NASA: We are SCaN - YouTube

# Quantum Technology Development at NASA

**Presentation for the Quantum.Tech**
**Boston, MA**

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*Quantum-communications Science & Technology (QS&T)*

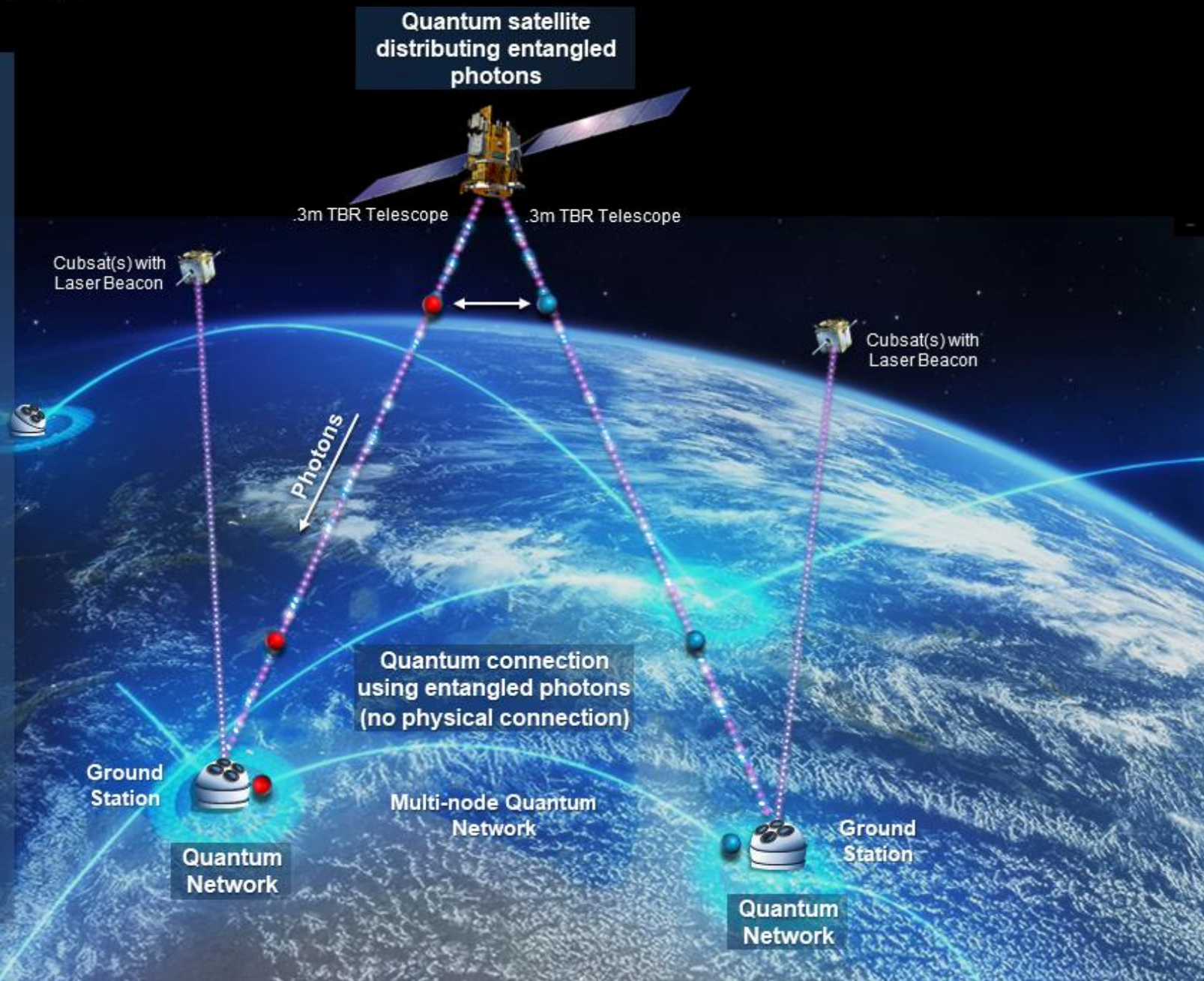
# Quantum Communications

**Information can now be encoded (represented) by multi-state quantum bits (qubits)**

- Entangled photons as qubits can interact with each other at any distance
- By having a satellite distribute entangled photons via optical links to well separated stations on Earth, those stations can "talk" to each other via the entangled photons - without needing to be physically connected

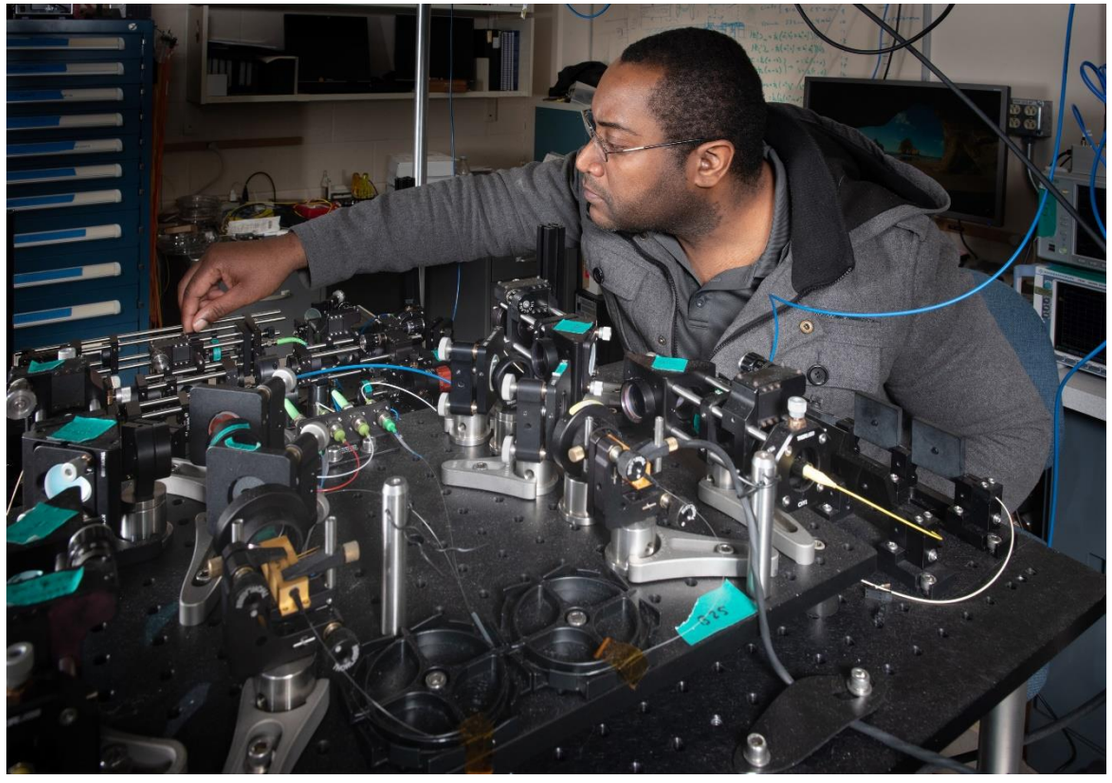
**Benefits**

- Quantum networks with space links
- Data security
- Improved energy efficiency for optical communications
- Improved bandwidth efficiency for optical communications




***Credits: NASA/Badri Younes***

# Quantum Metrology Studies
# NASA Glenn Research Center



***Credits: NASA/Marvin Smith***

Quantum Information Scientist, Daniel Hart, aligning optics for a setup that converts laser light from one wavelength to another. Wavelength conversion technique allows researchers to use a single laser for multiple laboratory applications.

***Credits: NASA/Marvin Smith***

Between two optical objectives sits an integrated photonics chip that contains waveguide entanglement sources. Red laser light is used to highlight the chip.

# Distributed Quantum Computing
# NASA Ames Research Center

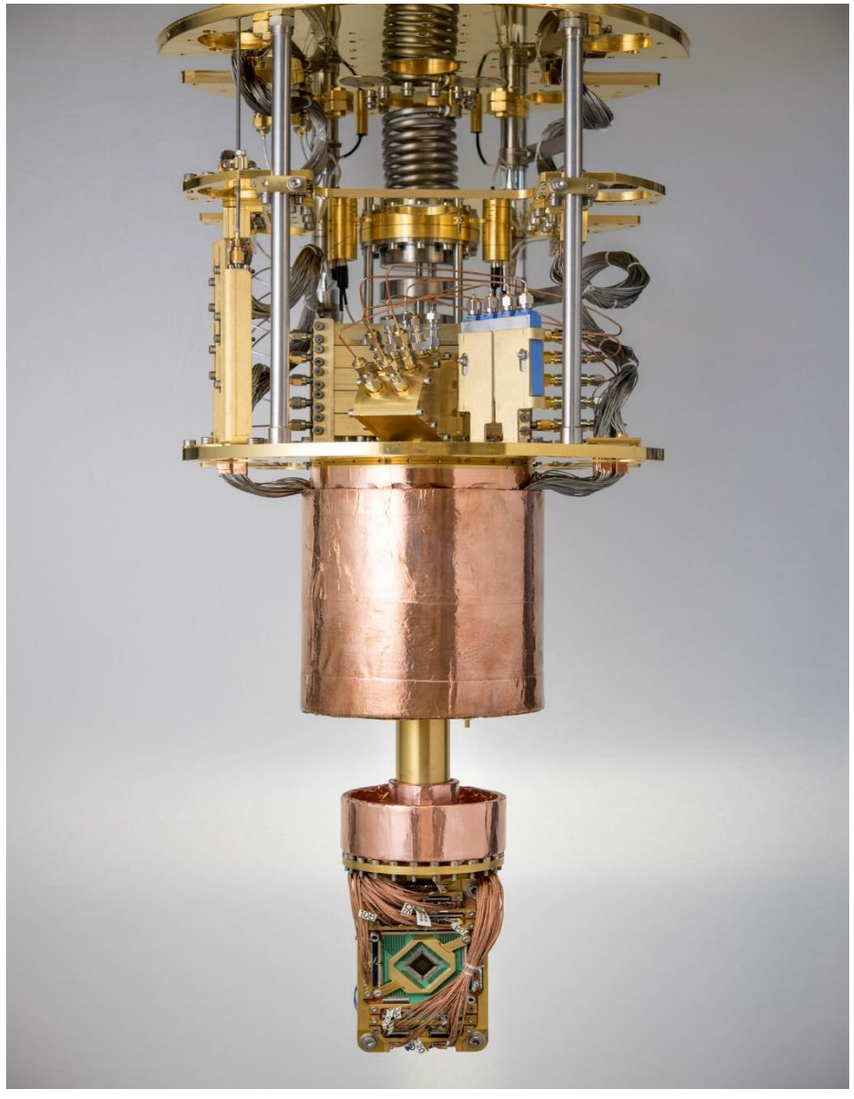


***Image credit:*** *D-Wave*

**Task**:

Support a broader effort related to distributed quantum computing over a quantum network, particularly where the computing devices may be special purpose processors with differing advantages and limitations

**Background:**

- **Distributed Computation:** Network of Multiple Processors that communicate
- **Distributed graph algorithms**: Answer some question about that graph, by computing across the processors in a distributed fashion
- **Steiner Tree Problem (informal)**: Given a set of terminal nodes, find a minimum weight tree in the graph that contains them

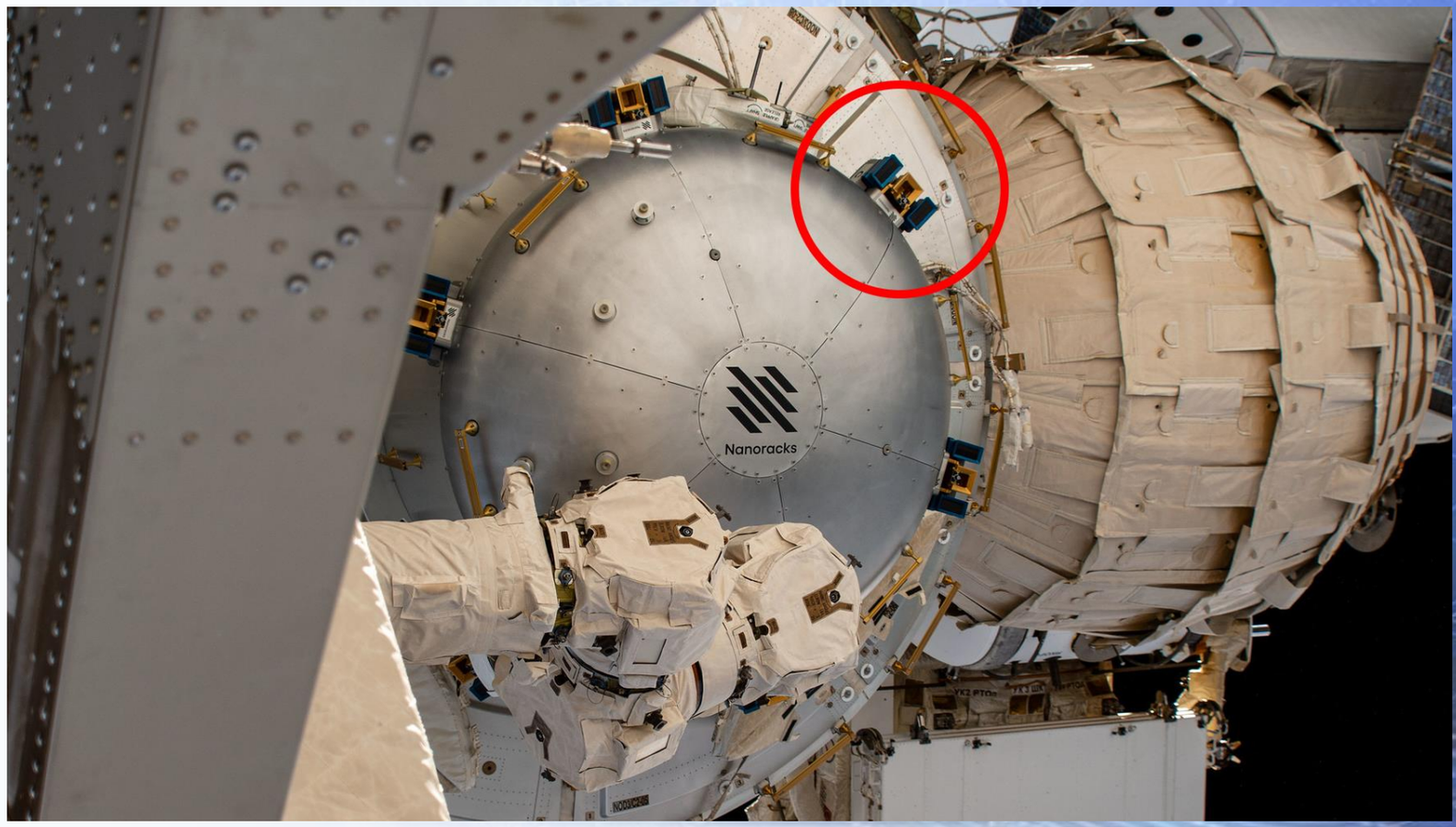
**Banner Image:**

The D-Wave processor, a quantum system that was operated at the NASA Advanced Supercomputing facility's Quantum Artificial Intelligence Laboratory at NASA's Ames Research Center in California's Silicon Valley.

# Space Entanglement and Annealing QUantum Experiment ( SEAQUE)

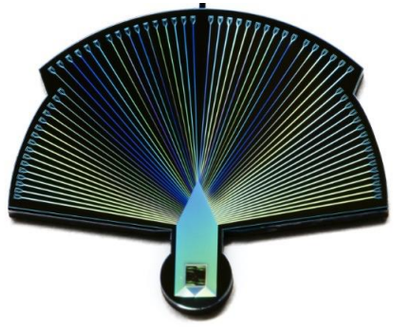
## A ‘Self-Healing’ Quantum Communications Tech Demo

- SEAQUE will be hosted on the International Space Station by the Nanoracks Bishop airlock.
- Counts photons generated by its entanglement source by using its detector array.
- Leverages a bright laser to periodically repair radiation-induced damage that will affect the detector array’s count




***Credits: NASA. Principal Investigator (Dr. Paul Kwiat, UIUC) and Co-Investigator (Dr. Makan Mohageg, NASA JPL)***

# SCaN Quantum Ground Station
# NASA Jet Propulsion Lab



Photograph of a 32-channel SNSPD array

Validate critical subsystems that compensate for polarization rotation and timing desynchronization on an emulated Space-Earth quantum communication system

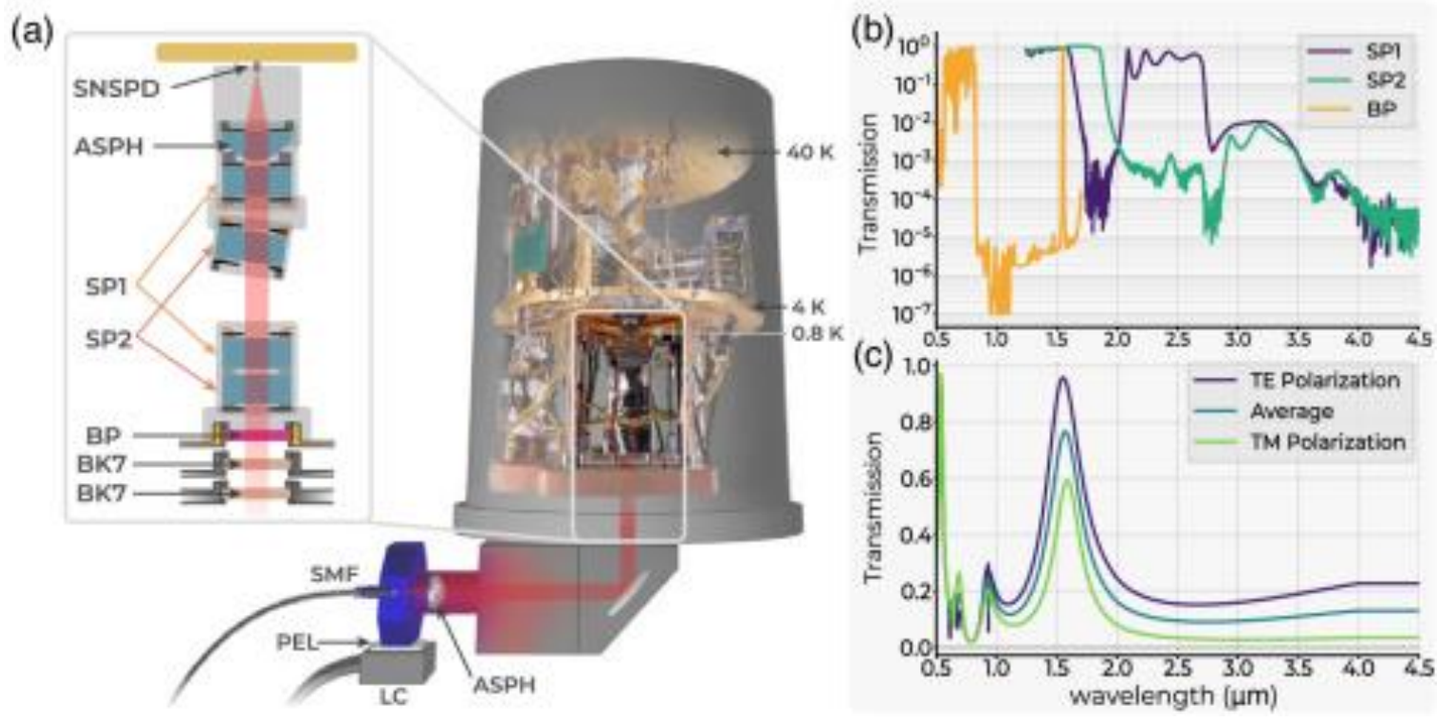
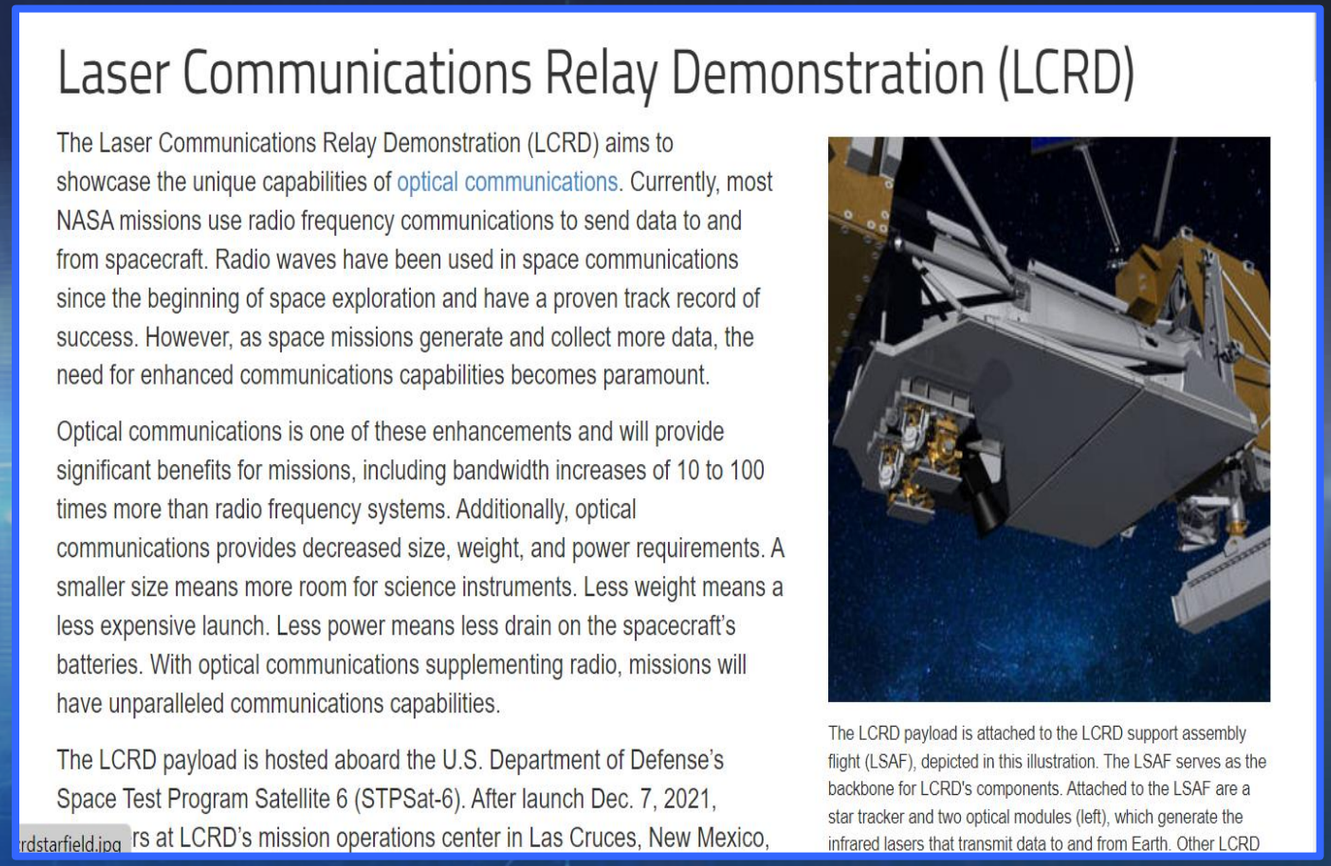



**Figure.** (a) System hardware. (b) Transmission spectra for the three filters utilized. (c) Absorption spectrum for the SNSPD efficiency-enhancing optical stack.

**Credit: NASA Jet Propulsion Lab (JPL), Free-space coupled superconducting nanowire single-photon detector with low dark counts,** Andrew S. Mueller, et. al., **Optica** Vol. 8, Issue 12, pp. 1586-1587 (2021)

# Laser Communications Relay Demonstration (LCRD)

- LCRD showcases the unique capabilities of optical communications
- Provides benefits for missions, including bandwidth increases of 10 to 100 times more than radio frequency systems.
- Compared to RF, Optical Comms offer decreased size, weight, and power requirements.
- Optical communications will supplement radio frequency (RF), giving missions unparalleled communications capabilities.



## Laser Communications Relay Demonstration (LCRD)

The Laser Communications Relay Demonstration (LCRD) aims to showcase the unique capabilities of optical communications. Currently, most NASA missions use radio frequency communications to send data to and from spacecraft. Radio waves have been used in space communications since the beginning of space exploration and have a proven track record of success. However, as space missions generate and collect more data, the need for enhanced communications capabilities becomes paramount.

Optical communications is one of these enhancements and will provide significant benefits for missions, including bandwidth increases of 10 to 100 times more than radio frequency systems. Additionally, optical communications provides decreased size, weight, and power requirements. A smaller size means more room for science instruments. Less weight means a less expensive launch. Less power means less drain on the spacecraft's batteries. With optical communications supplementing radio, missions will have unparalleled communications capabilities.

The LCRD payload is hosted aboard the U.S. Department of Defense's Space Test Program Satellite 6 (STPSat-6). After launch Dec. 7, 2021,

rdstarfield.jpg

rs at LCRD's mission operations center in Las Cruces, New Mexico,



The LCRD payload is attached to the LCRD support assembly flight (LSAF), depicted in this illustration. The LSAF serves as the backbone for LCRD's components. Attached to the LSAF are a star tracker and two optical modules (left), which generate the infrared lasers that transmit data to and from Earth. Other LCRD

**Laser Communications Relay Demonstration (LCRD) Overview - YouTube**