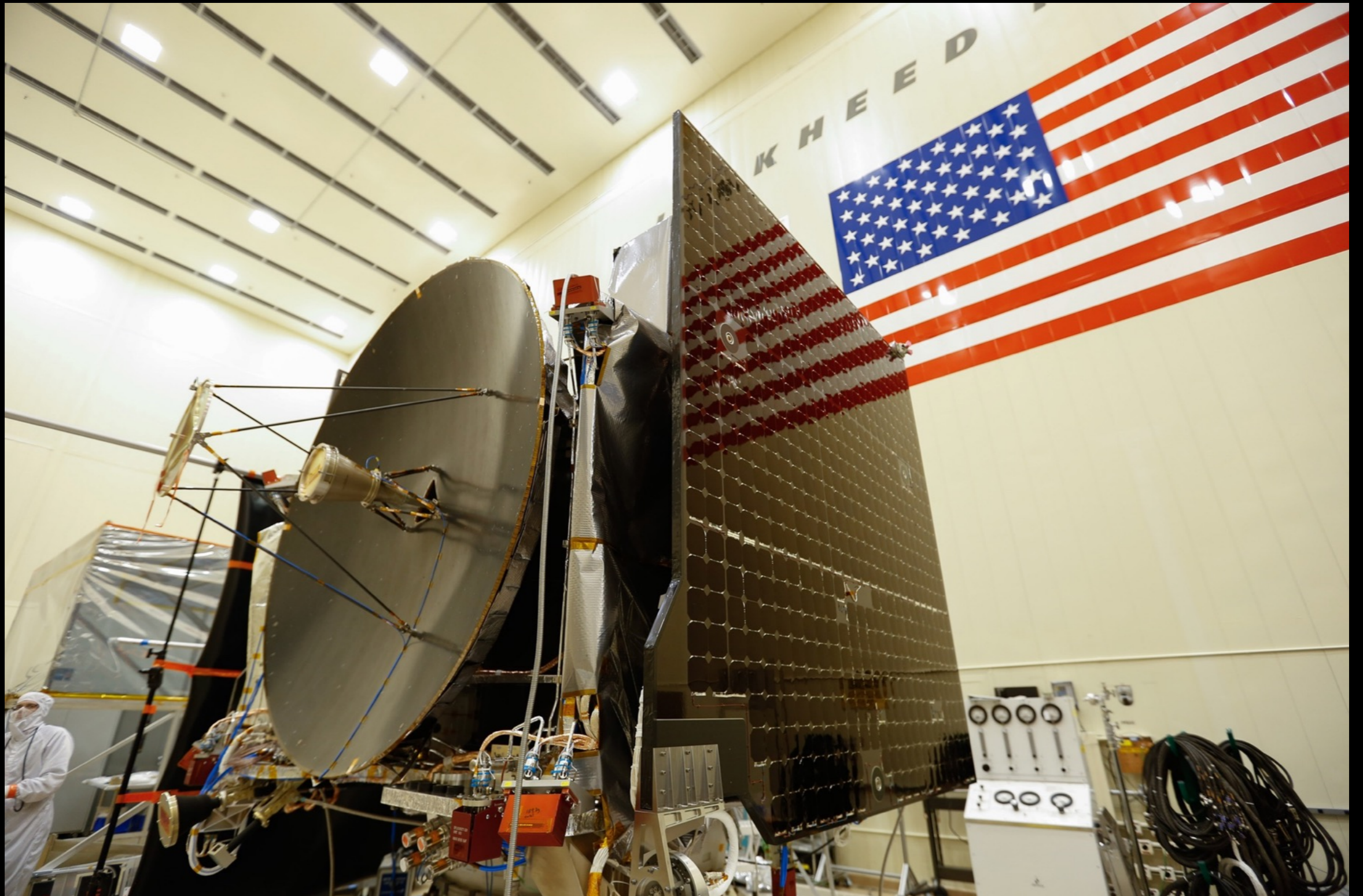
- The Touch-and-Go Sample Acquisition Mechanism (TAGSAM) collects the sample
- Equipped for three tries



# Mission Timeline



# *OSIRIS-REx Spacecraft After Assembly and Testing Operations*



# *Arriving at NASA's Kennedy Space Center*











RESTRICTED  
AREA  
PGOC  
SAFETY



BALLYMOR

EXIT

NOTICE

NOTICE

CHANGE

















# *OSIRIS-REx Launched!*

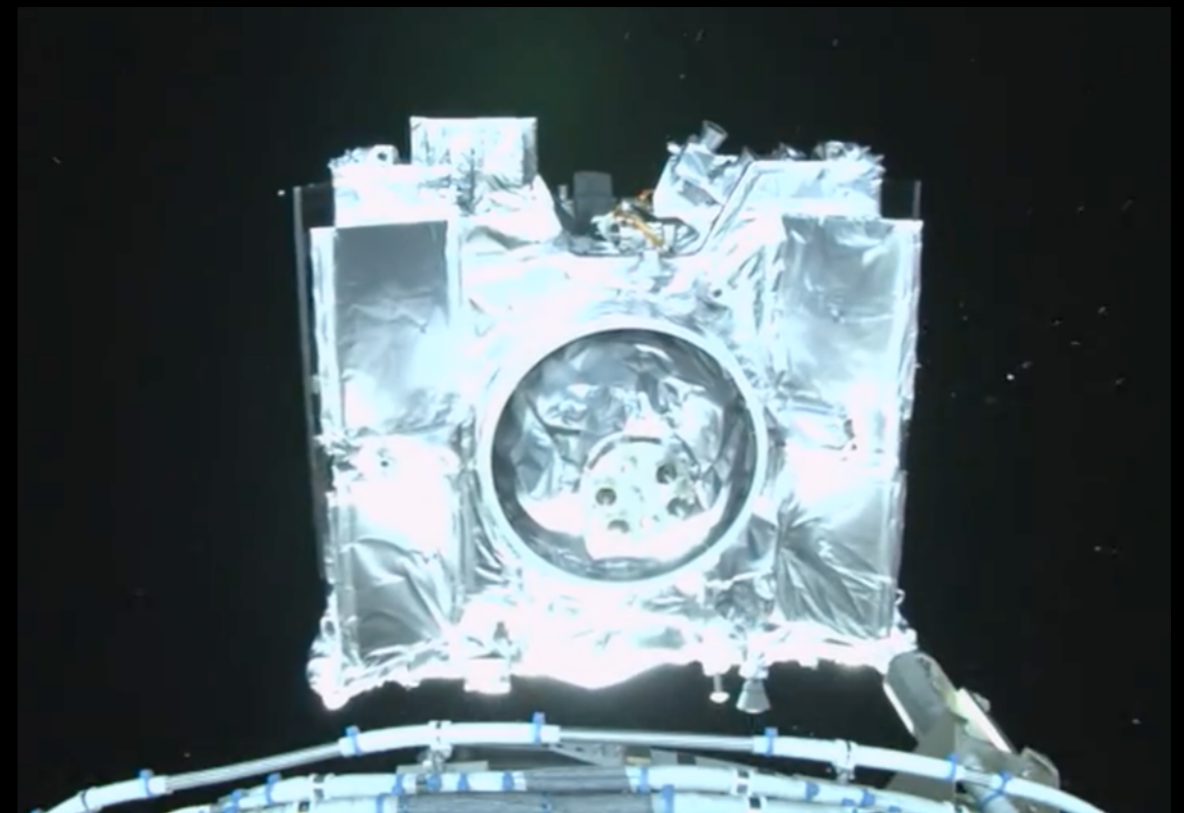
- OSIRIS-REx launched 8 September 2016 at 7:05 pm EDT on an Atlas V 411
- Liftoff occurred 180 ms into the opening of our window
- Vehicle performance was near-perfect



J.D. SEKORA / SEKORAPHOTO

# *Spacecraft Status*

- Spacecraft operations have been “nominal”
- Post-launch instrument aliveness checkouts occurred in late September and all are operating as expected



OSIRIS-REx spacecraft at separation

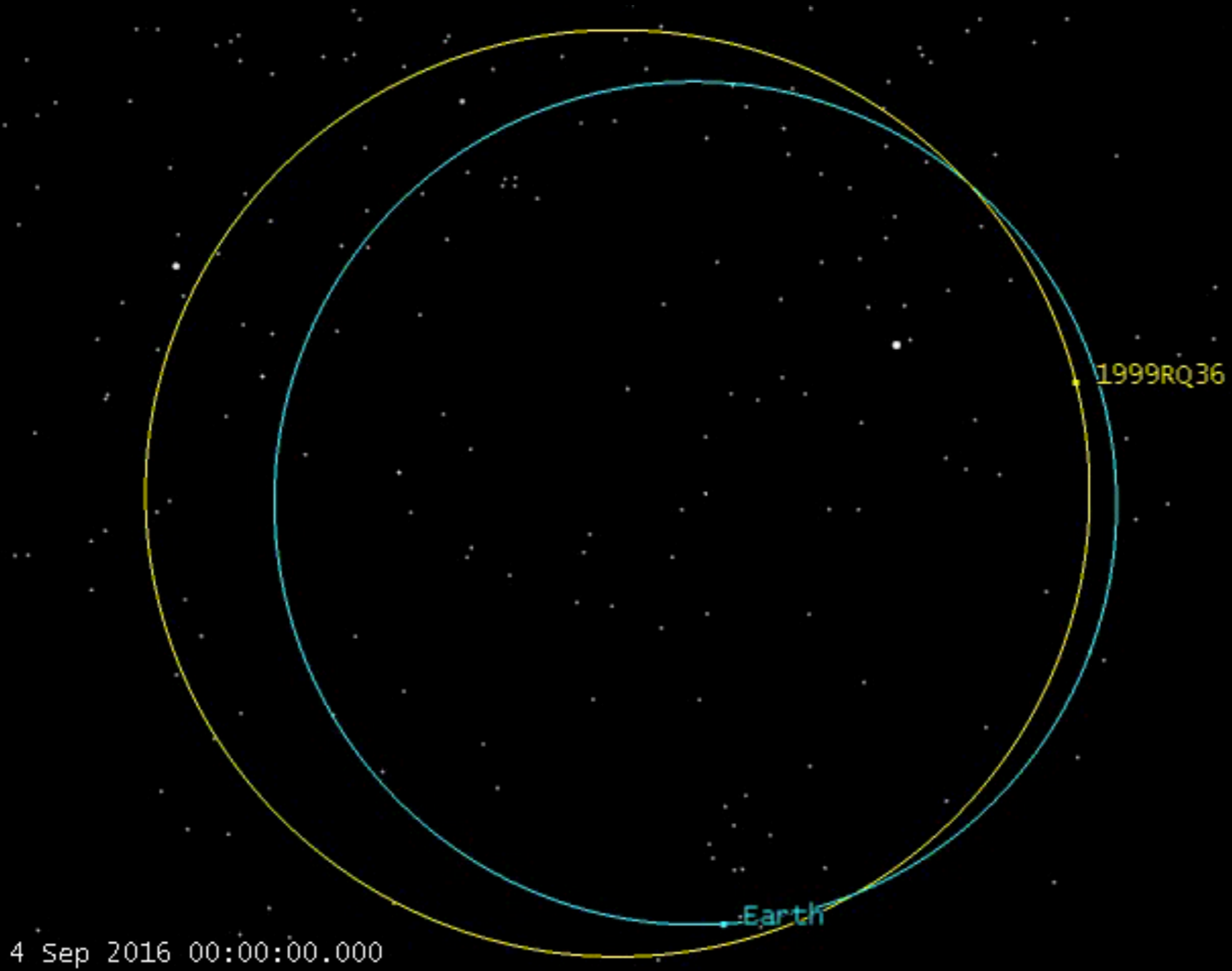
# *First Image from MapCam*



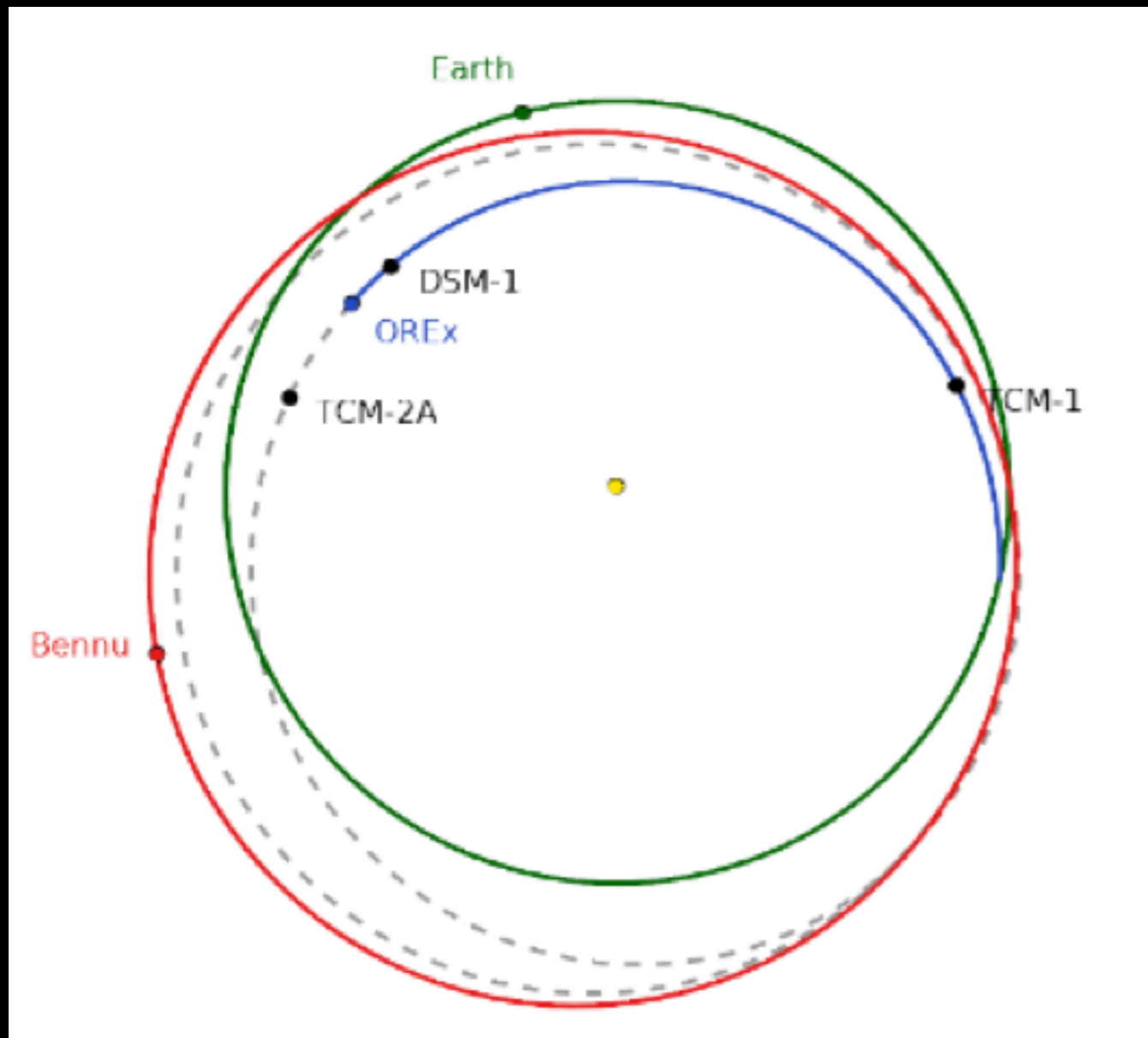
- First image from MapCam taken on September 19
- Star field in Taurus, north of the top of the constellation Orion
- Composite of three of its four color filters, roughly corresponding to blue, green, and red wavelengths

Credit: NASA/GSFC/University of Arizona

# *How Does OSIRIS-REx Travel to Bennu?*



# Current Orbit Configuration



*Statistics as of Jan 04, 2017, L+118 days*

*Earth Range = 97,000,000 km (0.65 AU)*

*Sun Range = 122,000,000 km (0.82 AU)*

*Sun-Probe-Earth Angle = 83 deg*

*One Way Light Time = 00:05:27 hh:mm:ss*

*Round Trip Light Time = 00:10:54 hh:mm:ss*

# *Upcoming Activities*

- Earth Trojan asteroid search (mid-February)
- Instrument L+6 mo. calibrations (mid-March)
- Earth gravity assist (end of September)

# ***The Mission Movie***

# *It Takes A Big Team!*





# *Join the Mission on the Web!*



**OSIRIS-REX**<sup>TM</sup>  
ASTEROID SAMPLE RETURN MISSION

- *Website:* [asteroidmission.org](http://asteroidmission.org)
- *PI blog:* [dslauretta.com](http://dslauretta.com)
- [facebook.com/OSIRISREx](https://facebook.com/OSIRISREx)
- [twitter.com/OSIRISREx](https://twitter.com/OSIRISREx)
- [youtube/osirisrex](https://youtube.com/osirisrex)
- [instagram.com/osiris\\_rex](https://instagram.com/osiris_rex)