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What if New Horizons had laser communications?


Pluto's largest moon, Charon, was imaged by the New Horizons Long Range Reconnaissance Imager in July from a distance of 289,000 miles.
NASA

As exciting as it was to see the first images of Pluto and its moon Charon arrive from the New Horizons probe, the images were also a good example of a communications limit that NASA technologists are hard at work addressing. The pictures rolled into the Applied Physics Lab in Maryland at an average downlink rate of just 2 kilobits per second, and it will be another 16 months before all the data and images are in hand.

That lag stems from the sheer volume of the data and the spacecraft's reliance on radio frequency signals, which are currently the only means of receiving data from space probes.

That could change in perhaps five years because of experiments NASA has conducted and plans to conduct with optical communications technology. Although radio and optical waves have the same transit time, around 4.5 hours from Pluto to Earth, laser wavelengths are packed more tightly with bits and bytes than radio wavelengths, transmitting more data per second. So lasers would be able to carry about 10 times more data than radio waves. On a future mission to Pluto, the same amount of data could be returned in about 1.3 months.

NASA has not selected an operational mission to use the optical technology and, according to Matthew Abrahamson, mission manager for NASA's Optical Payload for Lasercomm Science (OPALS) experiment, it likely will be at least five more years before it's fully integrated into a spacecraft. But advocates of optical communications, also known as laser communications, expect the technology to fly within the next decade as a part of NASA's Discovery Program, an umbrella initiative for lower cost space probes with a mission cost cap of $425 million. NASA is looking to integrate optical communications into one or more of these missions to build confidence with the technology.

The new technology is needed to keep up with the volume of data that can be fetched from space, Abrahamson says.

"Until a few years ago, it was more convenient to use radio transmitters because the volume of data wasn't large enough to warrant spending a lot of money on new development for those communications," Abrahamson says. "But now that we have all these electronics that are more capable of getting high quantities of data, it's even more important to get it back down to Earth."

Optical communication technology transmits data by focusing a laser beam on a ground station that receives the downlink signal with a 1-meter aperture primary telescope, in the case of OPALS. A photodetector then converts the optical signal to electrical current, which allows the data to be digitized, synchronized, corrected and processed. Three main factors determine the downlink speed: the power behind the laser, the width of the beam and the laser's focus. Narrower and more focused beams channel more energy on the target, and higher laser power allows for faster downlink time.

The challenge is getting all those calibrations just right.

"It's kind of a trade-off because you can make the beam wider, but you're going to lose more energy in the transmission," Abrahamson says. "But if you narrow the beam and make it more focused, it's going to be hard to keep it pointed on the Earth."

So far, NASA has conducted two experiments to demonstrate optical communications: In 2013, an experimental laser transmitter on NASA's Lunar Atmosphere and Dust Environment Explorer passed data from lunar orbit to a receiving terminal at NASA's White Sands Complex in New Mexico. This Lunar Laser Communication Demonstration achieved a download speed of 622,000 kilobits per second, which is more than 300,000 times faster than that of New Horizons. Communications from deep space would not be that much faster, because of weakened signals, but they would still be many times faster than New Horizons. Less than a year after the lunar demonstration, OPALS transmitted data from the International Space Station using a 2.5-Watt 1,550-nanometer laser, at a rate of 400,000 kilobits per second. That video image took 3.5 seconds to arrive, compared to more than 10 minutes for radio downlinks.

NASA plans to conduct its next laser communications demonstration in 2019 aboard a geostationary commercial communications satellite, says Phil Liebrecht, NASA assistant deputy associate administrator for space communications and navigation. The experiment will focus on identifying the specific laser technology that works best for spacecraft close to Earth.

Liebrecht says engineers and technologists are trying to figure out how to narrow the beam and still maintain accuracy.

If a beam is orders of magnitude narrower, "it's orders of magnitude more difficult to point," Liebrecht says.

Optical communications pose other challenges as well. Clouds and dust, for instance, can obstruct signals. For that reason, Liebrecht says the first mission equipped with laser communications will still carry traditional radio communication as a back up.

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