

Space-based Optical Communications with CubeSats

Optical communication systems use lasers to encode and transmit data with higher speed and density than traditional radio frequency (RF)-based communications. Smaller antennas, lower power requirements, and increased spectrum availability enable optical communications to be integrated into CubeSats more easily than radios, enabling affordable communications solutions for future NASA missions.

Since its inception in 1958, NASA has relied almost exclusively on RF-based communications as a conventional medium for exchanging data between Earth and spacecraft. However, CubeSat-scale systems have the potential to enable new kinds of science missions at lower cost. CubeSats are satellites built to standard specifications of 1 unit (U), which is defined as 10x10x10 centimeters (about 4x4x4 inches).

CubeSats are demonstrating that technology advances allow small satellites to contribute to exploration, technology demonstration, scientific research, and educational investigations at NASA.

Laser-based communication technology has been used on Earth, primarily using fiber optic cables buried underground or in channels at the bottom of the sea. The same needs for more data faster has led NASA and others to investigate using lasers to communicate through space. The more data that can be sent back to Earth from NASA's missions, the more cost-effective and scientifically valuable they can be. Since laser light wavelengths are shorter than radio waves, laser energy spreads out less as it travels through space, thus allowing faster communication rates,

NASA facts



Figure 1. Laser Communications Rendering.

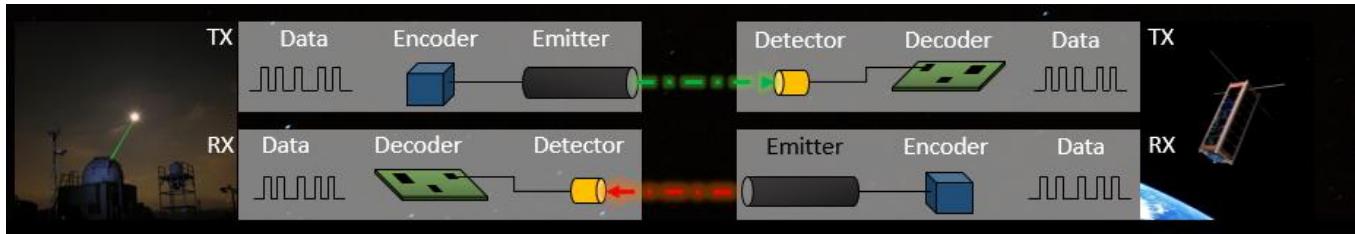


Figure 2. Two-way CubeSat based optical communications setup. The transmitter (TX) encodes data and emits laser pulses representing 0's and 1's of the dataset. The receiver (RX) detects the laser pulses and decodes them back to the original data. Both the ground segment (left) and space segment (right) have TX and RX systems.

communication over long distances (e.g. between planets), greater security, and more available bandwidth.

Optical communication at large scales has been demonstrated by the Lunar Atmosphere and Dust Environment Explorer (LADEE). NASA's Lunar Laser Communication Demonstration (LLCD) on LADEE transmitted data using a pulsed laser beam between the moon and the Earth. This demonstration achieved efficiencies with a 6 times faster download speed, and a 5,000 times faster upload speed, and using 25% less power than the best radio system ever flown to the moon.

Upcoming missions include the Optical Communications and Sensor Demonstration (OCSD) CubeSat mission, launching in 2017. OCSD is developed under NASA's Small Spacecraft Technology Program and will demonstrate high-speed optical transmission of data from the Earth's orbit to the ground in a 1.5 U spacecraft – the most compact optical communications system yet flown in space.

In addition, NASA's Advanced Exploration Systems Program in collaboration with the University of Florida is developing the 3U CubeSat Handling of Multisystem Time-transfer (CHOMPTT) spacecraft. CHOMPTT is slated for launch in 2018, and will use laser pulses to transfer data.

NASA's Small Business Innovation Research (SBIR) program is funding commercial development of CubeSat-scale optical communication systems as well. These programs enable development of the technologies needed to make such missions possible-- like cutting-edge optical communications, satellite-to-satellite communications, and autonomous

movement capabilities. While CubeSat-based optical communications offers many advantages, making the technology ready for everyday use offers the challenges of minimizing cost, improving pointing accuracy, and ensuring availability of Earth-based laser stations.

Continued development of CubeSat-based optical communications systems could eventually enable delivery of video and high-resolution measurements from spacecraft visiting planets across the solar system—creating advancements in the way researchers track hurricanes and other climate and environmental changes here on Earth and also on other planets. Optical communication systems on CubeSats provide a low-cost platform for NASA missions including: Earth observations, fundamental planetary and space science, solar system exploration, heliophysics, and astrophysics investigations.

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