Overview

Tried-and-tested radio frequency communications from deep space are approaching their bandwidth limit, raising the need for upgraded communications systems. Future space missions, meanwhile, are expected to transmit huge volumes of science data, including high-definition images and video, significantly increasing the bandwidth required. Much like fiber optics replacing old telephone wires on Earth as demand for data grows, going from radio communications to laser, or optical, communications will allow increased data rates throughout the solar system with 10 to 100 times the capacity of state-of-the-art radio systems currently used by spacecraft.

NASA's Deep Space Optical Communications (DSOC) experiment is the agency’s first demonstration of optical communications beyond the Earth-Moon system. DSOC is a system that consists of a flight laser transceiver, a ground laser transmitter, and a ground laser receiver. New advanced technologies have been implemented in each of these elements. The transceiver will “piggyback” on NASA’s Psyche spacecraft when it launches in fall 2022 to the metal-rich asteroid of the same name. The DSOC technology demonstration will begin shortly after launch and continue as the spacecraft travels from Earth to its gravity-assist flyby of Mars. DSOC operations are planned for one year after launch, with extended-mission opportunities to be evaluated.

Key Goals

- Demonstrate that flight laser transceiver and ground systems are able to “lock” onto each other’s laser signals during DSOC’s calibration and commissioning phase.
- Demonstrate specified downlink data rates as the Psyche spacecraft travels farther away from Earth. These data rates will decrease with increasing distance from Earth.
- Demonstrate a data uplink up to a distance of 1 astronomical unit (the average distance between the Earth and Sun – 93 million miles, or 150 million kilometers).
- Demonstrate operations for a year from the Psyche mission launch, at the cadence of one to two contacts per week for the duration of the technology demonstration.

Timeline

- Fall 2022: Psyche spacecraft is scheduled to launch from NASA’s Kennedy Space Center on a SpaceX Falcon Heavy rocket.
- ~14 days after launch: DSOC calibration and commissioning phase expected to begin, preparing the tech demo for operation.
- ~32 days after launch: First expected contact opportunity between DSOC ground systems and the flight transceiver aboard Psyche.
• April – May 2023: Spacecraft flies by Mars for gravity assist so it can gain speed. DSOC will continue testing optical communications at Earth-Mars distance and beyond.
• Fall 2023: End of DSOC tech demo one year after Psyche launch.

The System

Flight hardware: The DSOC flight laser transceiver will feature a near-infrared laser transmitter to send high-rate data to the ground system, and a sensitive photon-counting camera to receive a ground-transmitted laser. The transceiver’s 8.6-inch (22-centimeter) aperture telescope is mounted on an assembly of struts and actuators that stabilizes the optics from spacecraft vibrations. The flight hardware is fitted with a sunshade and protrudes from the side of the spacecraft, making it one of Psyche’s easily identifiable features.

Ground systems: A high-power near-infrared laser transmitter at the Jet Propulsion Laboratory’s Table Mountain facility near Wrightwood, California, will uplink a modulated laser beam to the flight transceiver and demonstrate the transmission of low-rate data. The uplink laser will also act as a beacon for the flight transceiver to lock onto. The downlink data sent back by the DSOC transceiver on Psyche will be collected by the 200-inch (5.1-meter) Hale Telescope at Caltech’s Palomar Observatory in San Diego County, California, using a sensitive superconducting nanowire photon-counting receiver to demonstrate high-rate data transfer.

History

Laser communications have already passed a key test: In 2013, NASA’s Lunar Laser Communications Demonstration tested record-breaking uplink and downlink data rates between Earth and the Moon. In 2021, NASA’s Laser Communications Relay Demonstration launched to test high-bandwidth optical communications from geostationary orbit and to demonstrate relay capabilities so that spacecraft don’t need to maintain a direct line of sight with Earth to communicate. In 2022, DSOC will take optical communications into deep space for the first time. This will set the foundation for establishing higher data-rate returns from future human and robotic missions to Mars and beyond.

Program Management

NASA’s Jet Propulsion Laboratory, a division of Caltech in Pasadena, California, manages the project for the Technology Demonstration Missions program within NASA’s Space Technology Mission Directorate, and the Space Communications and Navigation (ScaN) program within the agency’s Space Operations Mission Directorate. JPL’s William “Bill” Klipstein is DSOC’s project manager and Abhijit “Abi” Biswas is the project technologist.

For more information about NASA’s DSOC technology demonstration go to:

https://www.nasa.gov/mission_pages/tdm/dsoc/