NASA to map Asteroid Bennu from the ground up

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How do you study the topography of an asteroid millions of miles away? Map it with a robotic cartographer!

NASA's Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer, or OSIRIS-REx, will launch in September 2016 and travel to a near-Earth asteroid known as Bennu to harvest a sample of surface material and return it to Earth for study. But before the science team can select a sample site, it needs to know a little something about the asteroid's topography.

The OSIRIS-REx Laser Altimeter, or OLA, is provided by the Canadian Space Agency and will be used to create three-dimensional global topographic maps of Bennu and local maps of candidate sample sites.

"OLA will measure the asteroid's topography and shape in a detail that is unprecedented compared to other asteroid missions," said Michael Daly, OLA instrument scientist at York University in Toronto, Canada. " This 3-D shape will be the foundational dataset for the other instruments."

Think of your favorite computer animated movie. The characters and environment are colored and shaded in such a way that they look almost lifelike. But all of those details need a 3-D shape in order to take form. The same is true for the detailed data gathered by OSIRIS-REx's instruments.

To create these 3-D models, OLA uses LIDAR, which stands for light detection and ranging. LIDAR is similar to radar, but uses light instead of radio waves to measure distance. OLA will emit infrared laser pulses toward the surface of Bennu as the spacecraft moves around the asteroid. The laser pulses reflect back from the surface to a detector. The team will measure the time difference between outgoing and incoming pulses to calculate the distance between the spacecraft and Bennu.

LIDAR has been used on prior spacecraft, including the Mars Global Surveyor and the Lunar Reconnaissance Orbiter. Those laser altimeters are fixed to the spacecraft, meaning that the laser pulse will only travel in the direction that the spacecraft is pointing. This can limit the coverage and spatial resolution of their topographic maps. So, while they have generated a vast amount of data, fixed LIDAR are not ideal for missions where the data must be gathered quickly.

"OLA is the first scanning LIDAR to fly on a planetary mission," said Beau Bierhaus, an OLA team member at Lockheed Martin. "Because the LIDAR can articulate independently of the spacecraft, the LIDAR provides improved operational flexibility, and more importantly, much greater spatial coverage and resolution."

OLA is expected to thoroughly map Bennu with about 6 billion measurements of the asteroid's surface, which measures about one-third of a mile (one-half kilometer) in diameter. In comparison, the laser altimeter on the Lunar Reconnaissance Orbiter has received more than 6.8 billion measurements of the surface of the moon, which has a diameter of about 2,159 miles (3,500 kilometers).

The fundamental data of the asteroid's shape and topography that OLA will provide are essential for several key phases during the mission.

The science team will use the high-resolution topographic data, in conjunction with camera images and on-board navigation algorithms, to navigate around the asteroid and guide the spacecraft to the selected sample site.

"We're measuring topography down to one centimeter," said Olivier Barnouin, the Altimetry Working Group lead at Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. "We're looking at an asteroid at a scale that no other mission has before. We don't want to be off in some unknown area during sample acquisition."

The three-dimensional maps will also give geologic context to the returned asteroid sample. Just as geologists on Earth document where they collect their samples in the field on topographic maps, OLA will allow the science team to take their measurements and observations of the collected sample and apply them to their broader understanding of Bennu.

OLA will also allow the science team to study how regolith, or loose surface material, behaves in a microgravity environment. Scientists have done similar studies on the moon and Mars, but unlike Bennu, these bodies have relatively high gravity.

"What happens on asteroids is that you take that gravity dial and turn it way down," Bierhaus said. "The dynamics of how regolith moves on the surface of the asteroid are foreign to us. OLA data will give us a greater understanding of how granular material behaves in space."

This understanding is especially important for future asteroid missions. Scientists will need to know how regolith behaves in micro-gravity environments if we want to send astronauts to an asteroid someday to collect samples.

"Collaborating on this project reminds us of the unique relationship between Canada and the United States," said Daly. "It provides both countries access to additional technological expertise and people that they would not otherwise have."

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