OSIRIS-REx Overview Presentation to the Planetary Science Subcommittee

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Gordon Johnston
Program Executive
OSIRIS-REx Science Objectives

1. Return and analyze a sample of pristine carbonaceous asteroid regolith in an amount sufficient to study the nature, history, and distribution of its constituent minerals and organic material.

2. Map the global properties, chemistry, and mineralogy of a primitive carbonaceous asteroid to characterize its geologic and dynamic history and provide context for the returned samples.

3. Document the texture, morphology, geochemistry, and spectral properties of the regolith at the sampling site in situ at scales down to the sub-centimeter.

4. Measure the Yarkovsky effect on a potentially hazardous asteroid and constrain the asteroid properties that contribute to this effect.

5. Characterize the integrated global properties of a primitive carbonaceous asteroid to allow for direct comparison with ground-based telescopic data of the entire asteroid population.
OSIRIS-REx is a Seven-Year Mission from Launch to Earth Return

The Design Reference Mission (DRM) . . . “serves as the backbone for focusing the design effort” -- from NF-3 Step 1 evaluation

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<th>Year</th>
<th>Event</th>
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<td>2020</td>
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<td>2021</td>
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<td>2021</td>
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10/3/2012
Science Requirements are Fulfilled by the Instrument Capabilities

**OCAMS** (OSIRIS-REx Camera Suite)

**PolyCam** acquires 1999 RQ36 from 500K km range, refines its ephemeris, and performs high-resolution imaging of the surface

**MapCam** provides narrow angle OpNav, performs filter photometry, maps the surface, and images the sample site

**SamCam** provides wide-angle OpNav, images the sample site, and documents sample acquisition

**OLA** (OSIRIS-REx Laser Altimeter) provides ranging data out to 7 km and maps the shape and topography
Science Requirements are Fulfilled by the Instrument Capabilities

**OVIRS** (OSIRIS-REx Visible and IR Spectrometer) maps the reflectance albedo and spectral properties from 0.4 – 4.3 µm

**OTES** (OSIRIS-REx Thermal Emission Spectrometer) maps the thermal flux and spectral properties from 4 – 50 µm

**Radio Science** reveals the mass, gravity field, internal structure, and surface acceleration distribution

**REXIS** (Regolith X-ray Imaging Spectrometer) is a Student Collaboration Experiment that trains the next generation of scientists and engineers and maps the elemental abundances of the asteroid surface
OUR SAMPLE IS COLLECTED DURING A FIVE-SECOND TOUCH-AND-GO MANEUVER

- Approach surface within vertical and horizontal speed constraints
- Surface contact is made with sampler head
- Compression of spring in the Touch-and-Go Sample Acquisition Mechanism (TAGSAM) arm
- Rebound from surface using stored energy in spring
- Fire thrusters to accelerate away from RQ36
The OSIRIS-REx Sampling Strategy is Designed to Collect Abundant Pristine Regolith

Mylar flap lifts to allow regolith to “flow” into the compartment. The pressure of the gas/regolith flowing off the surface of RQ36 causes the flap to “open”.

Gas from N₂ Bottle

Gas escapes through mesh while regolith is collected

Gas Flow Agitates RQ36 Surface

Regolith Flows From Surface into Collector

Gas Flow Agitates RQ36 Surface
For more OSIRIS-REx Information

• University of Arizona (PI Institution) Web Page:
  – http://osiris-rex.lpl.arizona.edu/
  – Includes links/information on:
    • Name that Asteroid Contest
      – For Youth under 18
      – Contest started September 4, 2012
      – Deadline is December 2, 2012
      – In partnership with The Planetary Society and MIT Lincoln Labs
    • Target Asteroids! citizen science
      – An opportunity for amateur astronomers to participate in a long-term citizen science project that will contribute to basic scientific understanding of near-Earth objects (NEOs)
      – Amateur astronomers collect astrometric and photometric data on a selected list of asteroids

• NASA OSIRIS-REx Web Page:
  – http://science.nasa.gov/missions/osiris-rex/
OSIRIS-REx

Backup
OSIRIS-REx is a sample return mission that returns at least 60 g (and as much as 2 kg) of pristine carbonaceous regolith from asteroid 1999 RQ36.

OSIRIS REx is an acronym:
- Origins
  - provide pristine sample to reveal the origin of volatiles and organics that led to life on Earth
- Spectral Interpretation
  - provide ground truth for ground-based and space based spectral observations of B-type carbonaceous asteroids
- Resource Identification
  - identify carbonaceous asteroid resources that we might use in human exploration
- Security
  - quantify the Yarkovsky Effect on a potentially hazardous asteroid, thus providing a tool to aid in securing the Earth from future asteroid impacts
- Regolith Explorer
  - Explore the regolith at the sampling site \textit{in situ} at scales down to sub-millimeter
Science Assumptions and Constraints are Focused on the Nature of 1999 RQ36 and its Operational Environment

- It provides for the most exciting science, with a spectral signature suggesting a carbon- and volatile-rich surface
- It is primitive B-class carbonaceous asteroid, a class of object never before visited by a spacecraft
- Its size (500-m), shape (spheroidal “spinning top”), and rotation state (4.3 hr period, 180° obliquity) are known from extensive characterization by the Arecibo Planetary Radar System
- There is abundant regolith on the surface available for sampling
- Study of this Potentially Hazardous Asteroid is strategically important to NASA and Congress
Level-1 Requirements (1 of 4)

1. Return and analyze a sample of pristine carbonaceous asteroid regolith in an amount sufficient to study the nature, history, and distribution of its constituent minerals and organic material
   - 1.1 Return ≥60 g of pristine bulk sample from RQ36 and archive 75% of the total returned mass for future analyses. ‘Pristine’ is defined to mean that no foreign material introduced into the sample hampers the scientific analysis of the sample
   - 1.2 Document the contamination of the sample acquired from collection, transport, curation, and distribution
   - 1.3 Contact ≥26 cm² of surface material from RQ36, return the TAGSAM contact surface, and archive 75% of the contact surface for future analyses
   - 1.5a Produce a sample catalog within 6 months of return
   - 1.5b Analyze the returned sample to determine the presolar history, formation age, nebular and parent-body alteration history, relation to known meteorites, organic history, space weathering, resurfacing history, and energy balance in the regolith of RQ36
Level-1 Requirements (2 of 4)

2. Map the global properties, chemistry, and mineralogy of a primitive carbonaceous asteroid to characterize its geologic and dynamic history and provide context for the returned samples

- 1.6 – Produce a shape model of RQ36 with 1-m lateral and vertical resolution
- 1.7 – Determine the surface slopes, accelerations and geopotential of RQ36 at 1-m spatial resolution
- 1.8 – Determine the bulk density of RQ36 to within 1%, determine up to the fourth degree and order gravity harmonic coefficients, and search for and characterize any density inhomogeneities within the asteroid
- 1.9 – Measure the number, sizes, spatial distribution, and morphologies of possible craters and boulders, regolith distributions, and search for evidence of surface expression of internal structure on RQ36
- 1.10 – Resolve key mineralogical and organic features with spectral absorptions ≥5% to detect the following species: adsorbed water, phyllosilicates, carbonates, sulfates, silicates, oxides, and hydrocarbons, and determine mineral, organic, and phase abundances on the surface of RQ36, at a global spatial resolution of 50 m or better
2. Map the global properties, chemistry, and mineralogy of a primitive carbonaceous asteroid to characterize its geologic and dynamic history and provide context for the returned samples

- 1.11 – Search for and spectrally and visually characterize regions of active volatile outgassing from the surface of RQ36
- 1.12 – Search for and spectrally and visually characterize satellites in orbit around RQ36
- 1.13 – Search for and characterize the effects of space-weathering on RQ36
3. Document the texture, morphology, geochemistry, and spectral properties of the regolith at the sampling site \textit{in situ} at scales down to the sub-centimeter
   \begin{itemize}
     \item 1.4 – For the sample site, document the texture to sub-cm resolution and the morphology, geochemistry, and spectral properties sufficiently to select the site and provide context for the sample. ‘Resolution’ is defined as the root-mean-square spot size characterizing the sub-cm imager
   \end{itemize}

4. Measure the Yarkovsky effect on a potentially hazardous asteroid and constrain the asteroid properties that contribute to this effect
   \begin{itemize}
     \item 1.14 – Constrain the properties of RQ36 that contribute to the Yarkovsky effect and measure the magnitude of the Yarkovsky effect
   \end{itemize}

Characterize the integrated global properties of a primitive carbonaceous asteroid to allow for direct comparison with ground-based telescopic data of the entire asteroid population
   \begin{itemize}
     \item 1.15 – Measure the astrometric, photometric, and spectroscopic properties of RQ36
   \end{itemize}