An Overview of the OSIRIS-REx Asteroid Sample Return Mission

OSIRIS-REx™
ASTEROID SAMPLE RETURN MISSION

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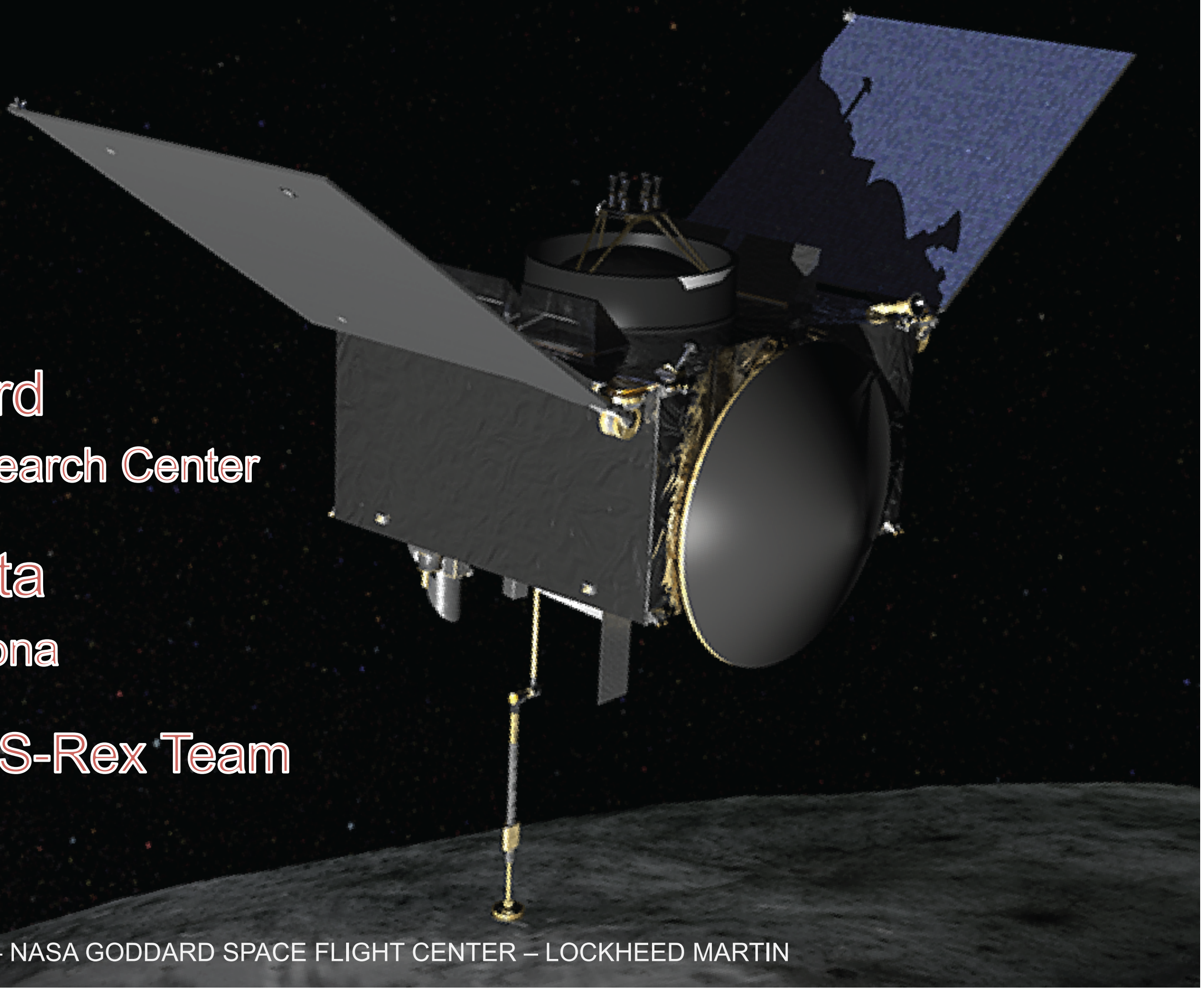


THE UNIVERSITY OF ARIZONA – NASA GODDARD SPACE FLIGHT CENTER – LOCKHEED MARTIN

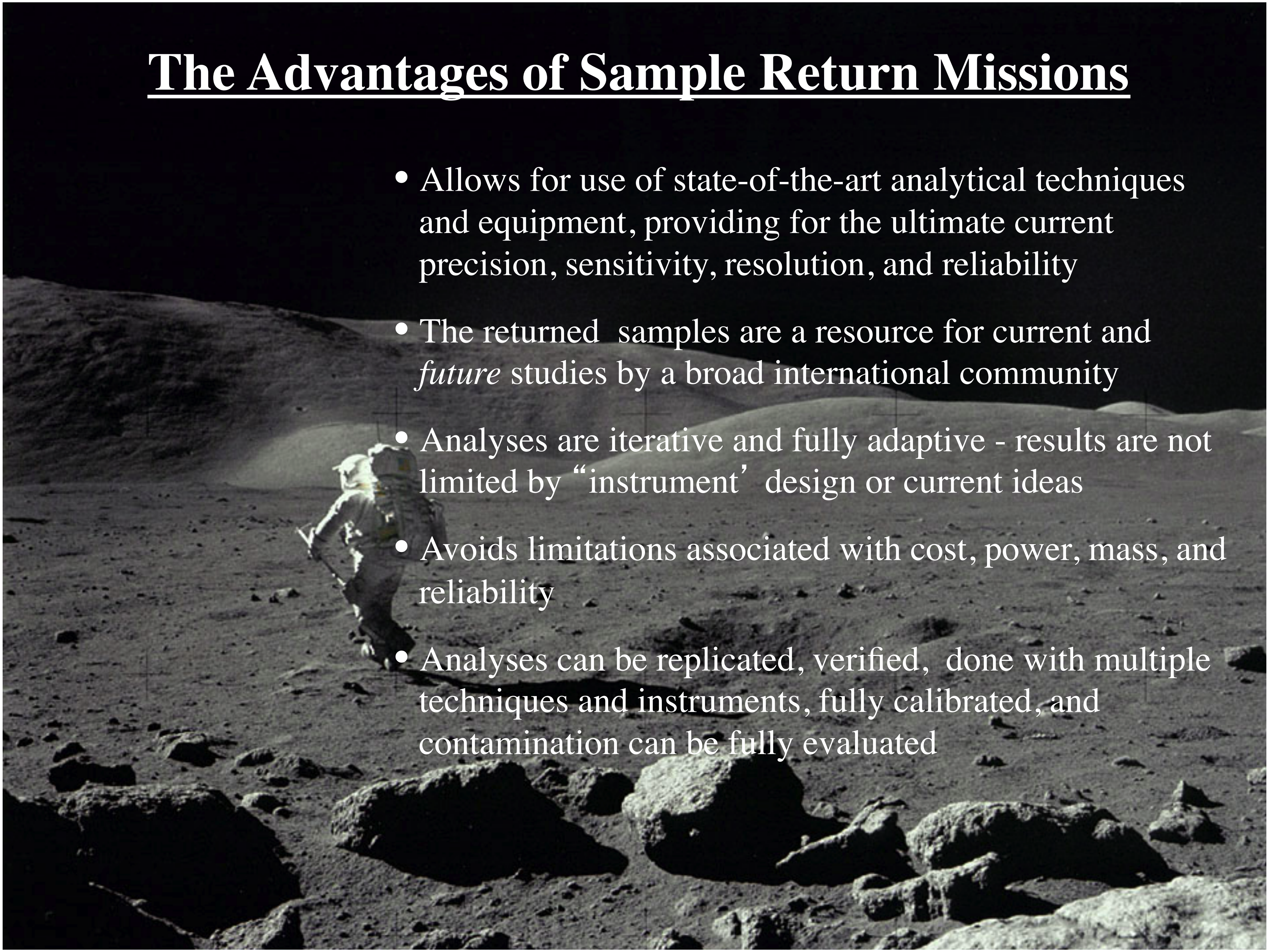
OSIRIS-REx Defined

- **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 **Ex**plorer
  - Document the regolith at the sampling site at scales down to the sub-cm

Why OSIRIS-REx is Important

OSIRIS-REx is a NASA funded mission designed to launch (2016) an unmanned vehicle to rendezvous with an asteroid, 101955 Bennu, collect a sample from the asteroid (2019) and conduct various experiments, and return the sample to Earth (2023). OSIRIS-REx will help us better understand:

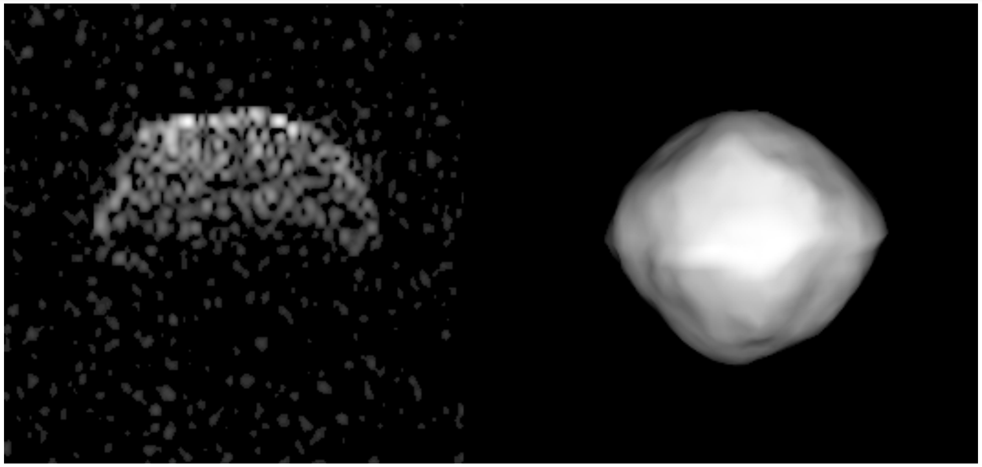
- The origins of the Earth, the Solar System, life on Earth, and beyond – helping us understand our place in the cosmos.
- The composition and structure of asteroids – enabling future exploration of asteroids for resources and economic development.
- The relationship between telescopic asteroid observation and up-close investigation – improving our ability to characterize asteroids throughout the solar system.
- How sunlight impacts the course and speed of asteroids – allowing us to accurately determine if an asteroid threatens the Earth.



The Advantages of Sample Return Missions

- Allows for use of state-of-the-art analytical techniques and equipment, providing for the ultimate current precision, sensitivity, resolution, and reliability
- The returned samples are a resource for current and *future* studies by a broad international community
- Analyses are iterative and fully adaptive - results are not limited by "instrument' design or current ideas
- Avoids limitations associated with cost, power, mass, and reliability
- Analyses can be replicated, verified, done with multiple techniques and instruments, fully calibrated, and contamination can be fully evaluated

OUR TARGET ASTEROID - 101955 Bennu
(provisional designation 1999 RQ36)



Radar generated shape model

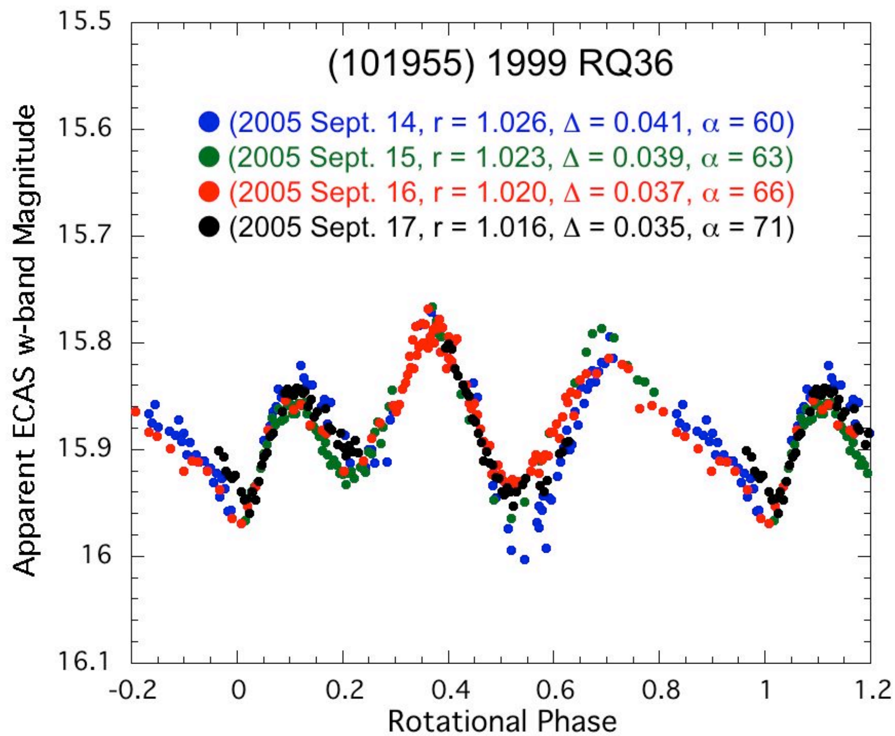
- Asteroid Bennu was discovered in 1999 and is a B-type, Apollo NEO
  - Orbital semi-major axis = 1.126 AU
  - Mean diameter = 492-m (±20 m)
  - Spheroidal with an equatorial ‘belt’
  - Rotation period = 4.2968 ± 0.0018 hr
  - Low albedo (0.035 ± 0.015)
  - Infrared spectra suggest the most likely meteorite analogs are CI or CM chondrites
  - Current best estimate of bulk density is 1260 ± 70 kg/m^3
- Observations support the presence of abundant regolith ideal for sampling (4-8 mm)
- Bennu comes within 0.003 AU of the Earth and has the highest impact probability of any known asteroid

101955 Bennu is small (but not *that* small)

- Bennu scaled (approximately) to the Golden Gate Bridge

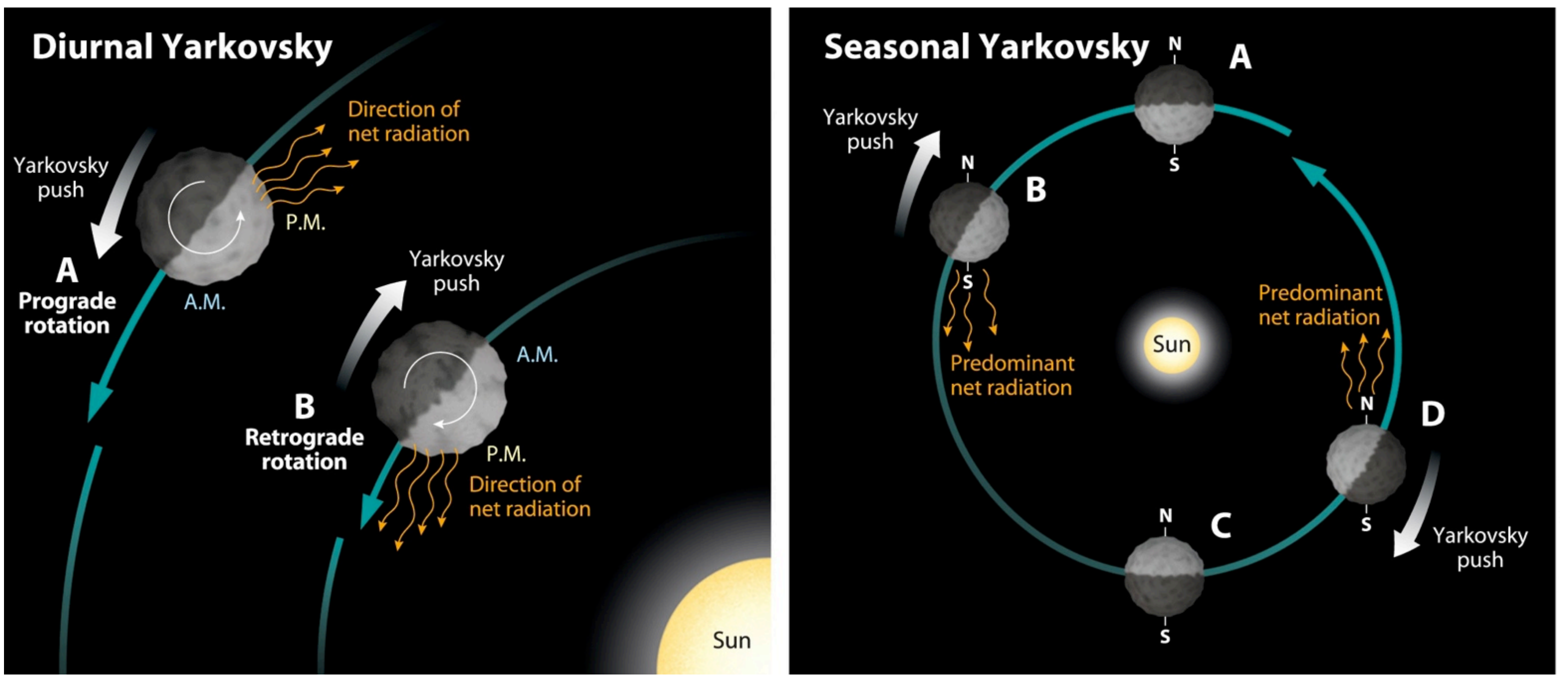
The Rotation State is Well Constrained from Lightcurve Measurements

- Achieved observations which resulted in a lightcurve covering a full rotation cycle each night for 4 nights of observing
- Lightcurve reveals a rotation period of 4.2968 ± 0.0018 hours
- The low amplitude is consistent with the rotation of a nearly spherical body



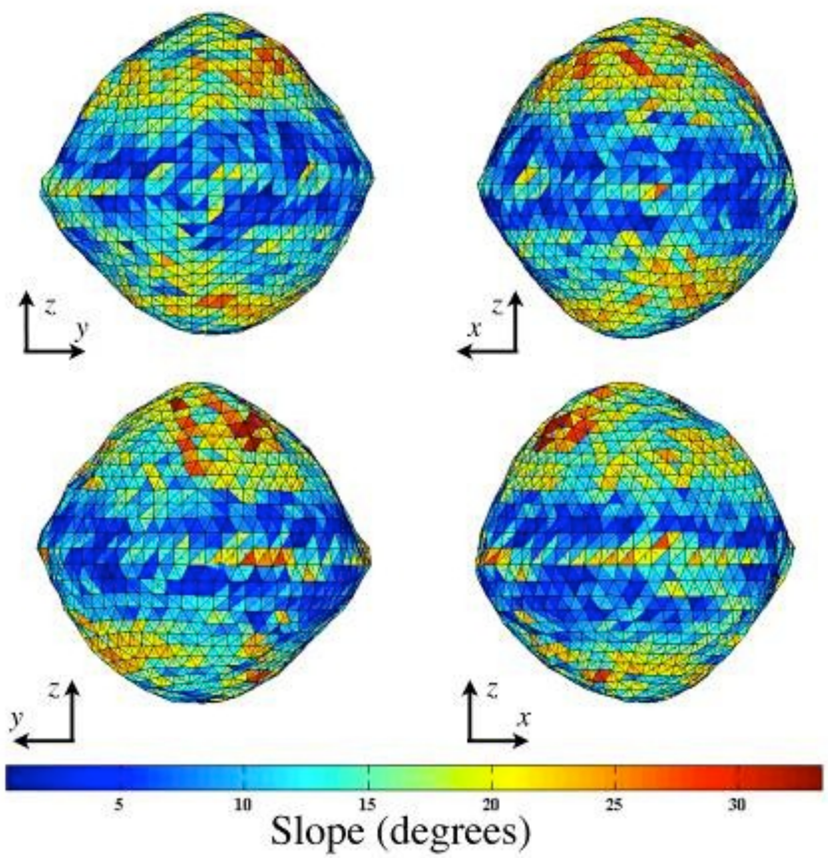
An OSIRIS-REx First: Measuring a Planetary Mass Using Radar and Infrared Astronomy

- The three precise series of radar ranging position measurements over two synodic periods allows us to measure the Yarkovsky acceleration
- The asteroid has deviated from its Keplerian gravity-ruled orbit by 160 kilometers in just 12 years
- This result, when combined with the thermal inertia and the shape model, constrains the mass to 6.278 (-0.942/+1.883) x 10^{10} kg



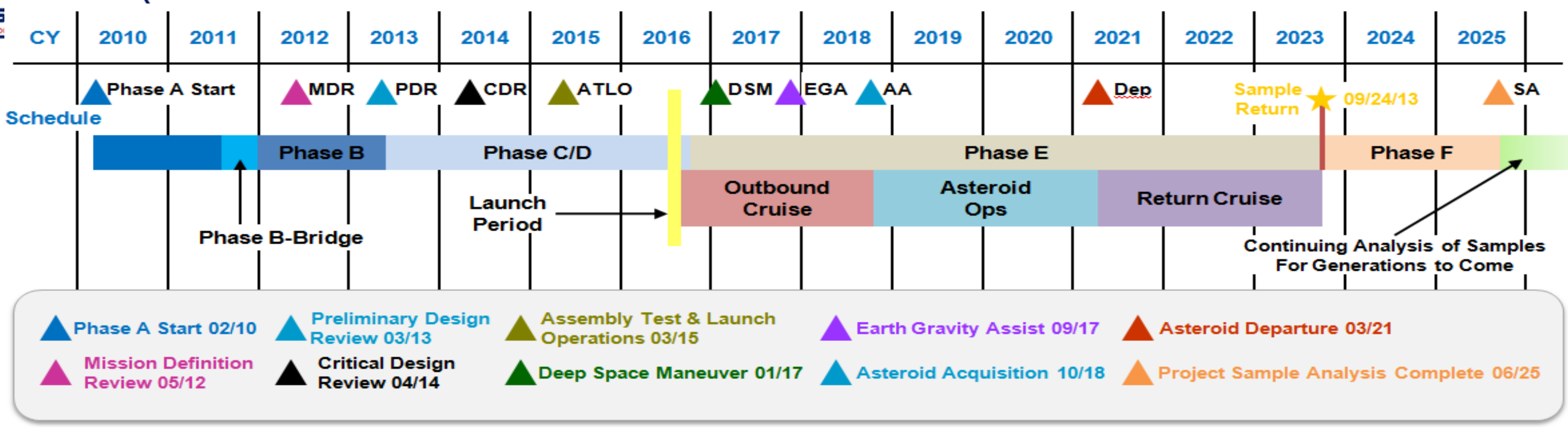
S&T ILLUSTRATION (SOURCE: RICHARD P. BINZEL)

KNOWLEDGE OF ASTEROID MASS AND SHAPE SUBSTANTIALLY ENHANCES MISSION PLANNING



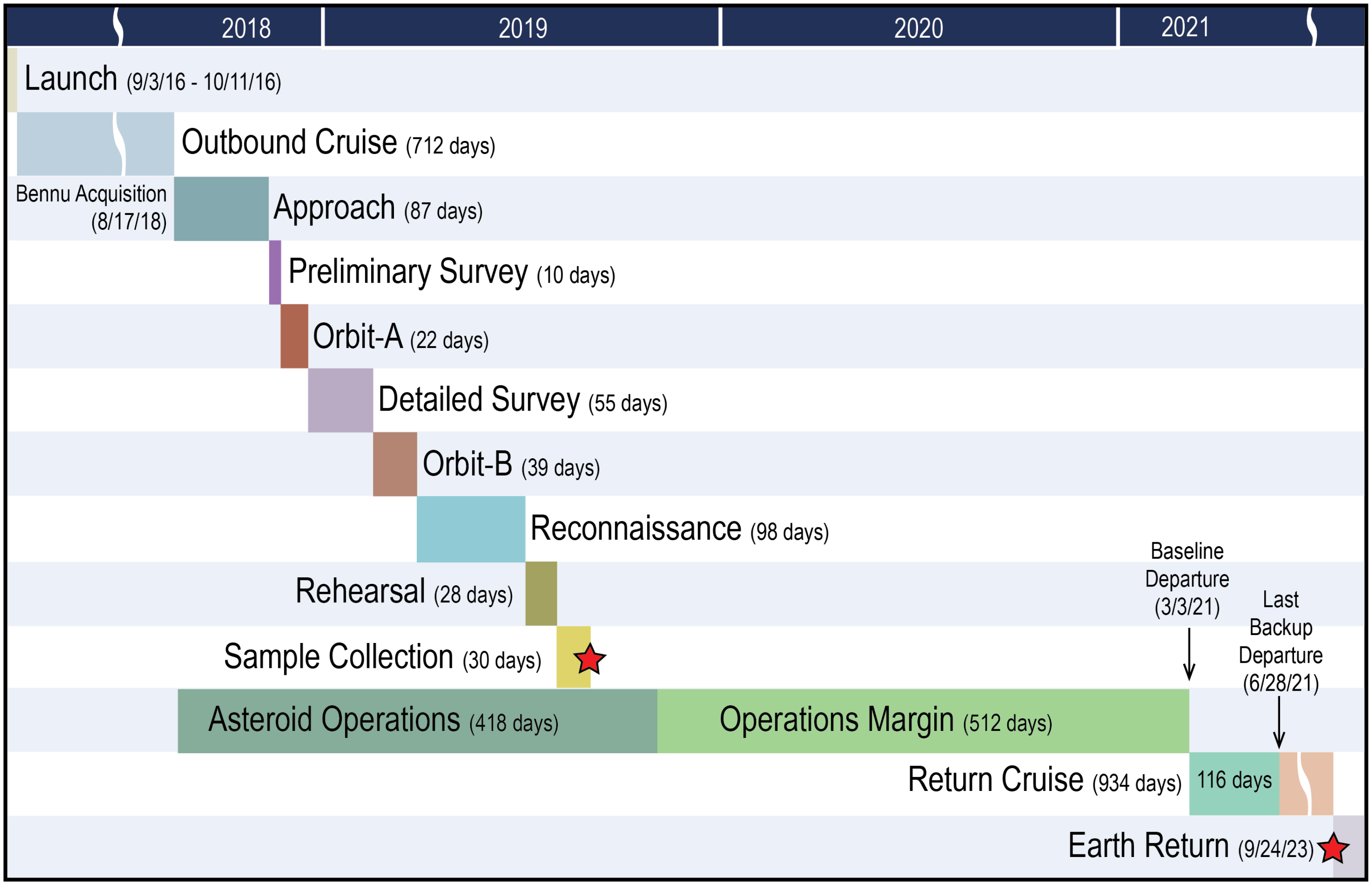
- Combined mass and shape knowledge yield a global gravity-field model that facilitates orbital stability analysis
- Combining the gravity-field model and rotation state yields global surface-slope distributions and accelerations
- All this information is critical to evaluating our ability to safely deliver the spacecraft to the asteroid surface and maintain nominal attitude during sampling

Mission Timeline



- Selection: May 25, 2011
- Preliminary Design Review (PDR): March, 2013
- Critical Design Review (CDR): April, 2014
- System Integration Review (ATLO): February, 2015
- Launch: September, 2016
- Earth Gravity Assist (EGA): September, 2017
- Asteroid Arrival (AA): August, 2018
- Asteroid Departure (Dep): March, 2021
- Sample Return: 24 September 2023
- End of Mission (Sample Analysis): September 2025

Mission Operations Timeline

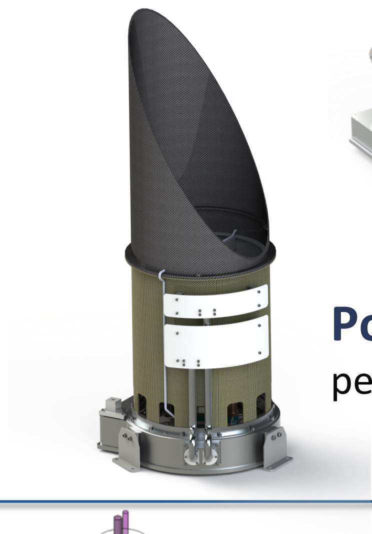


Our Payload Performs Extensive Characterization at Global and Sample-site-specific Scales

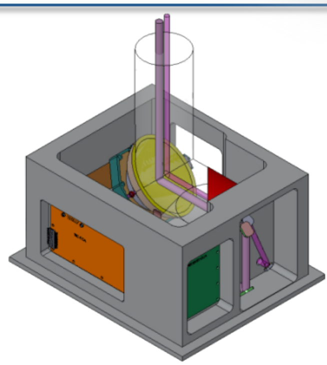
OCAMS (UA)

SamCam images the sample site, documents sample acquisition, and images TAGSAM to evaluate sampling success

MapCam provides landmark-tracking OpNav, performs filter photometry, maps the surface, and images the sample site

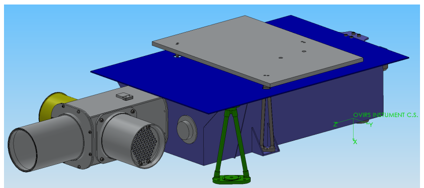


PolyCam acquires Bennu from >500K-km range, performs star-field OpNav, and performs high-resolution imaging of the surface



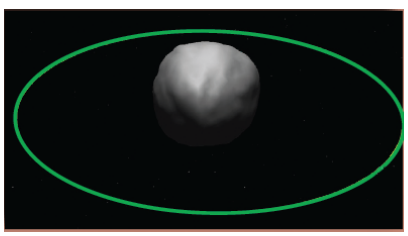
OLA (CSA) provides ranging data out to 7 km and maps the asteroid shape and surface topography

Spacecraft-Based Remote Sensing Provides Ground Truth for our Astronomical Data

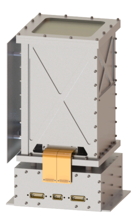


OVIRS (GSFC) maps the reflectance albedo and spectral properties from 0.4 – 4.3 µm

OTES (ASU) maps the thermal flux and spectral properties from 4 – 50 µm



Radio Science (CU) reveals the mass, gravity field, internal structure, and surface acceleration distribution

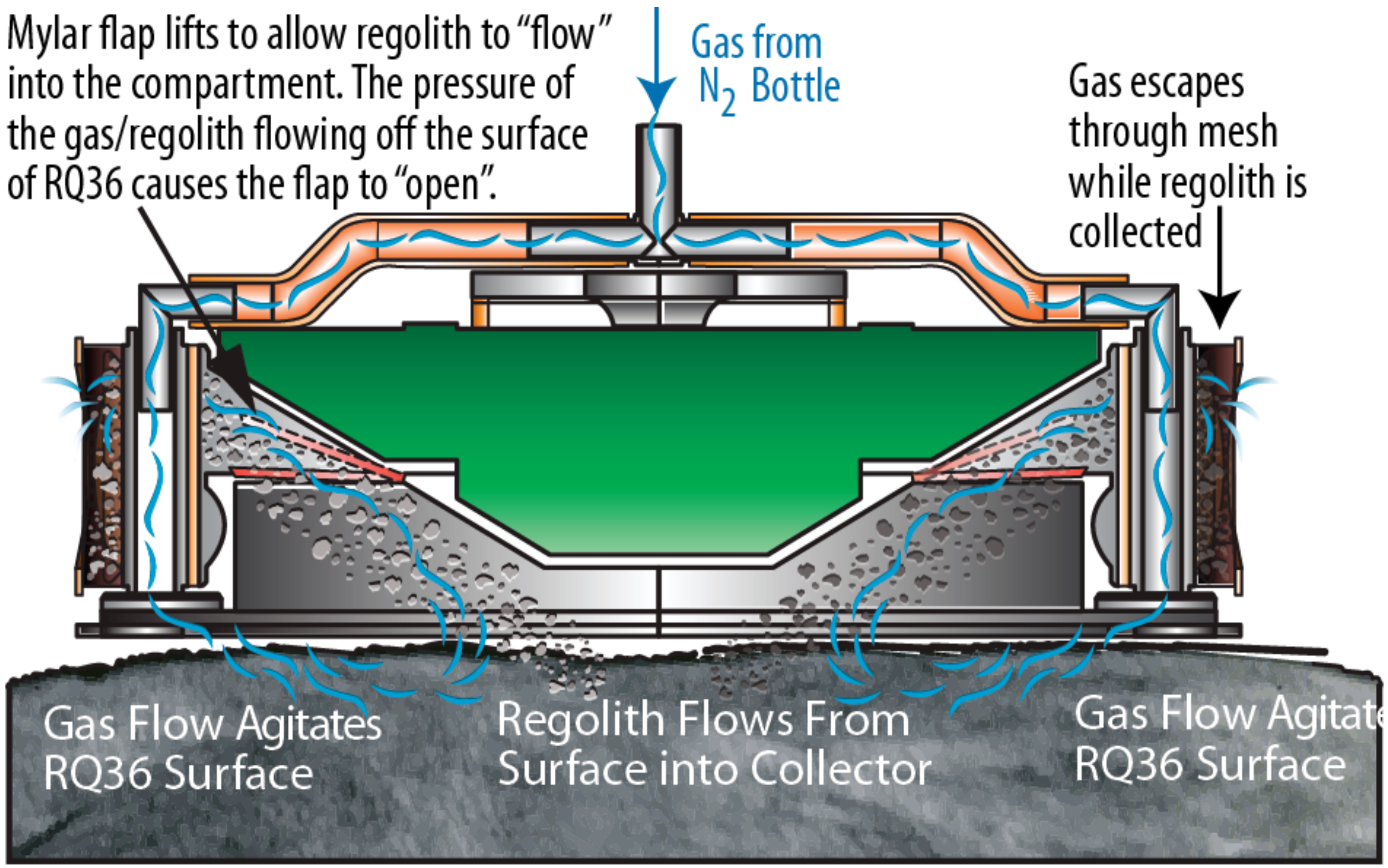


REXIS (MIT) maps the elemental abundances of the asteroid surface

TOUCH-AND-GO SAMPLE ACQUISITION SYSTEM (TAGSAM)

TAGSAM – The OSIRIS-REx Sampling Strategy is Designed to Collect Abundant Pristine Regolith

TAGSAM acquires samples using a jet of high-purity N_2 gas that “fluidizes” the regolith into a collection chamber.



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