

# Laser Communications Relay Demonstration (LCRD)

Update and the Path towards Optical Relay Operations  
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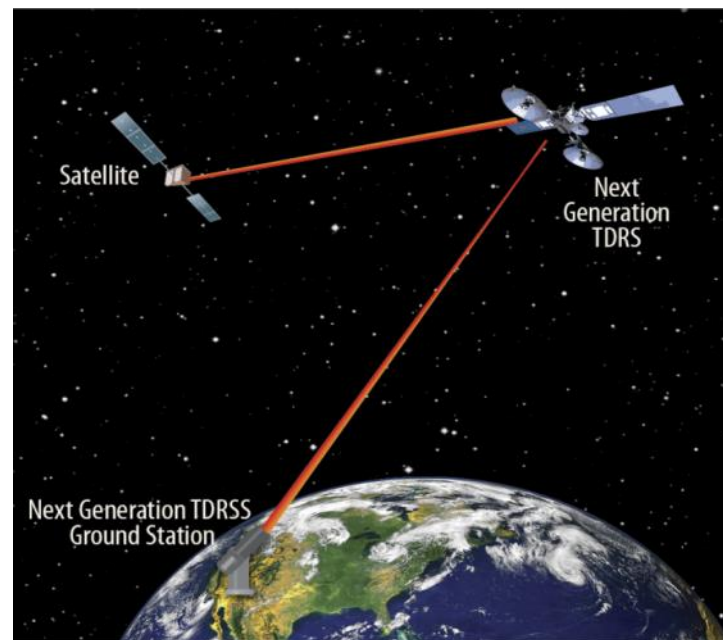
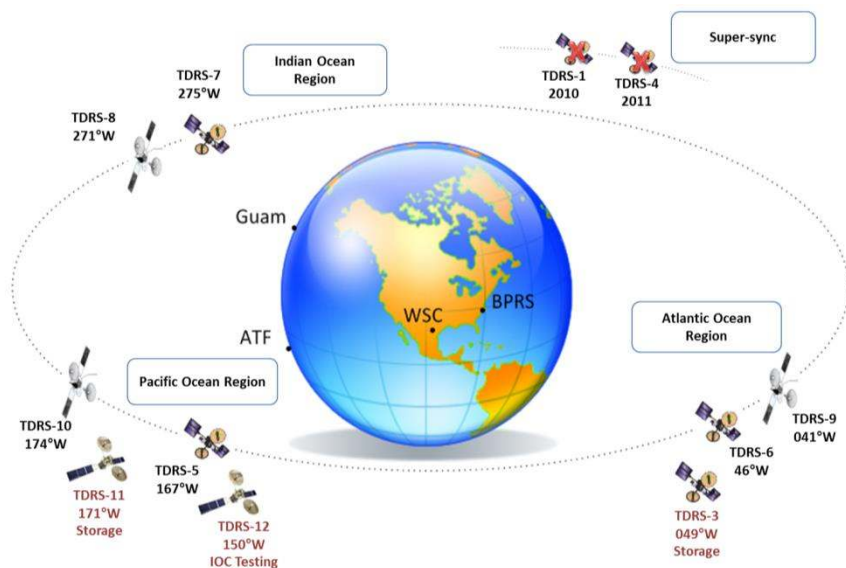


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- Introduction
- LCRD Mission Update
- Disaggregated Architecture Approach
- Moving towards a Next Generation Relay Architecture

# Introduction



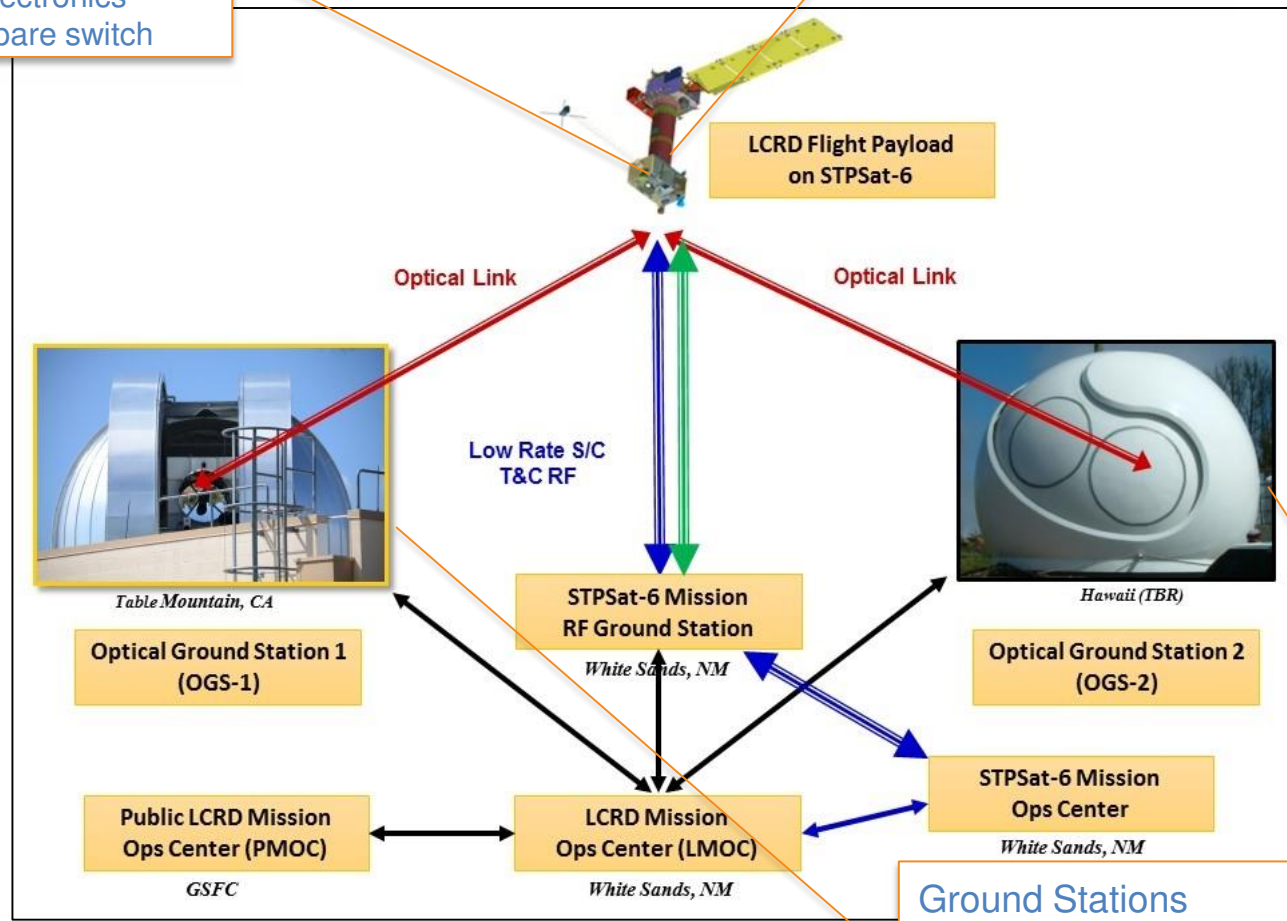
- The NASA Space Network or Tracking and Data Relay Satellite System is comprised of a constellation of Tracking and Data Relay Satellites (TDRS) in geosynchronous orbit and associated ground stations and operation centers.
- NASA is currently targeting a next generation of relay capability on orbit in the 2025 timeframe.

# LCRD Mission Architecture



- Payload**
- Two optical communications terminals
  - Associated electronics
  - Added cold spare switch

- Spacecraft**
- New spacecraft
  - New RF Trunkline



- Ground Stations**
- Two optical ground stations
  - OGS-2 relocated to Hawaii
  - Added RF ground station

# Change in Spacecraft Host



- After the project's Preliminary Design Review (PDR), LCRD was chosen to demonstrate the Information Assurance (IA) concept needed in a future operational relay that could be hosted.
  - Critical for future operational relay satellites to ensure that the integrity and confidentiality of the end-to-end system is maintained
  - Important for NASA's human exploration missions such as the future Orion Crew Exploration Vehicle
- A key component of IA is encryption technology
- This new requirement became a schedule risk for remaining as a hosted payload on an Space Systems Loral spacecraft (not expected to be a risk for any potential future activities)
- A mission partner opportunity has been found on Space Test Program Satellite (STPSat-6)
  - Space Test Program mission scheduled to launch in 2019
  - LCRD will continue to fly hardware and operate to allow demonstration of commercially hosted payload concepts

# Added High-bandwidth RF



## Original Design:

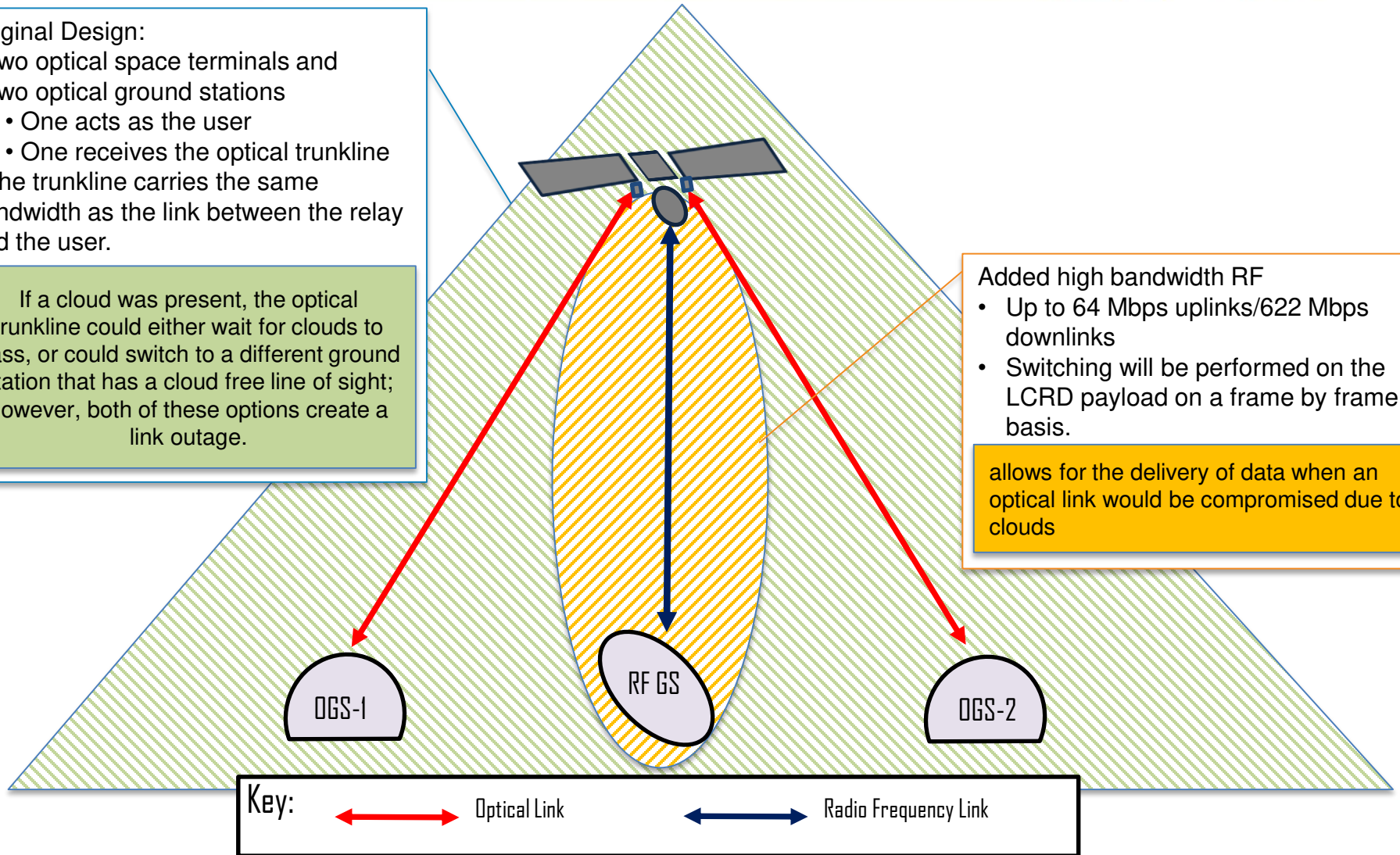
- Two optical space terminals and
- Two optical ground stations
  - One acts as the user
  - One receives the optical trunkline
- The trunkline carries the same bandwidth as the link between the relay and the user.

If a cloud was present, the optical trunkline could either wait for clouds to pass, or could switch to a different ground station that has a cloud free line of sight; however, both of these options create a link outage.

## Added high bandwidth RF

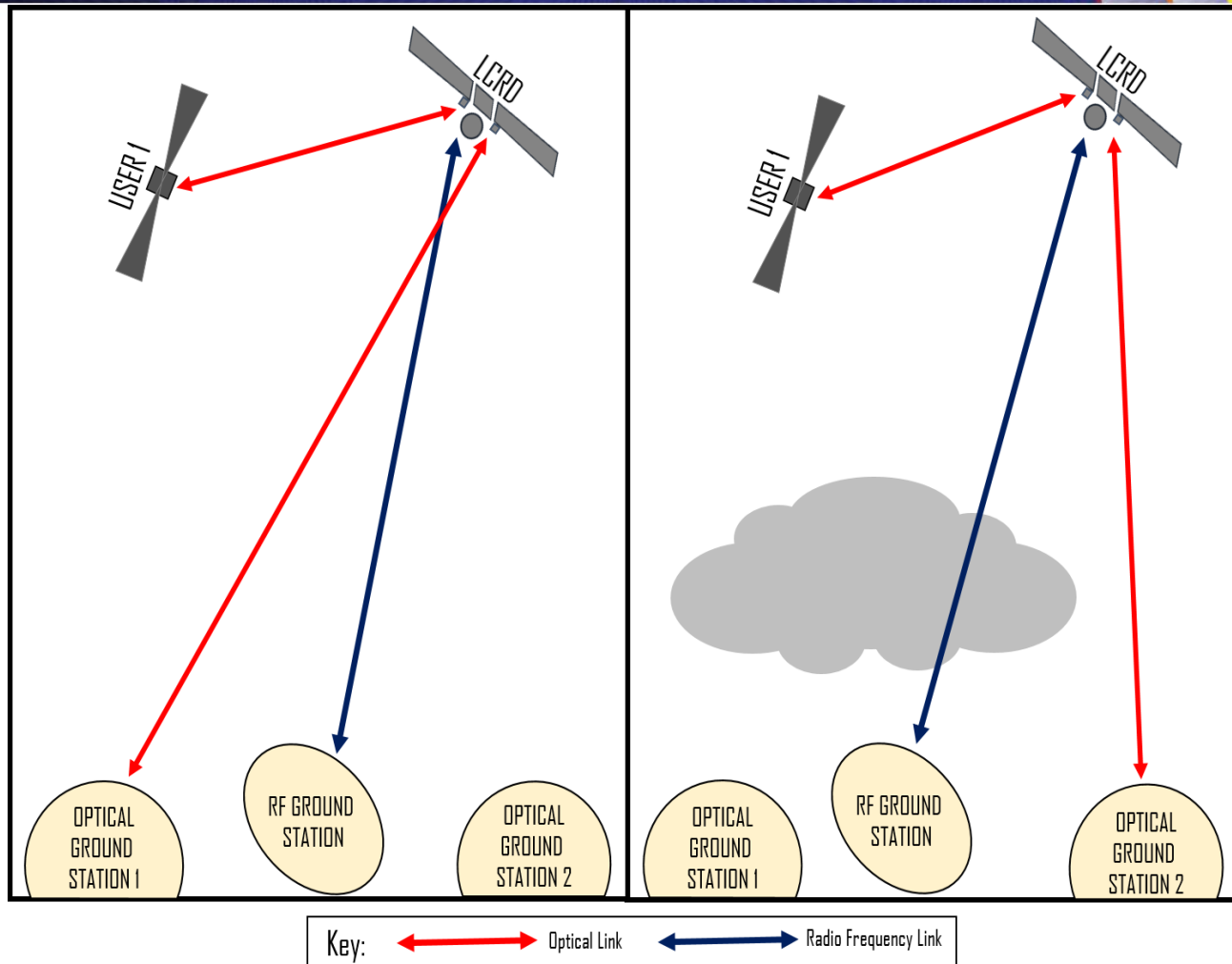
- Up to 64 Mbps uplinks/622 Mbps downlinks
- Switching will be performed on the LCRD payload on a frame by frame basis.

allows for the delivery of data when an optical link would be compromised due to clouds



Key: Optical Link Radio Frequency Link

# Clouds Happen



RF ensures that requirements for real-time or very low latency delivery (such as commanding, telemetry, science alerts, voice, video, etc.) will be delivered, even when clouds happen!

# Spacecraft Operations Center at WSC



Spacecraft operations center and TT&C RF ground station at the White Sands Complex.

- Provides cost savings
- Allows NASA to gain insight into the operations of a spacecraft with an optical relay capability.

Separation of the payload operations in the LMOC allows the development of operations concepts that will not preclude future relay capabilities flying as hosted payloads.

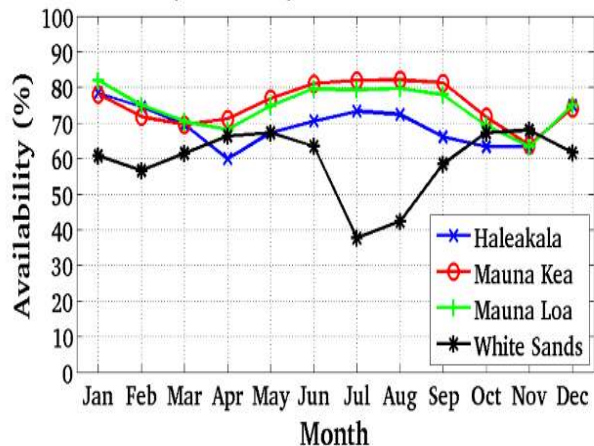


# OGS-2 in Hawaii



- Originally, LCRD was going to use a ground station deployed at White Sands, New Mexico, which was the site of the primary ground station for the Lunar Laser Communication Demonstration (LLCD)
- Both optical ground stations need to be available to perform a relay demonstration at full data rates
- A study to replace the original White Sands location with a location with better cloud free line of sight (CFLOS) statistics.
  - Northrop Grumman found that the optical turbulence is typically much more benign on Maui than White Sands or at Table Mountain
  - OGS-2 was moved to Hawaii
  - OGS-1 continues to be the Optical Communications Telescope Laboratory (OCTL), Table Mountain, California

Mean Monthly Availability at Each Site with a GEO Satellite



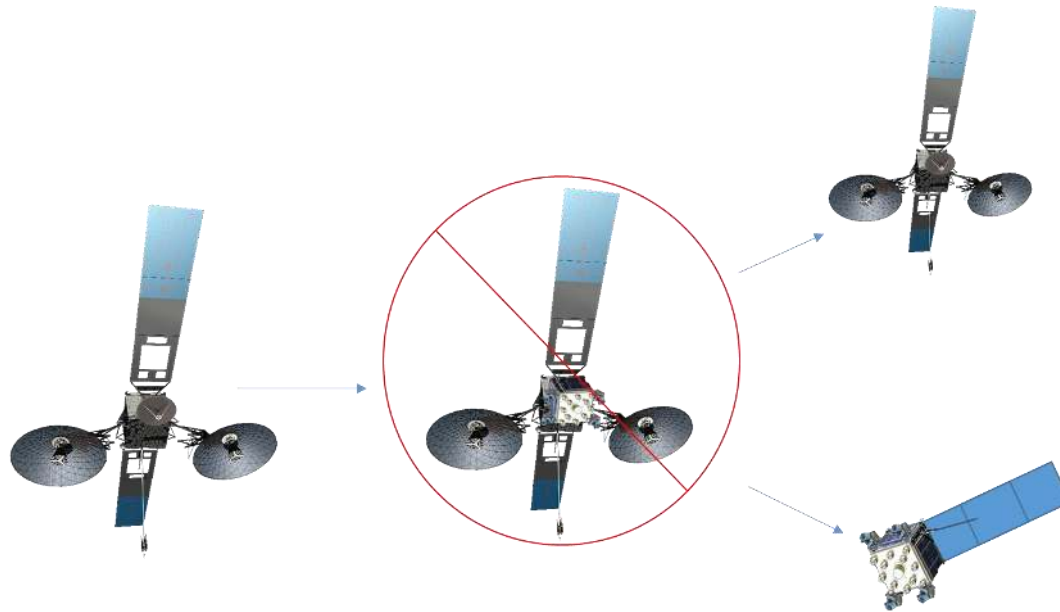


# Expected LCRD Products



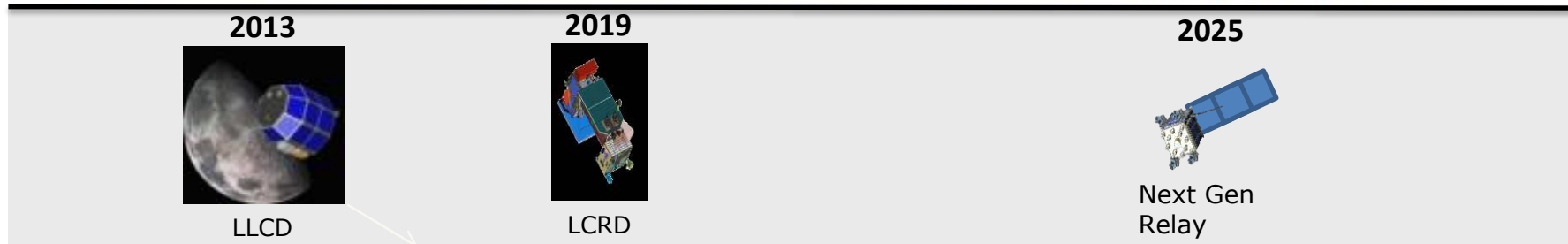
- Understanding of necessary requirements for future NASA systems
  - Flight and ground systems operational experience
  - Resolution of Future System TBD/TBRs
  - Data for trade studies
  - Optimized operational procedures
- Atmospheric measurements and model development
- Link performance measurements and model development
- Flight hardware performance characterization and flight hours
- Demonstration of ability to procure, integrate, test, and operate space optical communications hardware
- Demonstration of optical communications benefits for a variety of mission scenarios

# Disaggregated Services Approach



- Current Earth Relay architecture incorporates all services on copies of a single dedicated spacecraft (TDRS)
- The next generation architecture under consideration disaggregates the services between multiple spacecraft
  - Optical services separate from RF services
  - Nodes could be dedicated spacecraft or hosted payloads
  - Some services could be provided by commercial or industry partners.
- Independent replenishment of existing service capabilities
- Deployment of new services based on requirements and technology development

# Towards a Next Generation Relay Architecture



- LCRD will support experiments for two years following launch in June 2019
- The addition of HBRF system and redundant onboard data switch increases likelihood of an extended mission to include early operational support
- An optical relay capability is being targeted for a 2025 launch as the first node of the next generation relay architecture

# References



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