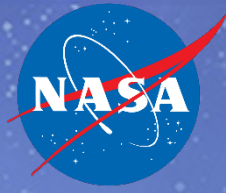
National Aeronautics and Space Administration



NASA Optical Communications Update

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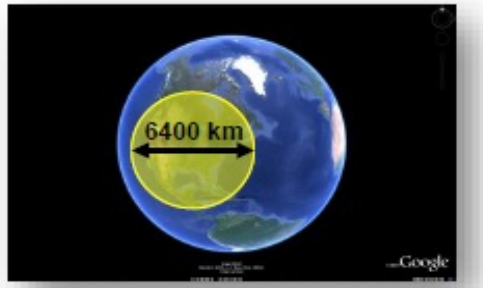
Benefits of Optical Communications

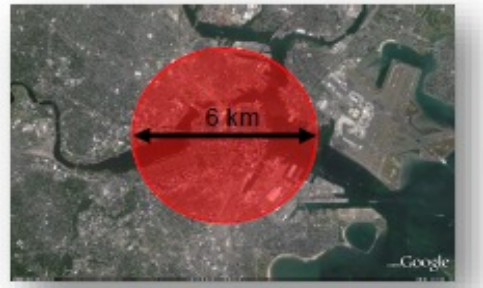
- Extremely narrow beams with small apertures
- Small, low power terminals
- Unlimited, unregulated spectrum
- High data rates
  - Provides high speed real-time data (e.g. for video)
  - Enables shorter contact times
  - Delivers large data volume over the duration of mission

Historic Challenges:
beam pointing, efficient transmitters and receivers, high bandwidth processing, atmospheric effects

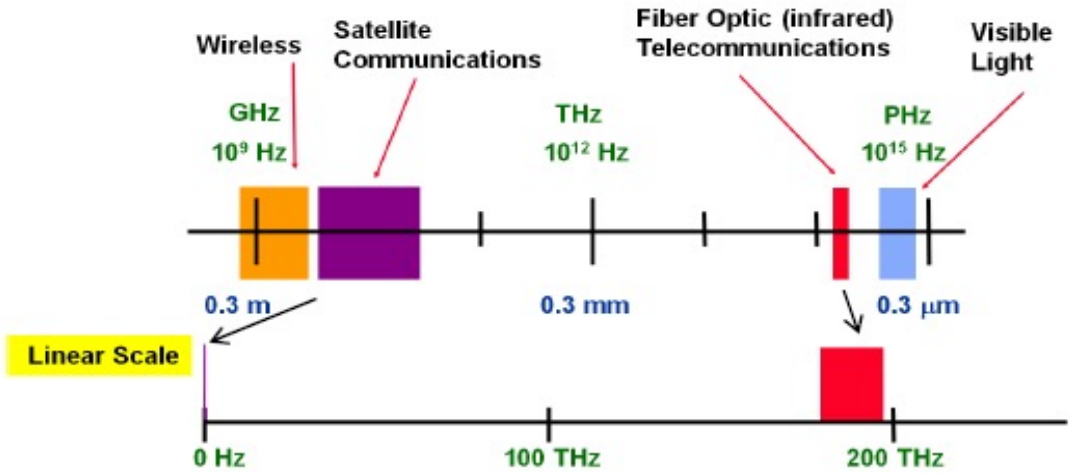
Beam Size From Moon



RF Ka Band (26 GHz)
75-cm Antenna → 6400 km Spot



Optical C-Band (1550 nm)
10-cm Antenna →6 km Spot



NASA wants to build upon the success of the 2013 Lunar Laser Communications Demonstration (LLCD) and previous efforts

Optical Communications Technology Demonstrations

From Near Earth/Moon

LCRD
1.244 Gbps
Optical Relay
(622 Mbps RF down)

O2O
Lunar: 250/20 Mbps

ILLUMA-T on ISS
1.244 Gbps / 155 Mbps
Relay User (ISS)

Lunar Relay
Coherent optical:
5+/1 Gbps

TBIRD

2U CubeSat Payload
2TB On-board Storage
200 Gbps LEO to Earth

LCOT
Low-Cost
Optical
Terminal

To Deep Space

DSOC Gen-1 User Terminal
DSOC on Discovery Psyche
Asteroid Mission
267 Mbps / 1.6 kbps maximum
1 Mbps @ 2.6 AU to Palomar
~2 Mbps @ 2.6 AU w/ RF/optical

RF/Optical Hybrid Antenna
Integrate 8-m optical
apertures into a DSN
34m Beam Waveguide
antenna

LCRD 2021	TBIRD 2022	ILLUMA-T 2023	O2O 2024	Lunar Relay *TBD*

Psyche/DSOC Optical User Terminal (*TBD* 2023+)	Advanced DSOC Optical User Terminal (2026+)

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SCaN's Technology Timeline: From Near Earth/Moon to Deep Space

TechEdSat 13 Cognitive Neuromorphic Nano–scale Processors

TechEd Satellite will demonstrate the efficiency gains of AI/ML subsystems for implementing cognitive algorithms, in analog and digital communications. Examine the reliability and performance in space.

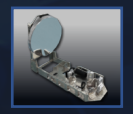
LCRD
1.244 Gbps Optical Relay (622 Mbps RF down)

Cognitive CubeSats
Space networks with artificial intelligence (AI) optimizing communication links throughput, data routing, and system-wide asset management.

ILLUMA-T on ISS
1.244 Gbps / 155 Mbps Relay User (ISS)

TBIRD
2U CubeSat Payload
2TB On-board Storage
200 Gbps LEO to Earth

DSOC User Terminal



DSOC on Discovery Psyche Asteroid Mission

O2O Coherent Optical Relay
Employ optical communications capability for Orion spacecraft, starting with the demonstration of operational utility on Artemis II

Advanced RF – Wideband Multilingual User Terminals
Frequency flexibility ground demo hardware. Missions would be able to connect to government and commercial networks that best fit their needs.

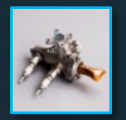
X-ray Navigation (XNAV)
Millisecond pulsars enable GPS-like *Galactic* Positioning System for independent navigation and timing.

Information encoded on X-ray Pulse Signal

Advanced RF – Wideband Cognitive Flight Demo
Establish Bi-directional data path with Ka-band fixed beam over commercial spectrum.

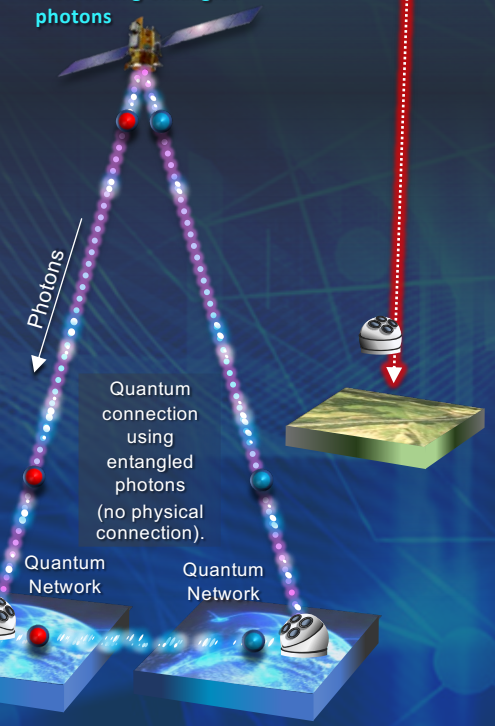
Cognitive Flight Demo
Applying machine learning to automate and alleviate the constrains of traditional communication systems.

RF/Optical Hybrid Antenna
RF/Optical User Terminal Integrates 8m optical apertures into a DSN 34m Beam Waveguide antenna.



X-ray Communications (XCOM)
Tight beams achieve better power efficiency for very long-distance communication and enable physically secure GEO-LEO links.

Quantum satellite distributing entangled photons



2020 ▸ 2030