

NASA's Deep Space Optical Communications demonstration transmits data over 140 million miles

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NASA's Psyche spacecraft is shown in a clean room at the Astrotech Space Operations facility near the agency's Kennedy Space Center in Florida on Dec. 8, 2022. DSOC's gold-capped flight laser transceiver can be seen, near center, attached to the spacecraft. Credit: NASA/Ben Smegelsky

Riding aboard NASA's Psyche spacecraft, the agency's Deep Space Optical Communications technology demonstration continues to break

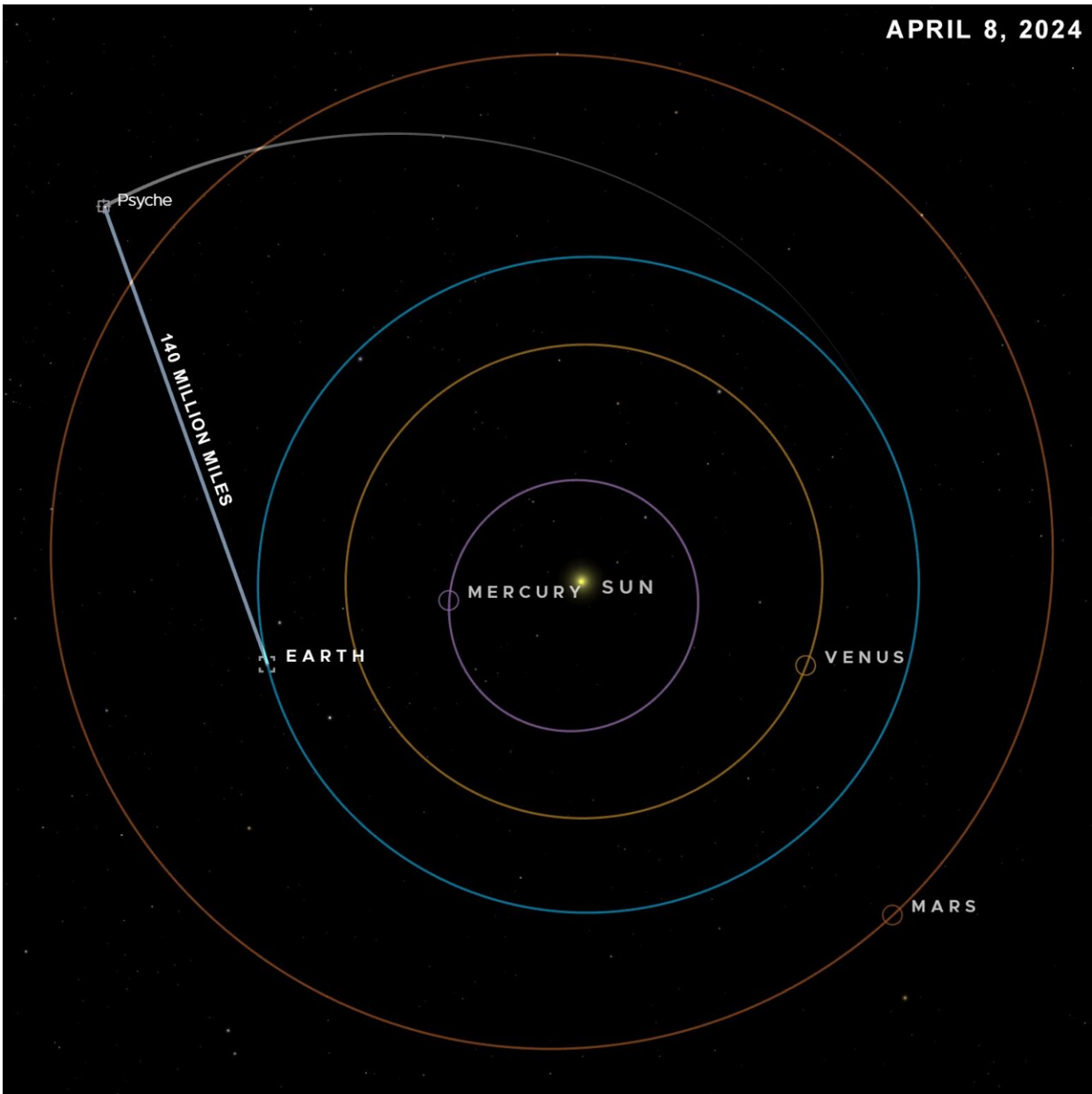
records. While the asteroid-bound spacecraft doesn't rely on optical communications to send data, the new technology has proven that it's up to the task. After interfacing with the Psyche's radio frequency transmitter, the laser communications demo sent a copy of engineering data from over 140 million miles (226 million kilometers) away, 1.5 times the distance between Earth and the sun.

This achievement provides a glimpse into how spacecraft could use optical communications in the future, enabling higher-data-rate communications of complex scientific information as well as high-definition imagery and video in support of humanity's next giant leap: sending humans to Mars.

"We downlinked about 10 minutes of duplicated spacecraft data during a pass on April 8," said Meera Srinivasan, the project's operations lead at NASA's Jet Propulsion Laboratory in Southern California. "Until then, we'd been sending test and diagnostic data in our downlinks from Psyche. This represents a significant milestone for the project by showing how optical communications can interface with a spacecraft's radio frequency comms system."

The laser communications technology in this demo is designed to transmit data from [deep space](#) at rates 10 to 100 times faster than the state-of-the-art radio frequency systems used by deep space missions today.

After launching on Oct. 13, 2023, the spacecraft remains healthy and stable as it journeys to the [main asteroid belt](#) between Mars and Jupiter to visit the asteroid Psyche.



This visualization shows the Psyche spacecraft’s position on April 8 when the DSOC flight laser transceiver transmitted data at a rate of 25 Mbps over 140 million miles to a downlink station on Earth. Credit: NASA/JPL-Caltech

Surpassing expectations

NASA's optical communications demonstration has shown that it can transmit test data at a maximum rate of 267 megabits per second (Mbps) from the flight laser transceiver's near-infrared downlink laser—a bit rate comparable to broadband internet download speeds.

That was achieved on Dec. 11, 2023, when the experiment beamed a 15-second ultra-high-definition video to Earth from 19 million miles away (31 million kilometers, or about 80 times the Earth-moon distance). The video, along with other test data, including digital versions of Arizona State University's Psyche Inspired artwork, had been loaded onto the flight laser transceiver before Psyche launched last year.

Now that the spacecraft is more than seven times farther away, the rate at which it can send and receive data is reduced, as expected. During the April 8 test, the spacecraft transmitted test data at a maximum rate of 25 Mbps, which far surpasses the project's goal of proving at least 1 Mbps was possible at that distance.

The project team also commanded the transceiver to transmit Psyche-generated data optically. While Psyche was transmitting data over its radio frequency channel to NASA's Deep Space Network (DSN), the optical communications system simultaneously transmitted a portion of the same data to the Hale Telescope at Caltech's Palomar Observatory in San Diego County, California—the tech demo's primary downlink ground station.

"After receiving the data from the DSN and Palomar, we verified the optically downlinked data at JPL," said Ken Andrews, project flight operations lead at JPL. "It was a small amount of data downlinked over a short time frame, but the fact we're doing this now has surpassed all of our expectations."

Fun with lasers

After Psyche launched, the optical communications demo was initially used to downlink pre-loaded data, including the [Taters the cat video](#). Since then, the project has proven that the transceiver can receive data from the high-power uplink laser at JPL's Table Mountain facility, near Wrightwood, California. Data can even be sent to the transceiver and then downlinked back to Earth on the same night, as the project proved in a recent "turnaround experiment."

This experiment relayed test data—as well as digital pet photographs—to Psyche and back again, a round trip of up to 280 million miles (450 million kilometers). It also downlinked large amounts of the tech demo's own engineering data to study the characteristics of the optical communications link.

"We've learned a great deal about how far we can push the system when we do have clear skies, although storms have interrupted operations at both Table Mountain and Palomar on occasion," said Ryan Rogalin, the project's receiver electronics lead at JPL. (Whereas radio frequency communications can operate in most weather conditions, [optical communications](#) require relatively clear skies to transmit high-bandwidth data.)

JPL recently led an experiment to combine Palomar, the experimental radio frequency-optical antenna at the DSN's Goldstone Deep Space Communications Complex in Barstow, California, and a detector at Table Mountain to receive the same signal in concert. "Arraying" multiple ground stations to mimic one large receiver can help boost the deep space signal. This strategy can also be useful if one ground station is forced offline due to [weather conditions](#); other stations can still receive the signal.

Provided by NASA

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