Next-Generation NASA Earth-Orbiting Relay Satellites: Fusing Microwave and Optical Communications

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The Space Network provides tracking and data acquisition services to spacecraft below geosynchronous orbit, and can connect user spacecraft with 100% coverage of the user's orbit.
Generations of TDRS

First Generation
TDRS-A to TDRS-G

Second Generation
TDRS-H to TDRS-J

Third Generation
TDRS-K to TDRS-M

TDRS-M LAUNCH:
August 18, 2017

TDRS-13 ACCEPTANCE:
February 2018
Disaggregated Communications

RF and optical communications are built and deployed on separate systems.
Disaggregation Benefits

• Fleet management at individual service level

• Greater opportunity for commercialization of RF services
The Future of NASA Space Comm: Optical Communications

Optical communications systems are under development to enable support of tremendous volumes of data at higher rates with quicker response times.

Optical communications will enable:

- Speed and Volume
- Less SWaP
- Availability
Optical: State of the Technology

Lunar Laser Communications Demonstration 2013-2014
“Proof of Concept” COMPLETE

Laser Communications Relay Demonstration Launch: 2019
“Relay Operations Demonstration” UNDER DEVELOPMENT

ILLUMA-T
Optical to Orion (EM-2)
“Mission Operations Demonstration” UNDER DEVELOPMENT
## Key Features of LCRD

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Two optical modules</td>
<td>10.8-cm telescope, 2-axis gimbal</td>
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<tr>
<td>Laser</td>
<td>1550 nm at 0.5W</td>
</tr>
<tr>
<td>RF downlink</td>
<td>Spacecraft bus provided</td>
</tr>
<tr>
<td>Module-to-module switching</td>
<td>Gbps-class high-speed space switching unit</td>
</tr>
<tr>
<td>Data rates</td>
<td>Up to 1.244 Gbps forward and return links</td>
</tr>
<tr>
<td>Optical ground stations</td>
<td>Haleakala, HI</td>
</tr>
<tr>
<td></td>
<td>Table Mountain, CA</td>
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<tr>
<td>Mission operations center</td>
<td>GSFC Space Network at WSC, NM</td>
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</table>
An optical relay capability is being targeted for a 2025 launch as the first node of the next-generation relay architecture. Early studies and technology developments are underway.
NASA’s Next Generation Earth Relay

- Gen-2 GEO Optical Relay
  - 100 Gbps Crosslinks
  - 10 Gbps User Links

- 1.2 Gbps Ka-band
downlink
  - 99.99% Available

- 100 Gbps downlink
  - 97% Available

- Gen-2 User Terminal
  - 10 Gbps User Link

- SCanN
  - Operated Gen-1 OGS
  - Gen-1 Optical Ground Station

- Operations Center
Next-Generation Earth Relay Concept of Operations

Satellite A is over the Atlantic.
Satellite B is over the Pacific.
Satellite C is over the Indian Ocean.
Next-Generation Earth Relay Payload Nomenclature

Spacecraft/Platform

Optical Communications Payload

Other Required Subsystems

Optical Space Terminal

Optical Module

Modem with Beacon, Amplifier and CODEC

Controller Electronics

Other Required Subsystems:

- Storage
- Data Processing
- Switch/Router
- Optical Comm Payload Controller
Conclusions

• The requirements for the first optical relay nodes continue to be refined.
• Relay nodes could be dedicated spacecraft or hosted payloads.
• Alternate acquisition strategies for the relay node are also under assessment.
  – Procure optical relay services, if commercially available
  – Form partnership with commercial entity