



The Laser Communications Relay Demonstration Experiment Program

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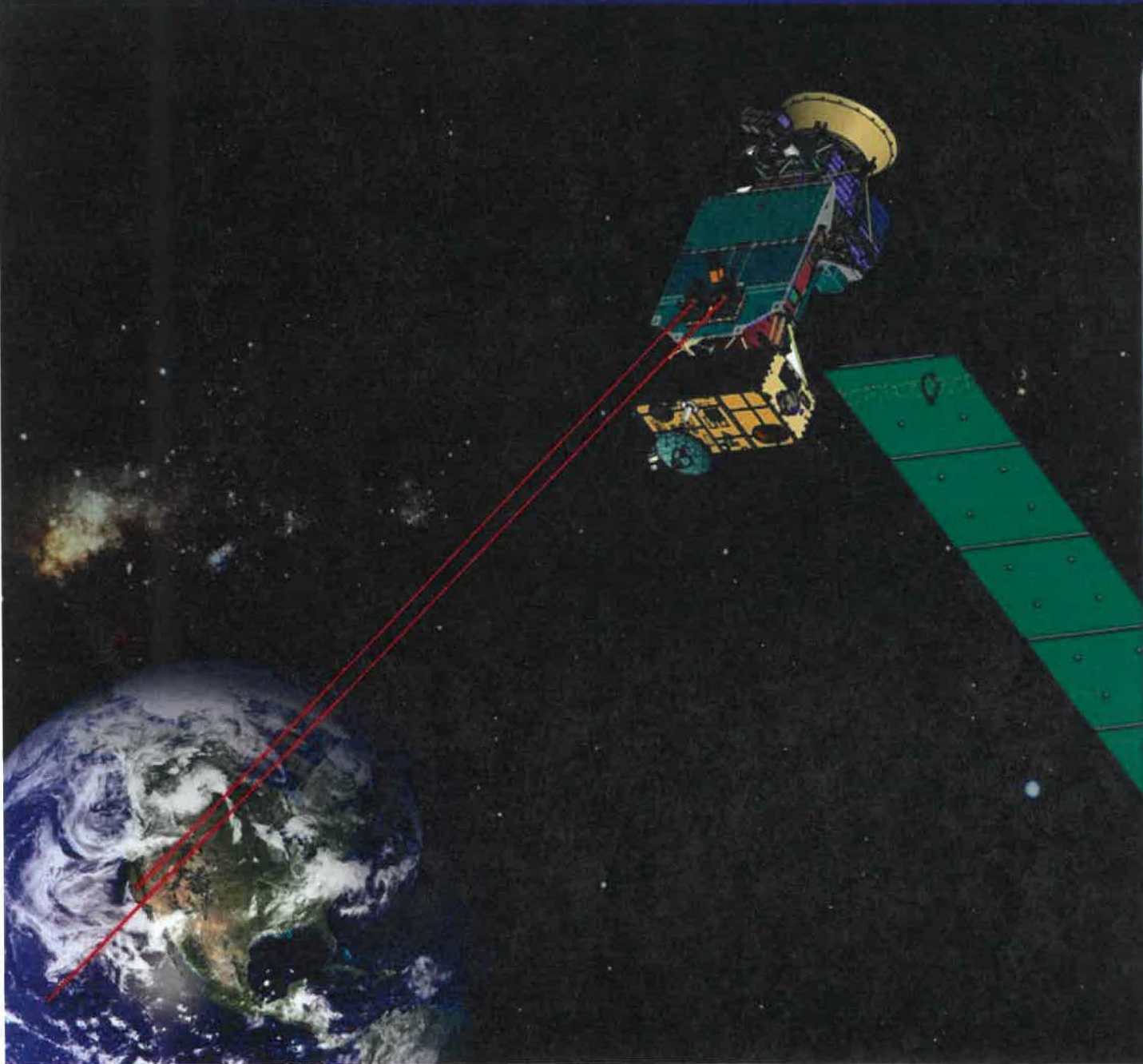


Exploration & **SPACE**
Communications

More than you ever imagined...



LCRD: Testing Optical Communications Links



Demo Description

A minimum two-year flight demonstration (goal of five years) to advance optical communications technology toward infusion into deep-space and near-Earth operational systems while growing the capabilities of industry sources

Objectives

- Demonstrate bidirectional optical communications between geosynchronous Earth orbit (GEO) and Earth
- Measure and characterize the system performance over a variety of conditions
- Develop operational procedures and assess applicability for future missions
- Provide an on-orbit capability for test and demonstration of standards for optical relay communications

Anticipated Benefits

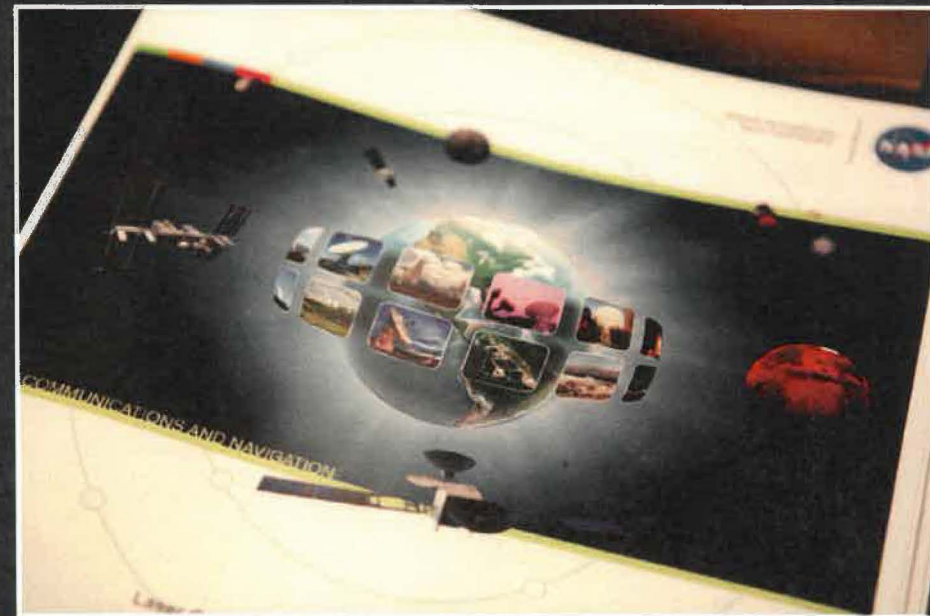
- A reliable, capable and cost-effective optical communications technology for infusion into future operational systems

LCRD Experiment Program

NASA

LCRD will engage various pre-determined experiments to test new laser communications technology and techniques for LEO and deep-space applications, and to gather valuable data. **The Guest Experimenters Program** encourages individuals and groups from international organizations, government, academia and industry to propose diverse experimentation ideas.

- Experiments will begin immediately following launch and payload checkout.
- The highest priority experiments will demonstrate technology readiness for the next-generation relay capability:
 - Laser communications link and atmospheric characterization
 - Relay operations
 - Optical-based networking services
- Other experiments include:
 - Development of operations efficiency
 - Planetary/near-Earth relay scenarios
 - Low Earth Orbit (LEO), real or simulated
 - Direct uplink/downlink
 - Commercial applications



The LCRD Introduction for Experimenters document describes possible experiments and processes for experiment solicitation.

lcrd.gsfc.nasa.gov

LCRD Mission Architecture

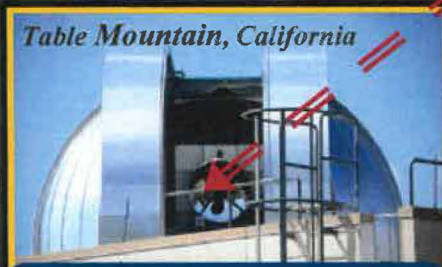


LCRD Flight Payload

- 2 optical relay terminals
 - 10.8-cm aperture
 - 0.5-W transmitter
 - DPSK and PPM
- Space Switching Unit
- High data rate RF

Optical Relay Link Features

- 2880 Mbps Uncoded DPSK
- 1244 Mbps Coded DPSK
- 311 Mbps 16-PPM
- Coding/Interleaving at link edges
 - Rate 1/2 DVB-S2 codec (LDPC)
 - One second of interleaving for atmospheric fading mitigation



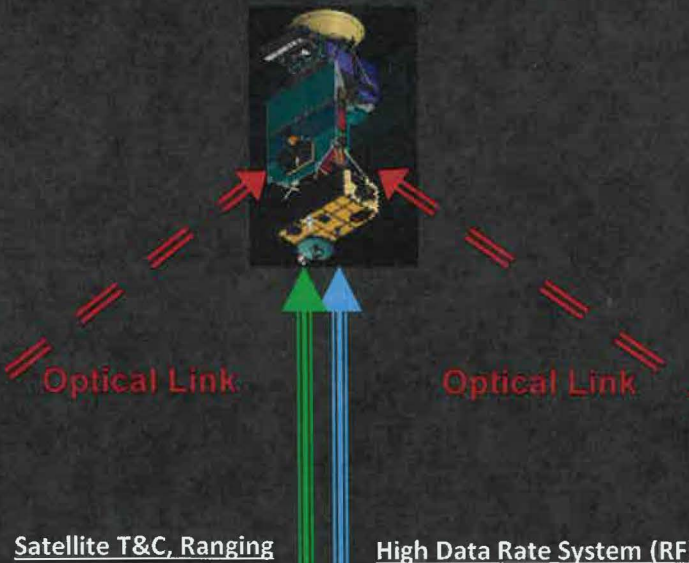
Optical Ground Station 1

- 1-m transmit and receive aperture
- 10-W transmitter



Optical Ground Station 2

- 60-cm receive aperture
- 15-cm transmit aperture
- 10-W transmitter



STPSat-6 Antenna and Ground Equip. (SAGE)

LMOC Extension

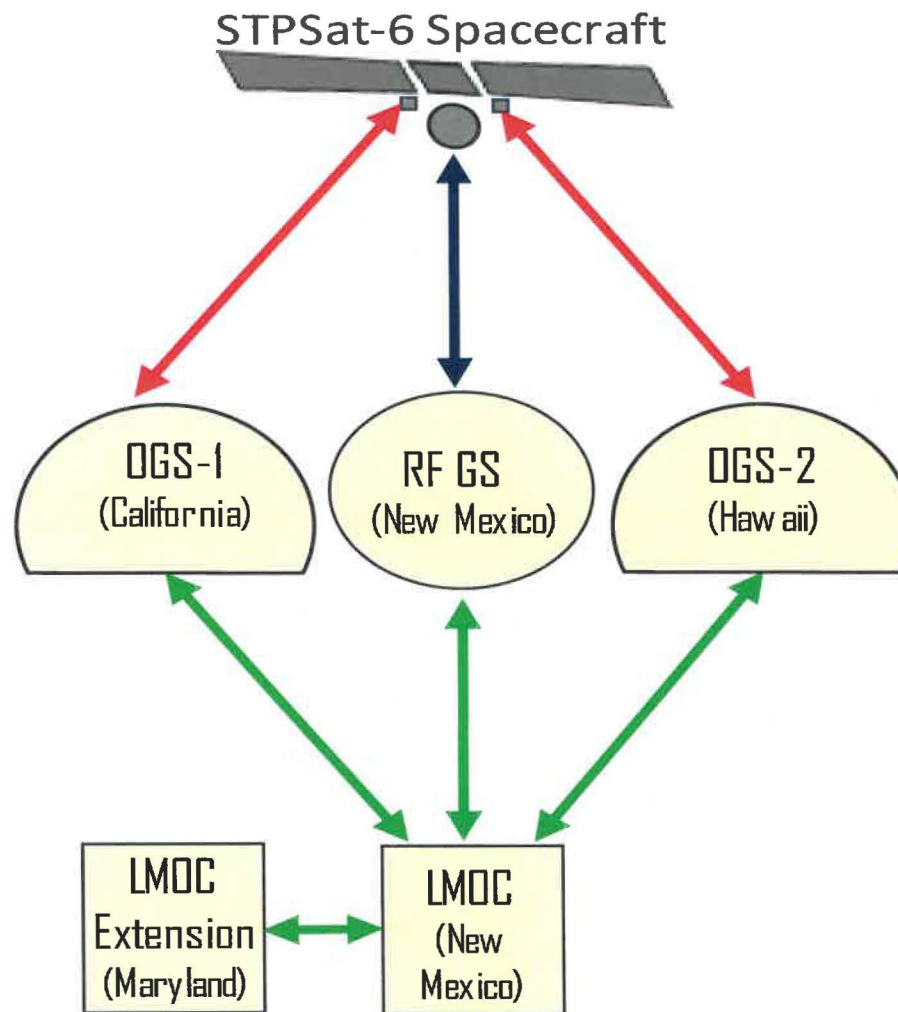
LCRD Mission Ops Center (LMOC)

STPSat-6 Satellite Ops Center (SSOC)

LCRD Mission Architecture



LCRD has a flight segment and a ground segment:

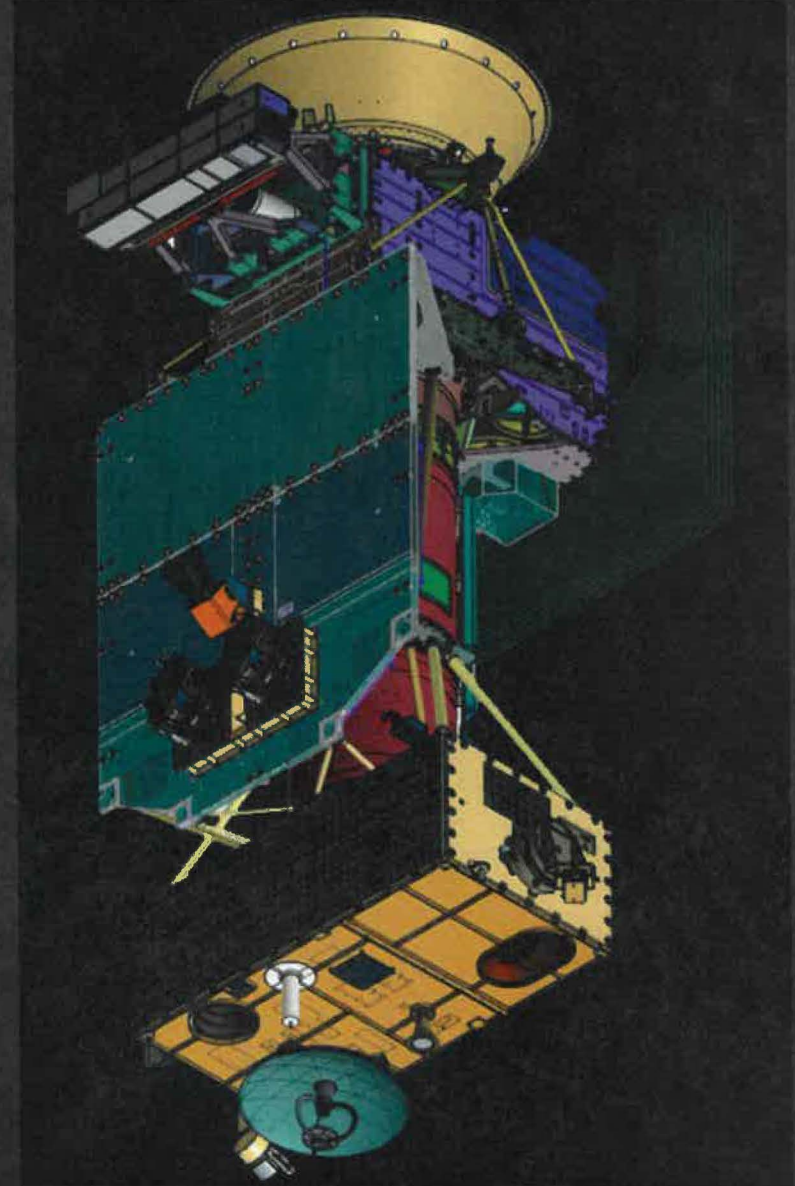
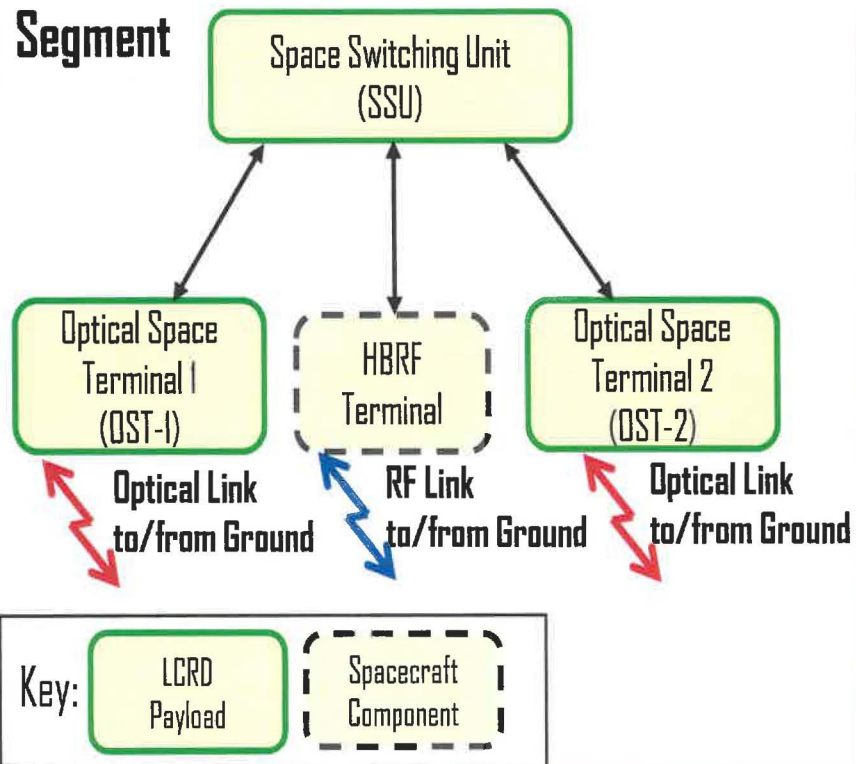


LCRD Spacecraft Host and Flight Segment



- LCRD will fly on the Air Force Research Laboratory's Space Test Program Satellite (STPSat-6) mission.
 - STPSat-6 is scheduled to launch in 2019.

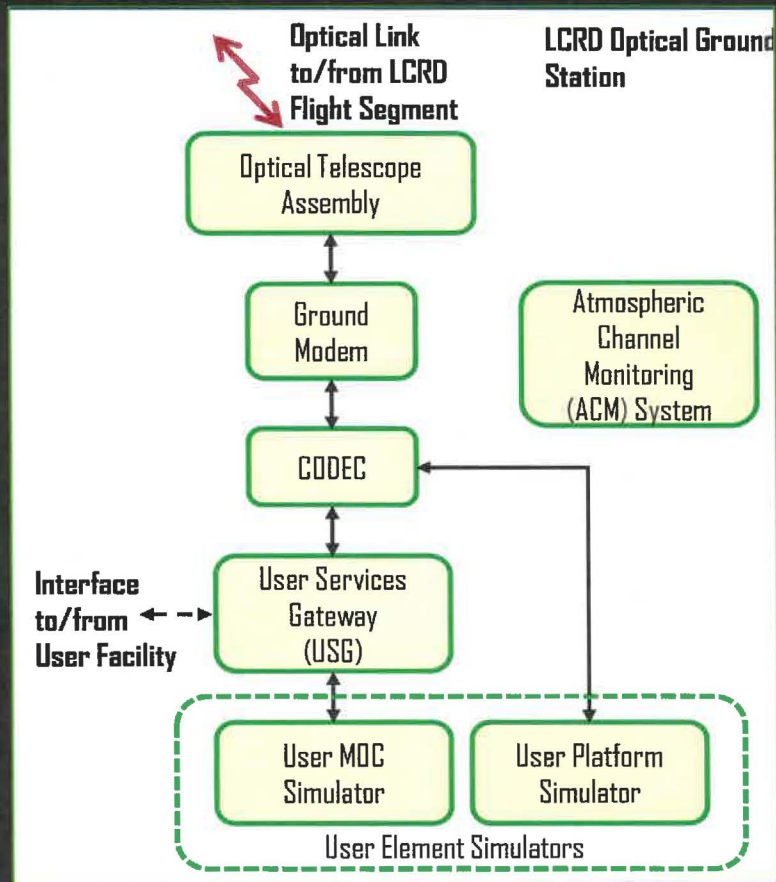
LCRD Flight Segment



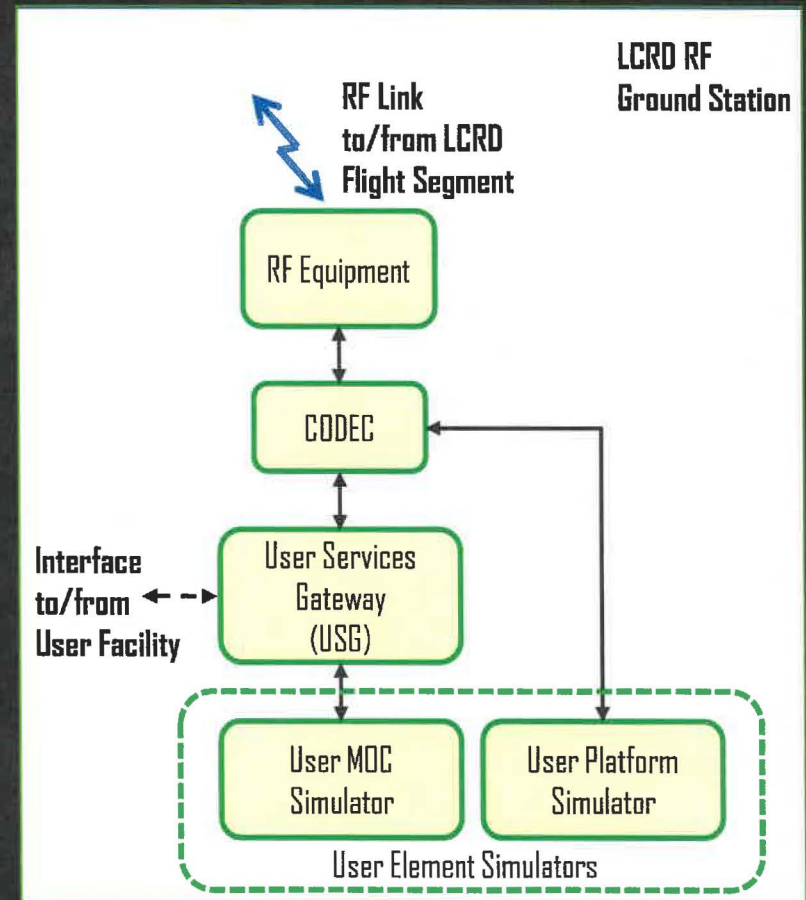
LCRD Ground Segment



Optical ground stations subsystems:

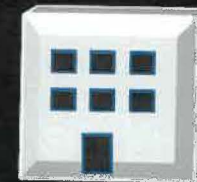


RF ground station subsystems:

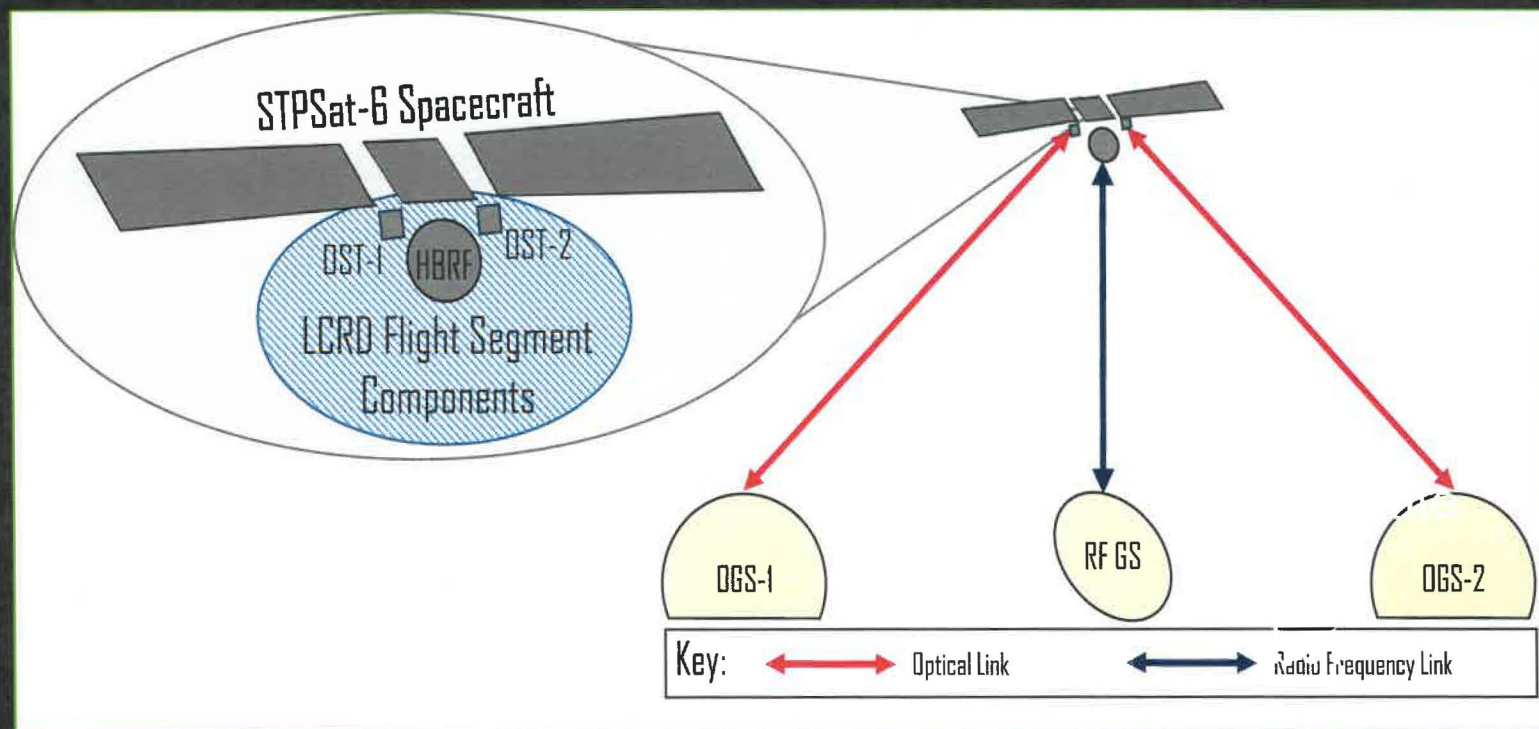


LCRD Mission Operations Center:

Mission Planning and Scheduling * Payload Telemetry and Command * Data Storage
Data Analysis * Central Operations Monitoring and Control * Service Management
Ground Station Remote Monitoring * Experiment Operations

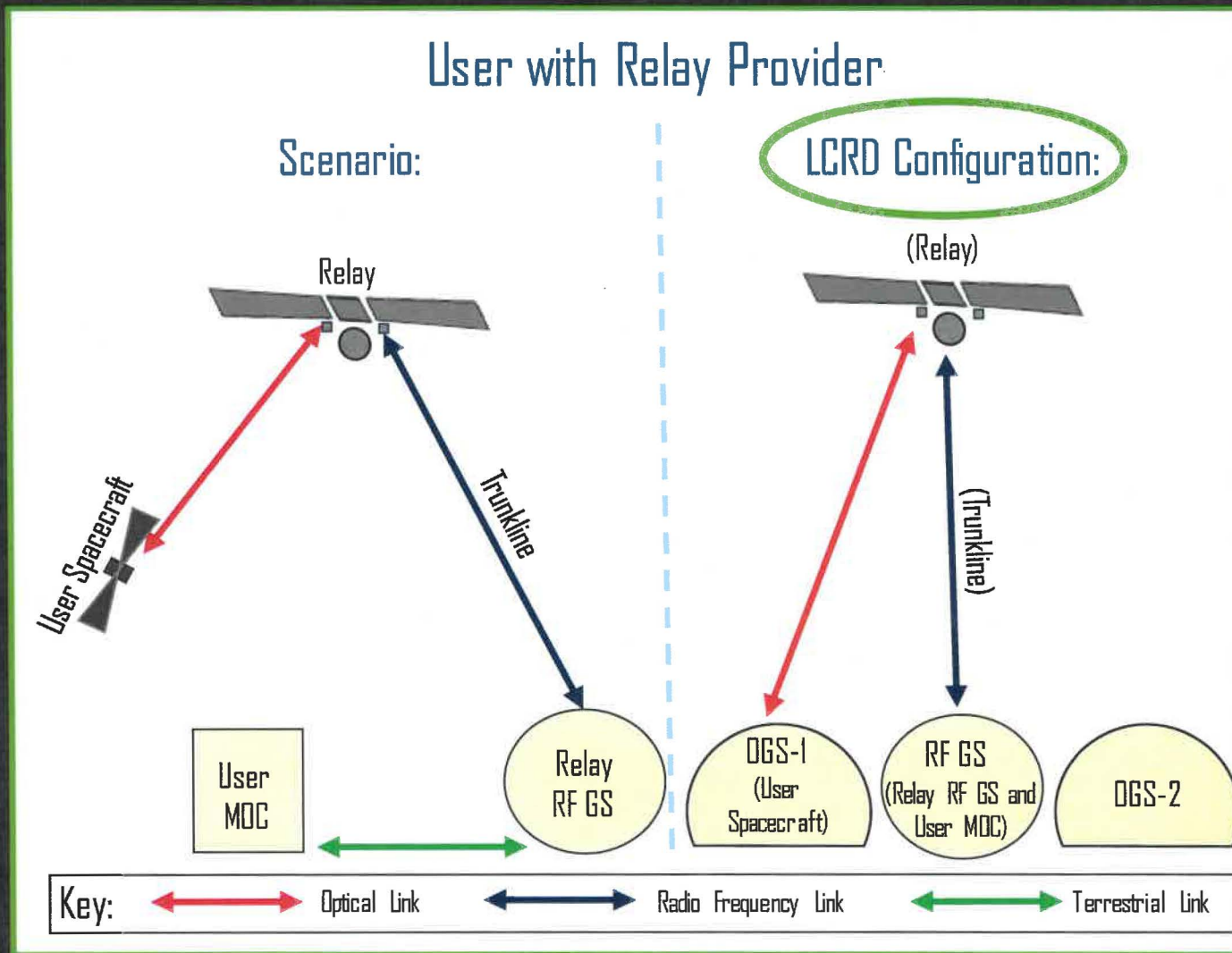


LCRD Example Experiments



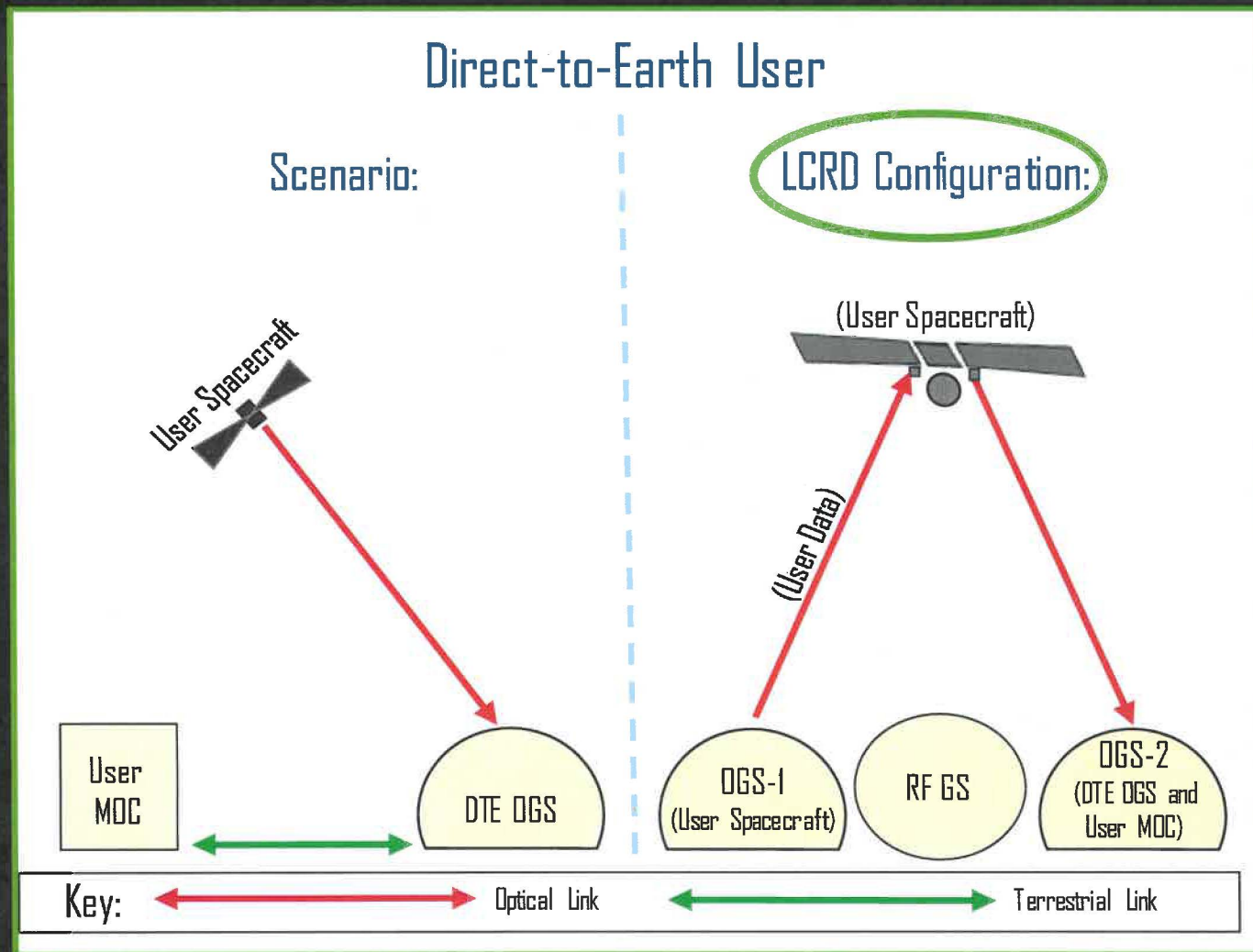
LCRD is capable of simulating numerous optical communication scenarios, and LCRD experiments will involve elements both on the ground and in space.

Example Scenario: User with Relay Provider



All links are **bidirectional**, and it is possible to **independently control** the data rates, coding and modulation on each link; therefore, one could demonstrate a **user with asymmetric data rates**.

Example Scenario: Direct-to-Earth User



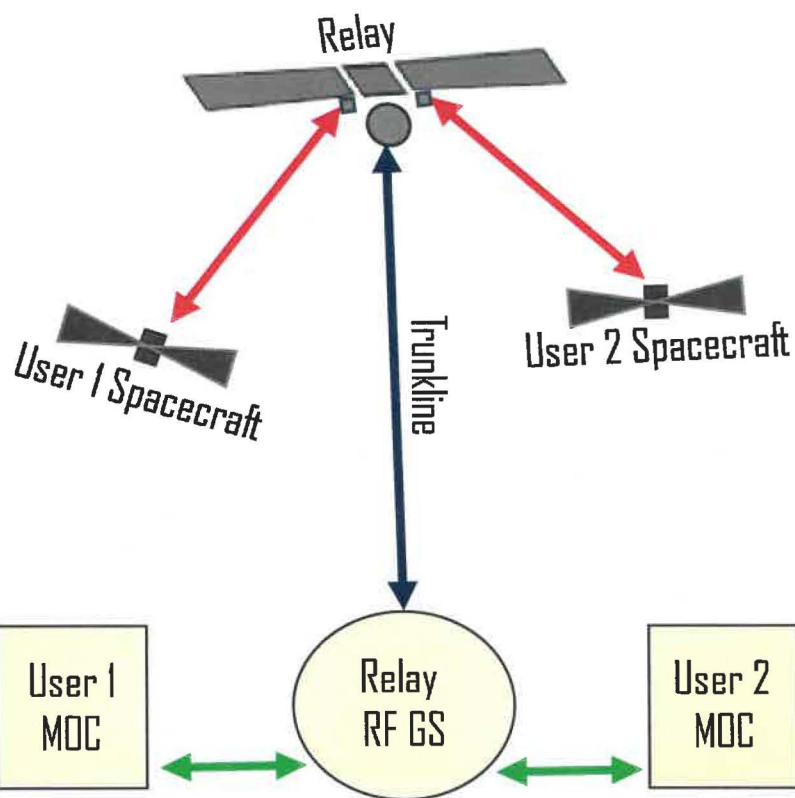
When executing the simulated user downlink to the ground, the LCRD flight segment can employ a modulation scheme different than that employed on the uplink to send the simulated user data from the ground to the LCRD flight segment.

Example Scenario: Relay Provider for Multiple Users

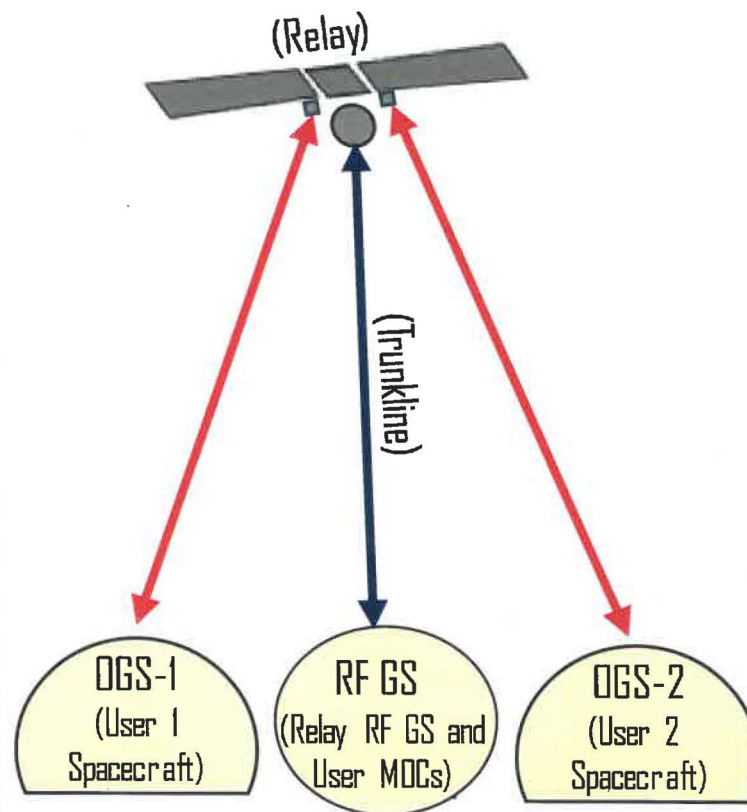


Relay Provider for Multiple Users

Scenario:



LCRD Configuration:



Key: Optical Link Radio Frequency Link Terrestrial Link

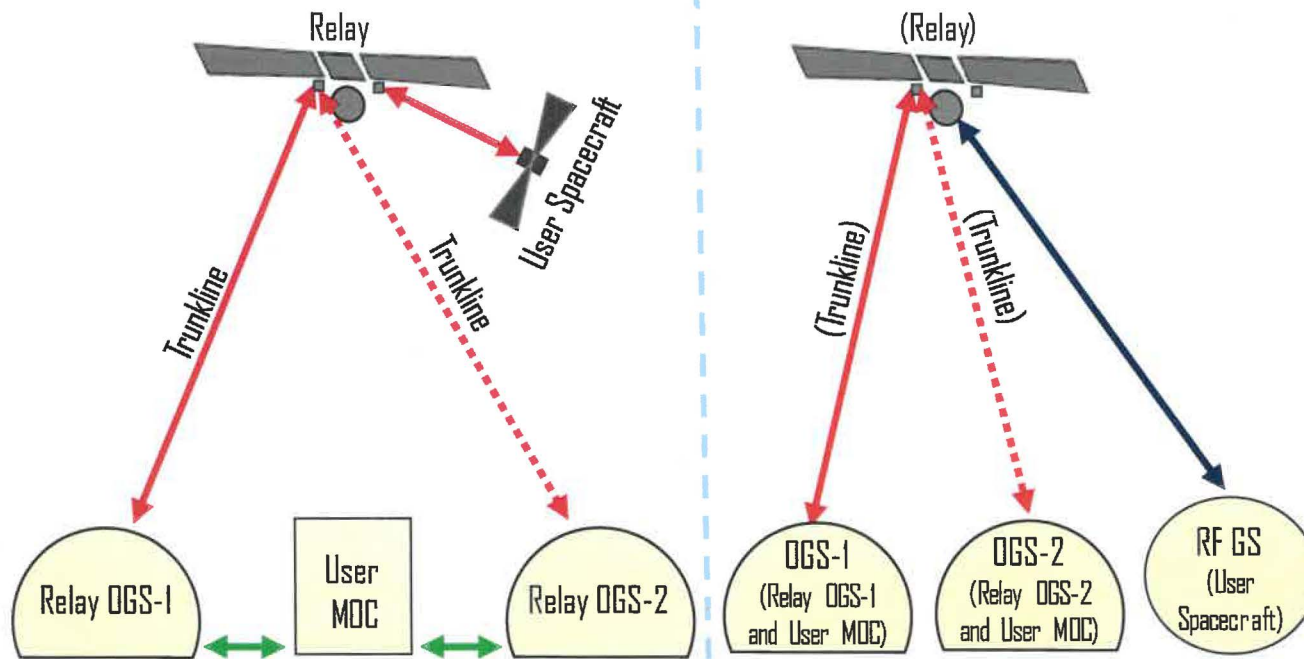
Example Scenario: Relay Provider with Station Handover



Relay Provider with Station Handover

Scenario:

LCRD Configuration:

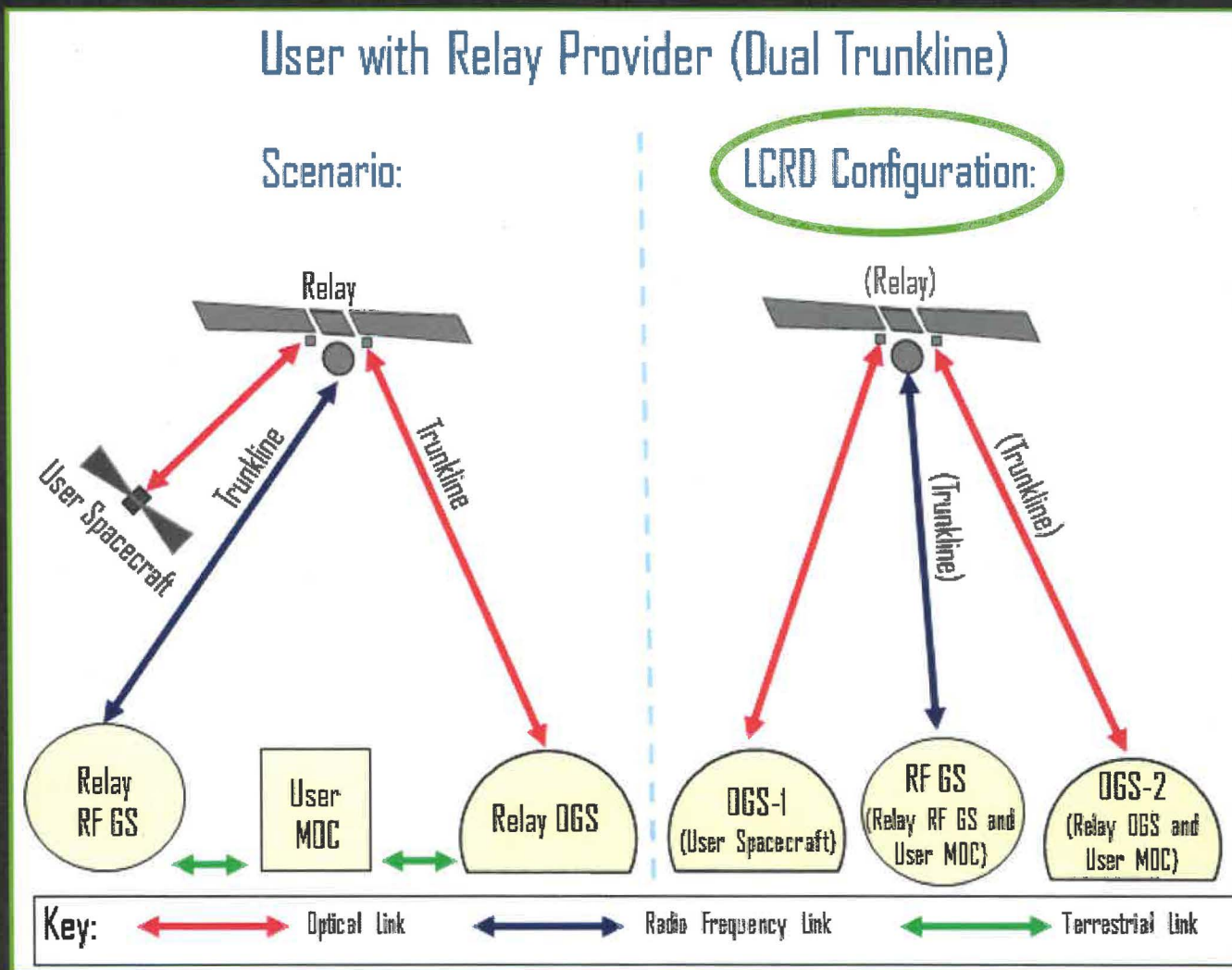


Key: Optical Link Radio Frequency Link Terrestrial Link

The relay hands off its trunkline (between its OST and the ground) from one ground station to another.

Related experiments could characterize the process for handing over relay spacecraft communications from one optical ground station to another, observing the time advance necessary to schedule handovers and the effects of weather conditions.

Example Scenario: User with Relay Provider (Dual Trunkline)



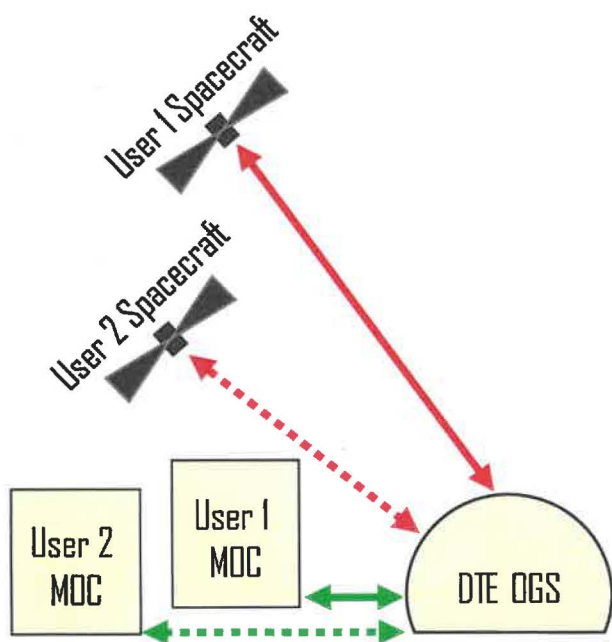
The optical and RF trunklines can operate simultaneously, allowing this configuration to support numerous scenarios. For example, it can demonstrate that an optical relay using an optical trunkline could support a user spacecraft with specific characteristics. It could also demonstrate whether LCRD can accommodate specific requirements for real-time data delivery.

Example Scenario: DTE Provider Supporting Multiple Users

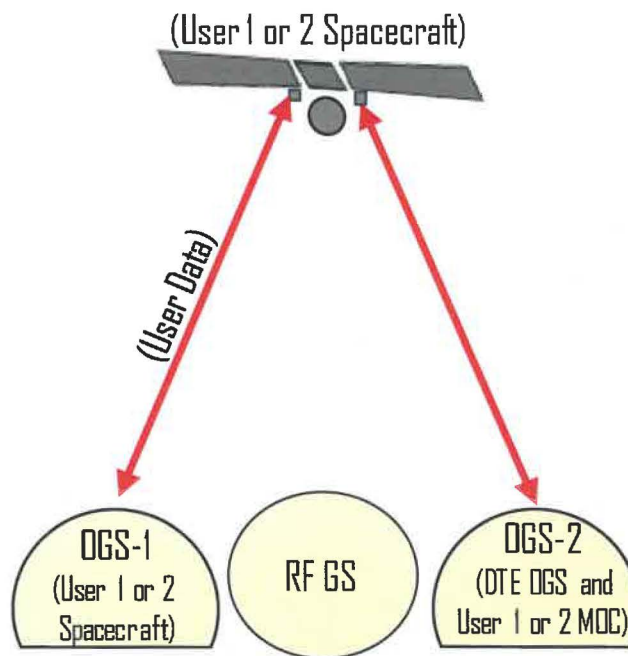


Direct-to-Earth Provider Supporting Multiple Users

Scenario:



LCRD Configuration:



Key: Optical Link Terrestrial Link

This scenario simulates a DTE ground station provider supporting **more than one DTE user spacecraft**.

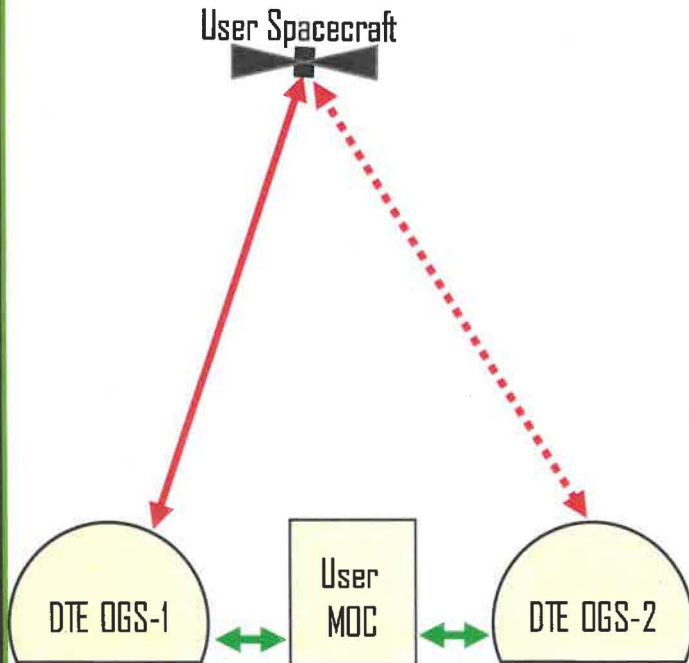
The DTE optical ground station would provide services based on a predetermined contact, servicing User 2 spacecraft as User 1 moves out of sight.

Example Scenario: DTE User Supported by Multiple Ground Stations

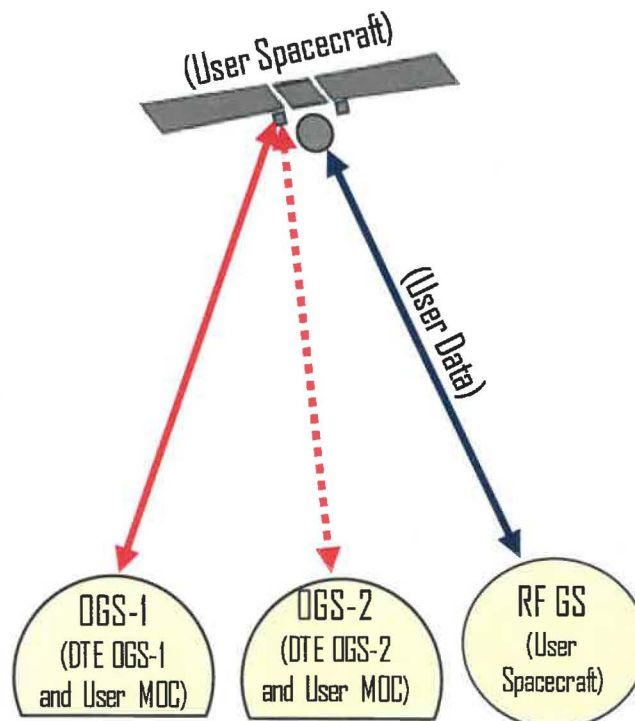


Direct-to-Earth User Supported by Multiple Ground Stations

Scenario:



LCRD Configuration:



Key: Optical Link Radio Frequency Link Terrestrial Link

In this scenario, two different optical ground stations are potentially available to support a DTE user spacecraft.

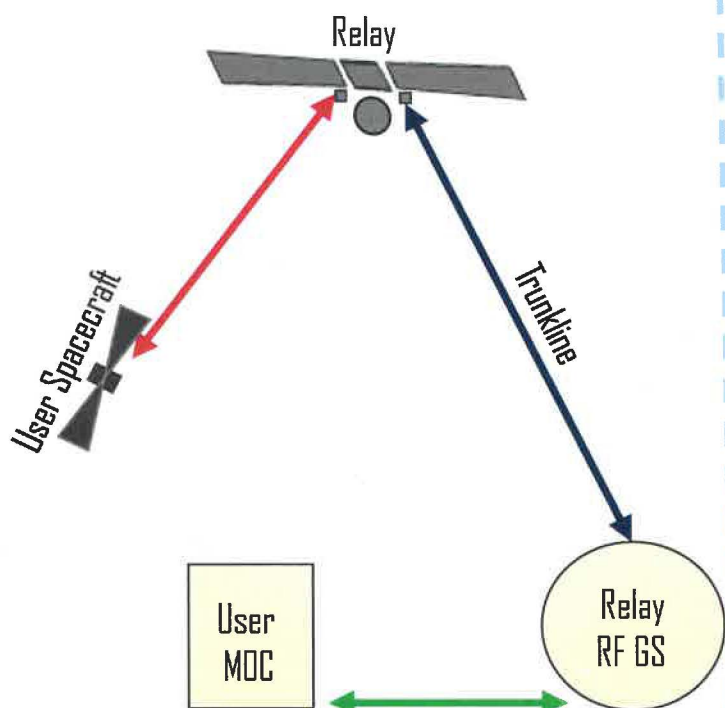
Experiment can support scenarios involving limited station availability.

Example Scenario: Relay Provider for Multiple Users

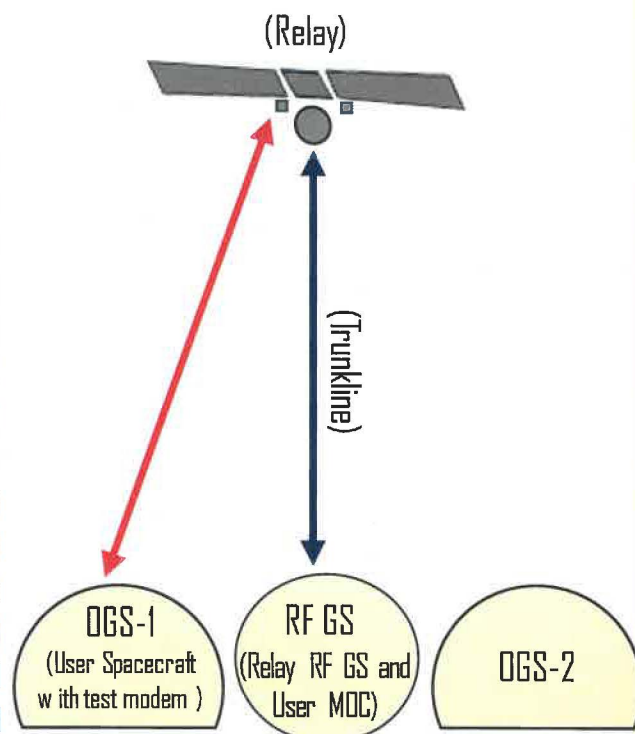


User with Relay Provider (User Modem Test)

Scenario:



LCRD Configuration:



Key: Optical Link Radio Frequency Link Terrestrial Link

Experimenters can use LCRD to test new hardware and software technologies in various experiment configurations.

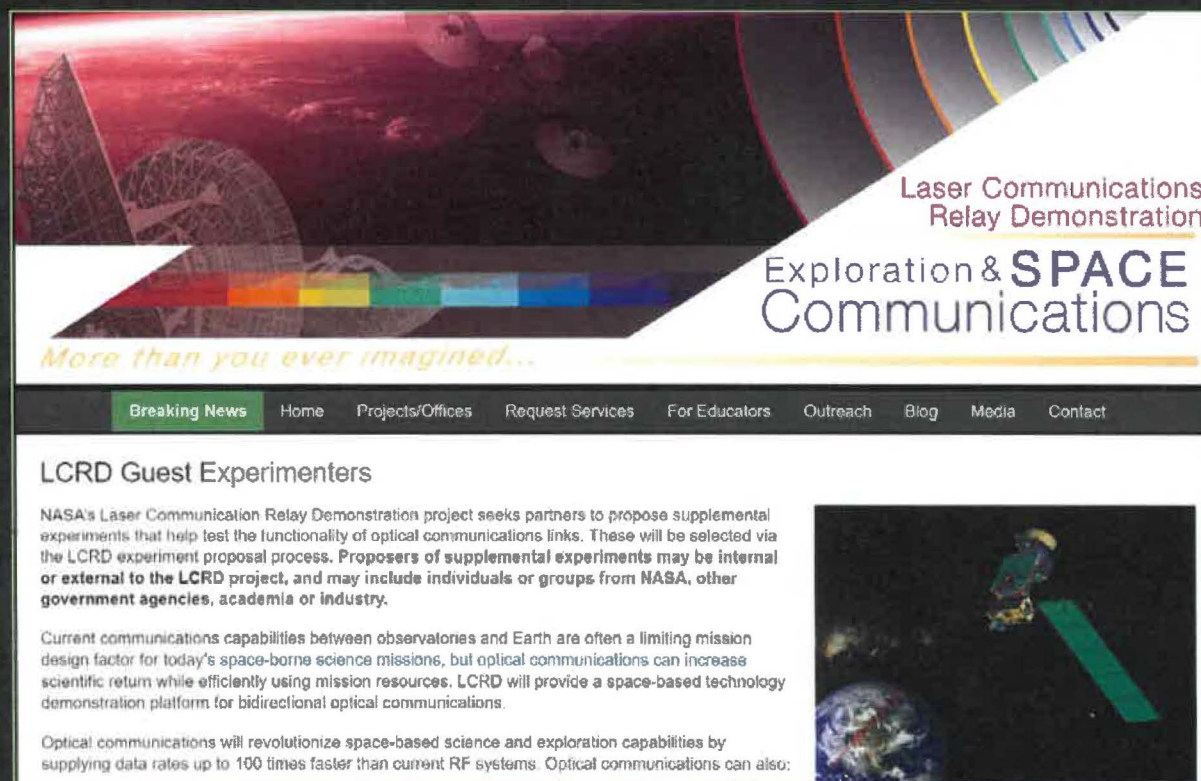
For example, to test a user spacecraft modem design, an experimenter could install a candidate modem at an LCRD optical ground station to interface directly with the optical telescope assembly.

Proposing LCRD Experiments



More details about example experiments can be found in the **LCRD Introduction for Experimenters** document at lcrd.gsfc.nasa.gov.

Additional details about proposal requirements and the proposal process can also be found at the LCRD website shown above.

A screenshot of the LCRD website. The header features a space-themed background with a red planet and a satellite. Text on the right reads "Laser Communications Relay Demonstration" and "Exploration & SPACE Communications". Below this is a navigation bar with links: "Breaking News", "Home", "Projects/Offices", "Request Services", "For Educators", "Outreach", "Blog", "Media", and "Contact". The main content area is titled "LCRD Guest Experimenters" and contains three paragraphs of text. To the right of the text is a small image of a satellite in space.

Laser Communications
Relay Demonstration

Exploration & **SPACE**
Communications

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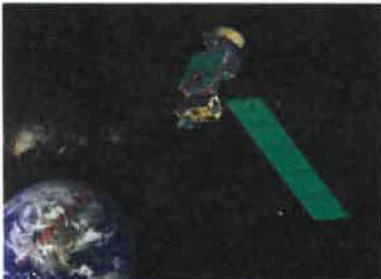
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LCRD Guest Experimenters

NASA's Laser Communication Relay Demonstration project seeks partners to propose supplemental experiments that help test the functionality of optical communications links. These will be selected via the LCRD experiment proposal process. **Proposers of supplemental experiments may be internal or external to the LCRD project, and may include individuals or groups from NASA, other government agencies, academia or industry.**

Current communications capabilities between observatories and Earth are often a limiting mission design factor for today's space-borne science missions, but optical communications can increase scientific return while efficiently using mission resources. LCRD will provide a space-based technology demonstration platform for bidirectional optical communications.

Optical communications will revolutionize space-based science and exploration capabilities by supplying data rates up to 100 times faster than current RF systems. Optical communications can also:





QUESTIONS?

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