Q&A With the Scientists Behind OSIRIS-REx's 'Eyes'

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How did the OSIRIS-REx spacecraft take the **first image** [1] of target asteroid Bennu? Lo Que Pasa spoke with three OSIRIS-REx mission scientists who planned the first-light image of Bennu: **Bashar Rizk**, senior staff scientist at the UA Lunar and Planetary Laboratory and OSIRIS-REx Camera Suite instrument scientist, **Christian d'Aubigny**, deputy camera suite scientist, and **Carl Hergenrother**, an associate staff scientist who leads the observations while the asteroid is still a point source of light.

Launched two years ago, the **OSIRIS-REx space probe** [2] has traveled more than a billion miles to catch up with Bennu, a near-Earth asteroid, on its orbit around the sun. Bennu is believed to represent a time capsule of the earliest building blocks of our solar system and may even contain the molecular precursors to the origin of life and the Earth?s oceans. In September 2023, OSIRIS-REx is scheduled to bring a sample of Bennu's surface material back to Earth for study. The UA leads the mission, with all science operations being conducted at the UA's Michael J. Drake Building in Tucson. Now that the spacecraft has captured the first glimpse of Bennu with its own "eyes," it will begin its approach phase, arriving at the asteroid in early December.

What does it take to spot a space rock from more than a million miles away?

Rizk: First of all, we need the spacecraft to be in a benign orientation with respect to the sun, so its cameras don't get overwhelmed with blinding light. An important part of this approach phase is to confirm the brightness of our target asteroid and carefully position the spacecraft with respect to the sun and the asteroid.

Hergenrother: We also have to make sure we're avoiding the worst parts of the Milky Way. In other words, we can't have the central portion of our galaxy in the background because it is so full of stars that it would make it difficult to find Bennu.

Which instrument aboard the spacecraft did you use to take the first snapshot of Bennu?

Rizk: We used a camera that we designed and built here at the UA, called PolyCam, because it's polyfunctional, taking high-resolution images. PolyCam has two jobs: one as a long-range acquisition camera, and the second is as a reconnaissance camera. In the later stage of the mission, when we get up close with Bennu, PolyCam's job will be to determine whether the material on the surface is suitable for sampling. In other words, to verify that the rocks and dust on the surface are small enough to fit into the sample head. To make that assessment, we will do a reconnaissance flyby, which involves staying two football fields away from the asteroid, imaging its surface and trying to detect pebbles that are 2 centimeters or smaller. And once we know they are there, we know that sampleable material exists on the surface.

D'Aubigny: Over the course of developing the mission, we have discovered more uses for the camera, including applications during the mapping phase. During that time, when the spacecraft will be close to Bennu to perform a detailed survey, PolyCam will be used in addition to the dedicated mapping camera, or MapCam, which also was developed here at the UA.

Did the spacecraft take the series of asteroid images autonomously, or while controlled from the ground?

Rizk: There actually is very little constant communication between mission control and the spacecraft. Communication time over NASA's Deep Space Network is in high demand, and it's not cheap, because there are so many spacecraft out there. People often think that the actions performed by the spacecraft are all automated, and it just does them effortlessly. But we're often white-knuckling. Once the images came streaming down, all of us were shedding a ton of stress that had accumulated over the previous week. There is so much that can go wrong. The way I deal with that is I try to take everything in stride, telling myself it's just another day at the office. If you don't, you make more mistakes. You have to take the human element into account much more than you'd think on a project like this.

From the spacecraft's distance, 1.4 million miles, Bennu looks like just a star among thousands. How do you spot it?

D'Aubigny: Ten years ago, during the early phase of the mission planning, Bennu's orbit wasn't as well-known as it is now, so we had to build a camera that could detect an asteroid as faint as Bennu from 2 million kilometers away for navigation purposes. The full frame in the animated image is a little bigger than the moon appears in the night sky. That tells you how easy it would be to miss the asteroid if the spacecraft didn't point the camera at the exact right spot in space. Within 12 hours or so, Bennu would have moved out of the frame, and we would have missed it.

Hergenrother: We could have detected Bennu two to three months ago, because the cameras were designed to detect a much fainter object. Taking this image on Aug. 17, plus or minus a few days, had been planned for years. When the spacecraft looked for the asteroid, it was in the exact spot where we calculated it to be. That isn?t too surprising since Bennu now has the best-known orbits of all known asteroids.

This part of the observation, where we observed Bennu for an hour, was important because we'll pass the images on to the (UA-led) Catalina Sky Survey, which will use later images to look for any potential natural satellites that may orbit Bennu. We also used this opportunity to test running the PolyCam data through the CSS software, to make sure everything works well together, rather than trying things out for the first time on the day we're scheduled to begin the in-depth search for natural satellites around Bennu.

What is next for the OSIRIS-REx mission?

Hergenrother: Every Monday, Wednesday and Friday, we do what we call OpNavs ? that means we use the spacecraft's cameras to image the starfield in the background to determine exactly where it is in relation to Bennu. Later in the mission, OpNavs will be conducted daily and then multiple times per day. The next science observations will be Sept. 11 and 12, when we will use MapCam and PolyCam to see if there is any dust around Bennu. It's very unlikely, but if there is any, it would be interesting because it tells us more about the asteroid. It would also be important to know for safety reasons. Oct. 16 will be the first time we will observe Bennu over one full rotation to determine if the preliminary data we gathered from the ground are correct. A week after that, we'll be looking for satellites around Bennu. In November, we will begin mapping observations, and we will start seeing craters and boulders. That's when Bennu will transition from being an astronomical object to a "real" geological world.

In the video below, Rizk discusses the different types of cameras on the OSIRIS-REx space probe and how each camera fulfills the mission's various needs.

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