NASA's Laser Communications Relay Demonstration: 6 things you need to know

November 18 2021, by Katherine Schauer

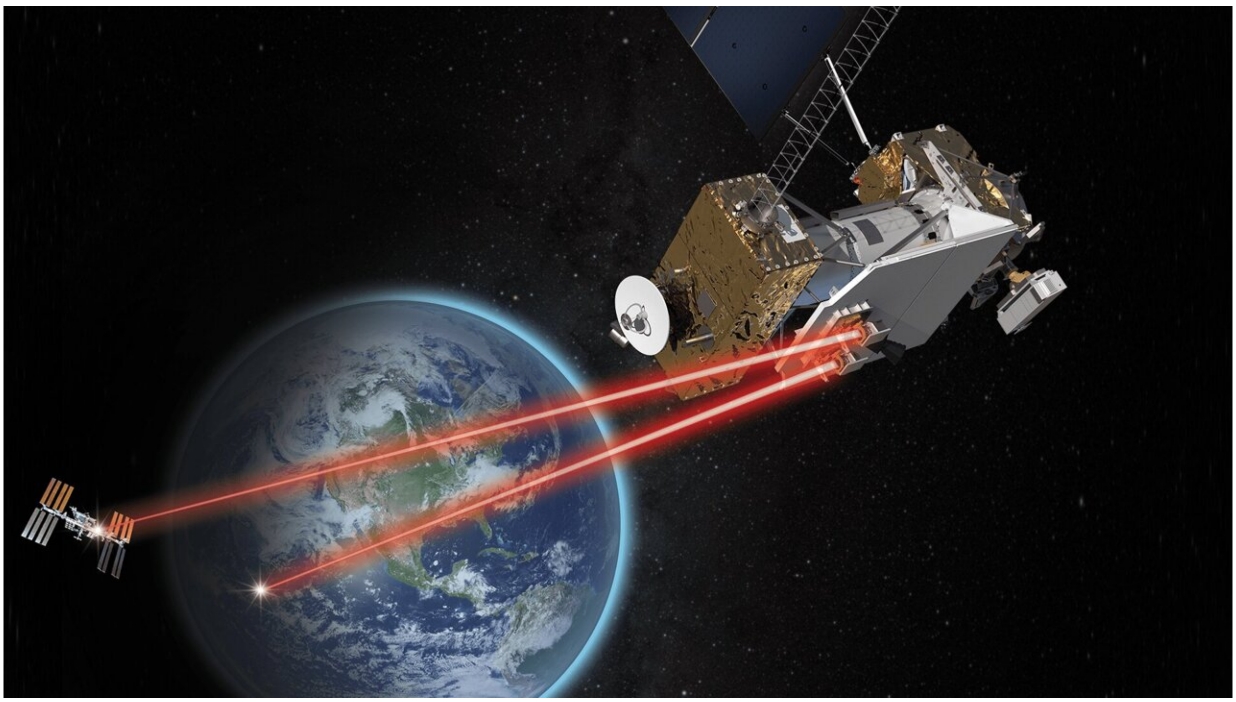


Illustration of NASA's Laser Communications Relay Demonstration communicating over laser links. Credit: NASA's Goddard Space Flight Center

NASA's Laser Communications Relay Demonstration (LCRD) will use laser communications systems to transmit data from space to Earth. Below are six things you need to know about NASA's revolutionary LCRD mission.

1. Laser communications will transform how NASA gets info to and from space

Since the dawn of space exploration, NASA has used radio frequency systems to communicate with astronauts and spacecraft. However, as space missions generate and collect more data, the need for enhanced communications capabilities increases. LCRD leverages the power of laser communications, which uses infrared light rather than radio waves, to encode and transmit information to and from Earth.

Both radio waves and laser infrared light waves are forms of electromagnetic radiation with wavelengths at different points on the spectrum. Missions encode their scientific data onto the electromagnetic signals to send back to Earth.

The infrared light used for laser communications differs from radio waves because it occurs at a much higher frequency, allowing engineers to pack more data into each transmission. More data yields more information and discoveries about space at once.

Using infrared lasers, LCRD will send data to Earth from geosynchronous orbit at 1.2 gigabits-per-second (Gbps). At this speed and distance, you could download a movie in under a minute.

2. Laser communications will let spacecraft send home more data in a single downlink

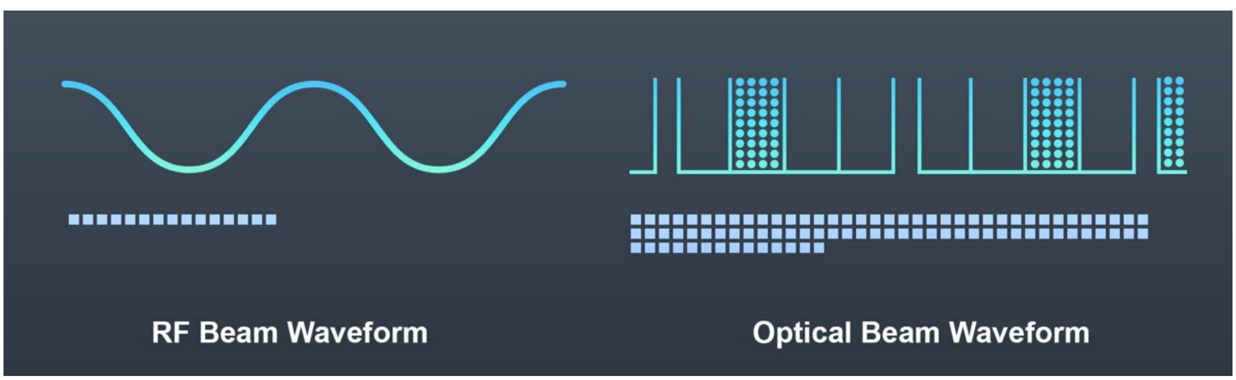
If you were alive in the late '80s and early '90s, you'll remember the dial-up speeds of the terrestrial internet—slow and painful. The addition of laser communications to spacecraft is similar to humanity's use of high-speed internet with technologies like fiber optic networking: revolutionary.

Our home internet connections these days allow high-definition videos, shows, and content to reach our screens almost instantaneously.This is, in part, due to the fiber optic connections sending laser light densely packed with data through plastic or glass cables, creating a faster user experience.

This same concept—minus the fiber cables—is applied to space-based laser communications, which allows spacecraft to send high-resolution images and videos over laser links.

With laser communications in place, spacecraft can send back more data at once in a single download. NASA and the aerospace industry are taking advantage of these new developments and creating more missions that use lasers to complement radio frequency satellites.

3. The payload has two optical modules, or telescopes, for receiving and transmitting laser signals



Radio waves versus optical waves Credit: NASA

LCRD is a relay satellite with many highly sensitive components that provide increased communications. As a relay, LCRD removes the need for user missions to have direct line-of-sight to antennas on Earth. LCRD has two optical terminals—one terminal receives data from a user spacecraft, while the other transmits data to ground stations on Earth.

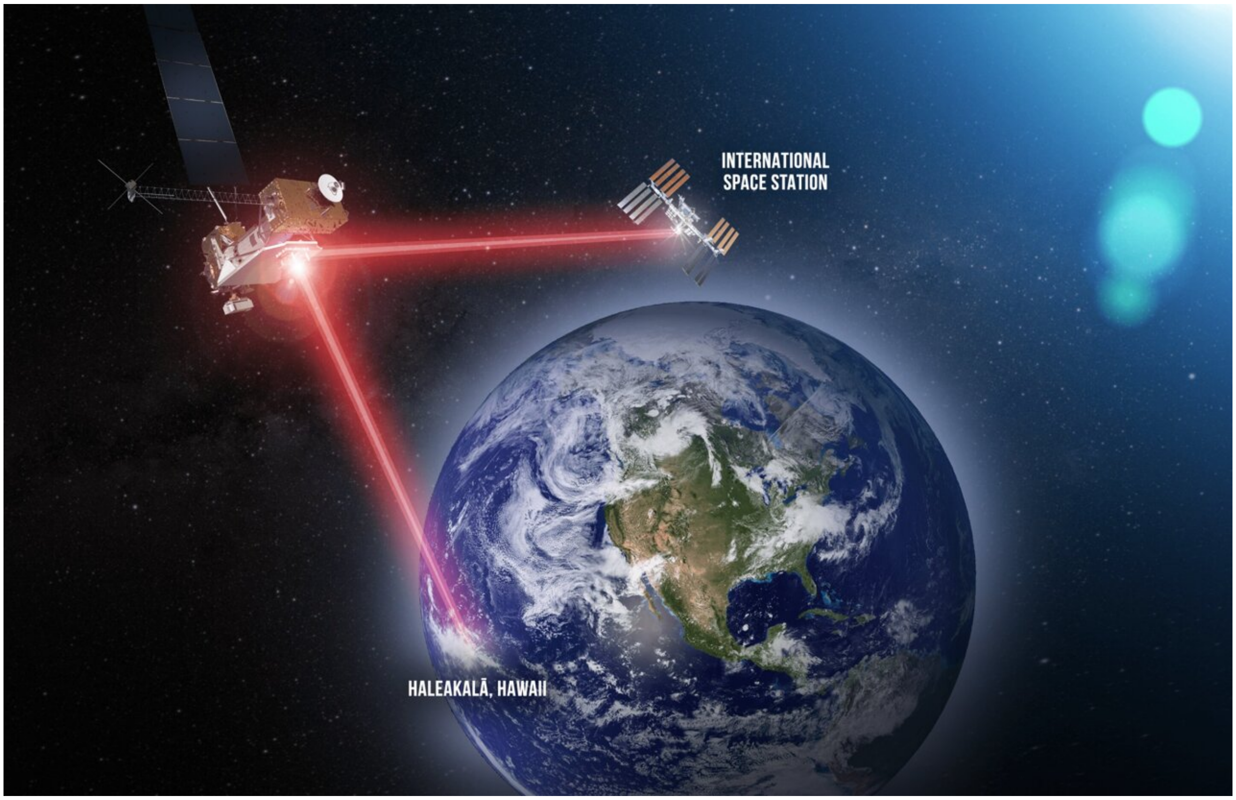
LCRD's modems translate digital data into laser signals, which are then transmitted via encoded beams of light, invisible to the human eye, by the relay's optical modules. LCRD can both send and receive data, creating a continuous path for flowing mission data to-and-from space. Together, these capabilities make LCRD NASA's first two-way, end-to-end optical relay.

These are just some of the components that make up the LCRD payload, which all together is the size of a king mattress.

4. LCRD depends on two ground stations in California and Hawaii

Once LCRD receives information and encodes it, the payload sends the data to ground stations on Earth that are each equipped with telescopes to receive the light and modems to translate the encoded light back into digital data.

LCRD's ground stations are known as Optical Ground Stations (OGS) -1 and -2, and are located on Table Mountain in Southern California, and on Haleakalā Volcano in Maui, Hawaii.



LCRD communicating data from the space station to Earth Credit: NASA/Dave Ryan

While laser communications can provide increased data transfer rates, atmospheric disturbances—such as clouds and turbulence—can interfere with laser signals as they travel through Earth's atmosphere.

The locations for OGS-1 and OSG-2 were chosen for their clear weather conditions and remote, high-altitude locations. Most of the weather occurring in those areas takes place below the summit of the mountains, leaving relatively clear skies perfect for laser communications.

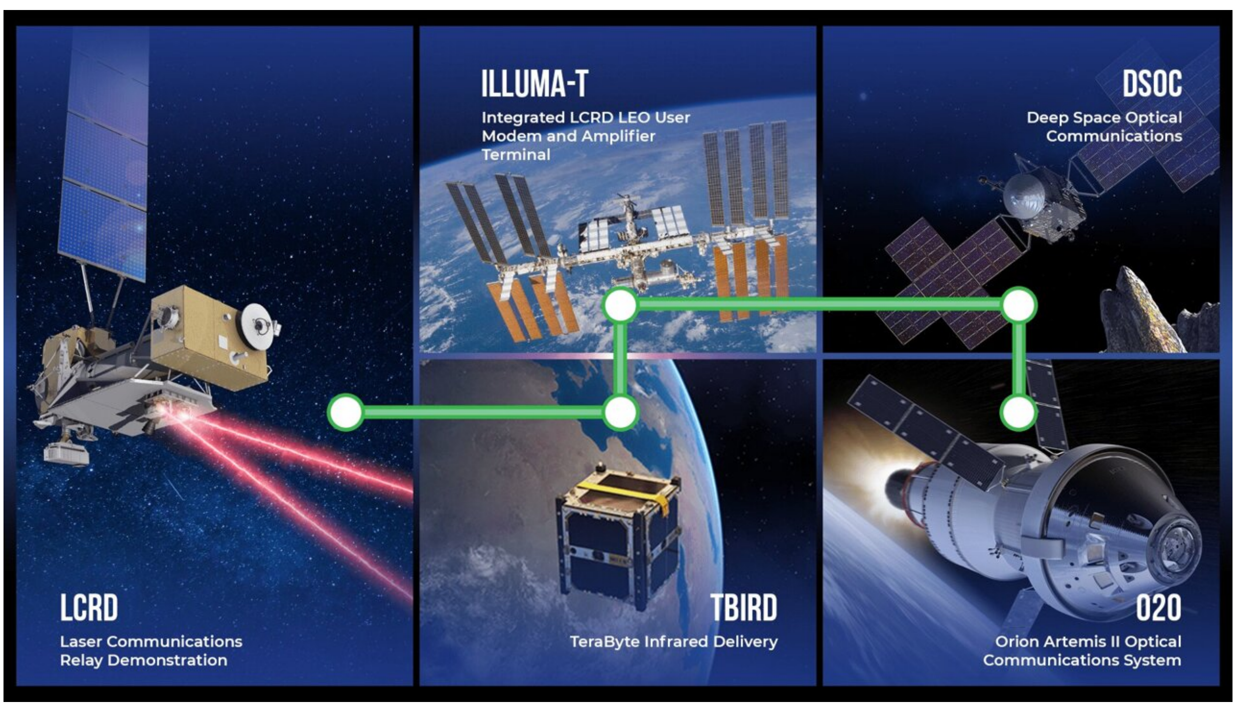
5. LCRD allows government, academia, and commercial partners to test laser capabilities from

geosynchronous orbit

LCRD will prove the viability of laser communications systems from geosynchronous orbit—about 22,000 miles above Earth's surface.

Prior to supporting other missions, LCRD will spend two years conducting tests and experiments. During this time, OGS-1 and OGS-2 will act as "missions," sending data from one station to LCRD then down to the other.

LCRD will test laser functionality with experiments from NASA, other government agencies, academia, and commercial companies. Some of these experiments include studying atmospheric disturbances on laser signals and demonstrating reliable relay service operations.



NASA's laser communication missions Credit: NASA/Dave Ryan

These tests will allow the aerospace community to learn from LCRD and further refine the technology for future implementation. NASA is providing these opportunities to grow the body of knowledge surrounding laser communications and promote its operational use.

After its experimental phase, LCRD will support in-space missions, including an optical terminal that will be installed on the International Space Station. This terminal will collect data from science experiments onboard and then transmit the information to LCRD to be relayed to Earth.

6. LCRD is one of many exciting and upcoming laser missions

LCRD is NASA's first-ever laser communications relay system. However, there are many missions in development that will demonstrate and test additional laser communications capabilities.

- The Terabyte Infrared Delivery (TBIRD) CubeSat payload will demonstrate laser downlinks at 200 Gbps—a new record for laser communications data rates.
- LCRD's first user will be the Integrated LCRD Low Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) aboard the space station. ILLUMA-T will provide the orbiting laboratory with 1.2 Gbps data rates to communicate high-resolution images and videos of ongoing experiments down to Earth.
- The Orion Artemis II Optical Communications System (O2O) terminal will enable an ultra-high-definition video feed over infrared light between Earth and Artemis II astronauts journeying around the Moon.
- In 2026, the Psyche mission will reach its destination—an asteroid over 150 million miles away from Earth. Psyche will

carry the Deep Space Optical Communication (DSOC) payload to test laser communications against the distinctive challenges presented by deep space exploration.

All of these missions will help the aerospace community standardize laser communications for implementation on future missions. With lasers lighting the way, NASA can glean more information from space than ever before.

Provided by NASA's Goddard Space Flight Center

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