

NASA SCaN and Space-based quantum communications and navigation: Towards a Vision

Nasser Barghouty, Chief Scientist
NASA SCaN

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**The 1st Australian Quantum
Communication Forum**

Approved for Public Release





Briefing Highlights & Main Takeaways



- **A collaborative vision**

- 5- and 10-year plans
- Towards a 'user-facility;' **quantum testbed** in LEO and ground station
- Then a **Quantum Mission** in MEO and 2 ground stations (**M2.0**)
- Quantum-Comm **Engineering Center**
- Quantum-Comm **Science Center**

- **Current activities**

- **technology** development, pre-formulation studies and analyses
- **Metrology** capability building, NASA Glenn Research Center (GRC)
- **Partnership** building, OGA, academia, industry, and international
- Blueprints for **public-private partnerships** for the two centers

- **NASA SCaN $\oplus$ QIS Industry**

- Use cases and applications; Technology development; Engr./science centers



About SCaN (www.nasa.gov/scan)



- Through the near earth and deep space networks SCaN provides NASA science and exploration missions with all their RF communications and navigation capabilities
- Near space network (NSN); for LEO and up to lunar missions, supported by a constellation of geosynchronous satellites for tracking/data relay
- Deep space network; continuous coverage via 3 ground stations, also radio telescopes
- SCaN is also responsible for **future capabilities**

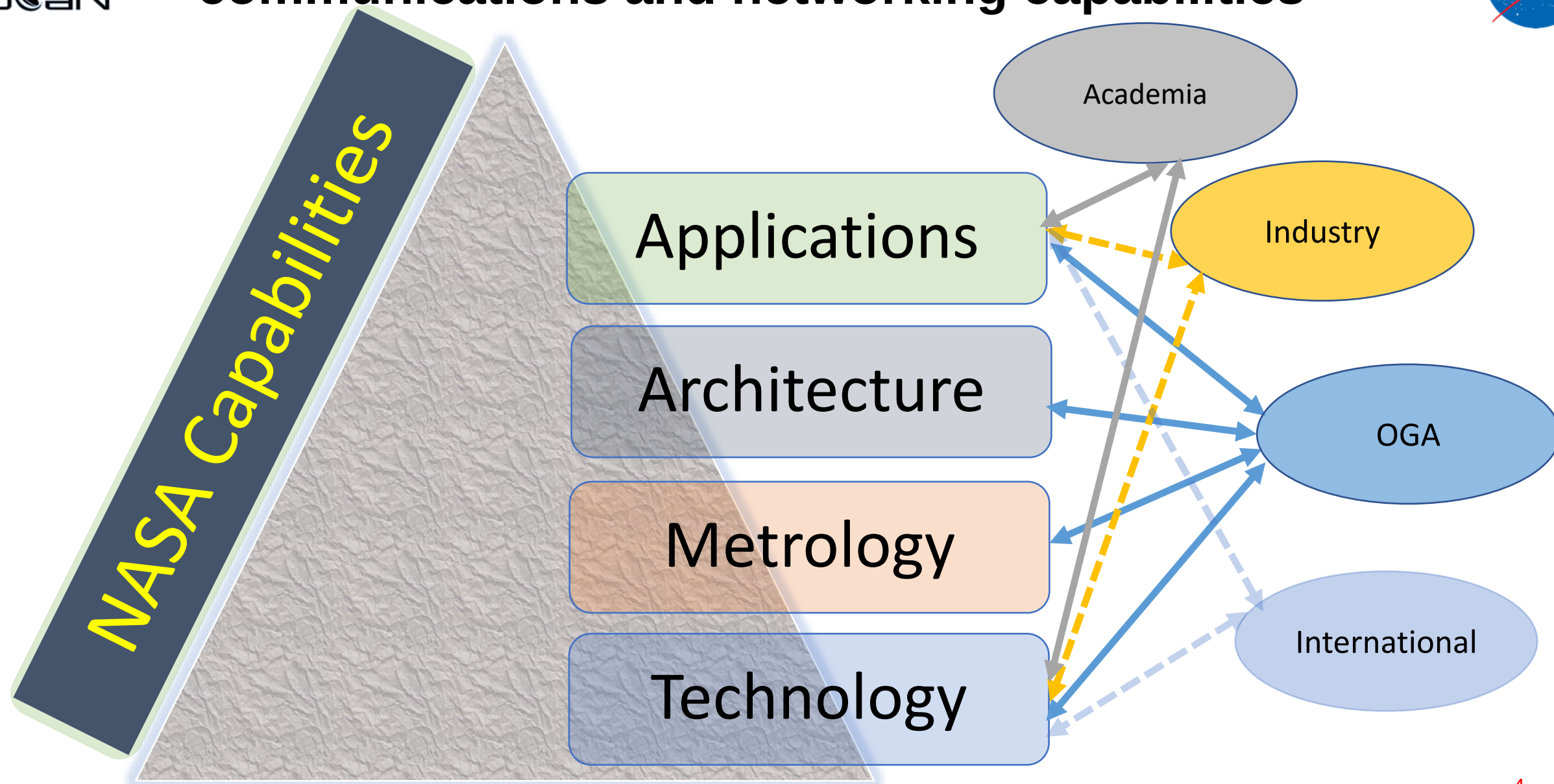


ALASKA SATELLITE FACILITY (NSN)

Fairbanks, Alaska

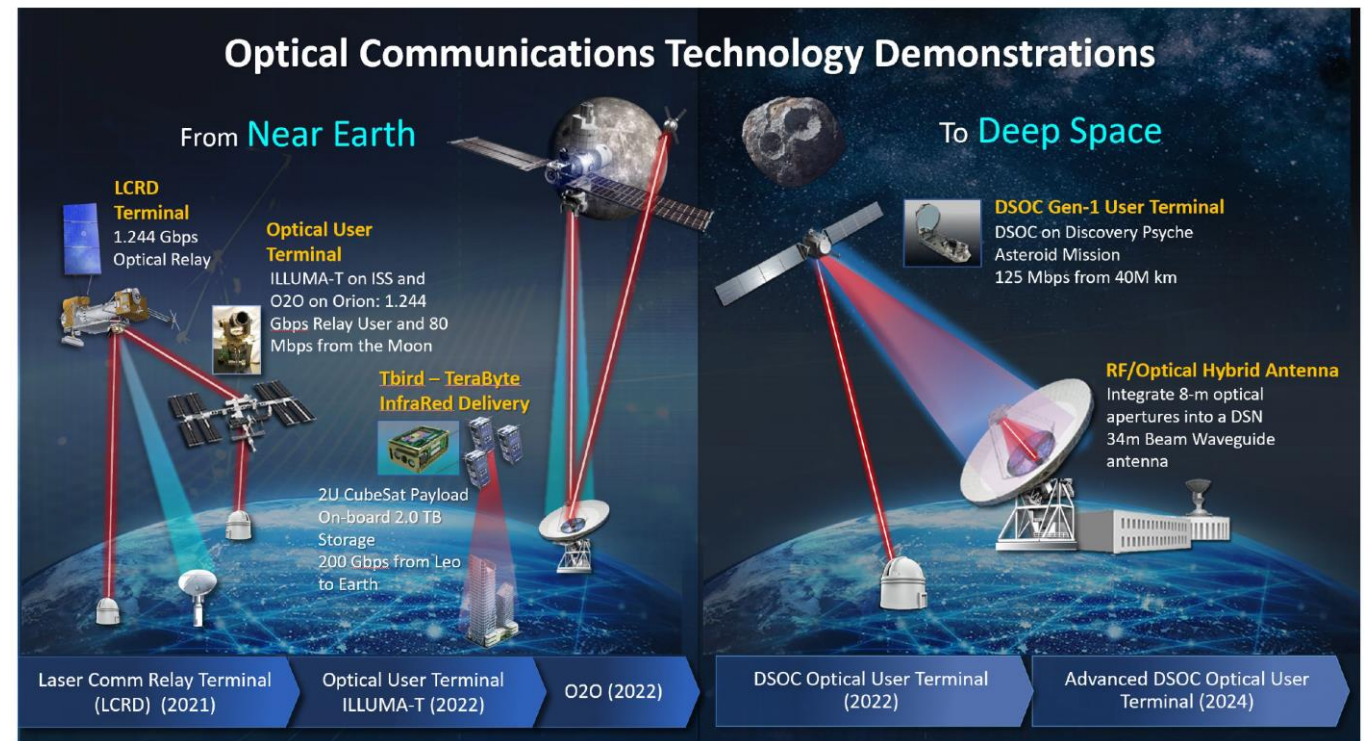
[NASA: We are SCaN - YouTube](#)

The **Vision**: Develop NASA's space-based quantum communications and networking capabilities



SCaN's quantum strategy

- Leverage optical communications investments, experience, and accomplishments to build foundational capabilities, including a quantum testbed and metrology capability
- Develop and mature key (low TRL) for space-based and ground-based quantum communications and networking technologies
- Seek partners to leverage similar investments and goals
- Keep NASA at the forefront of emerging quantum tech/apps
- Active quantum STEM, training and workforce engagement





Space-Based Quantum Communications Testbed:

QIS Benefits



- Space-based testbed will be made **available for US industry and academia** to use to gain insights into key technology drivers and limitations of these systems (physical layer)
 - Synchronization and atmosphere impacts
 - Delays
 - Interfaces
- System will serve as a platform for **testing future free-space technologies** and **testing use cases**
- Serve as bridge between **regional quantum networks** (can add ground stations)
- Industry will be involved in planning and execution of elements of both the space and ground systems building up expertise to be able to build **future generations of systems**
 - Gimbals, spacecraft, ground telescope, etc.
- **Technology development spinoff:** quantum memory and sources for terrestrial applications for quantum sensing, quantum computing, etc.
 - Integrated optics solutions could be widely enabling

Cross-cutting technologies

Quantum sources

- >GHz-class, entangled with high efficiency
- Frequency multiplexed

Quantum detectors

- Nanowire, photon resolving, warm/cold
- Space qualifiable

Quantum memory

- Si-vacancy, narrow bandwidth (uplink)
- Other materials (higher temp. effects)

Quantum-enhanced technologies

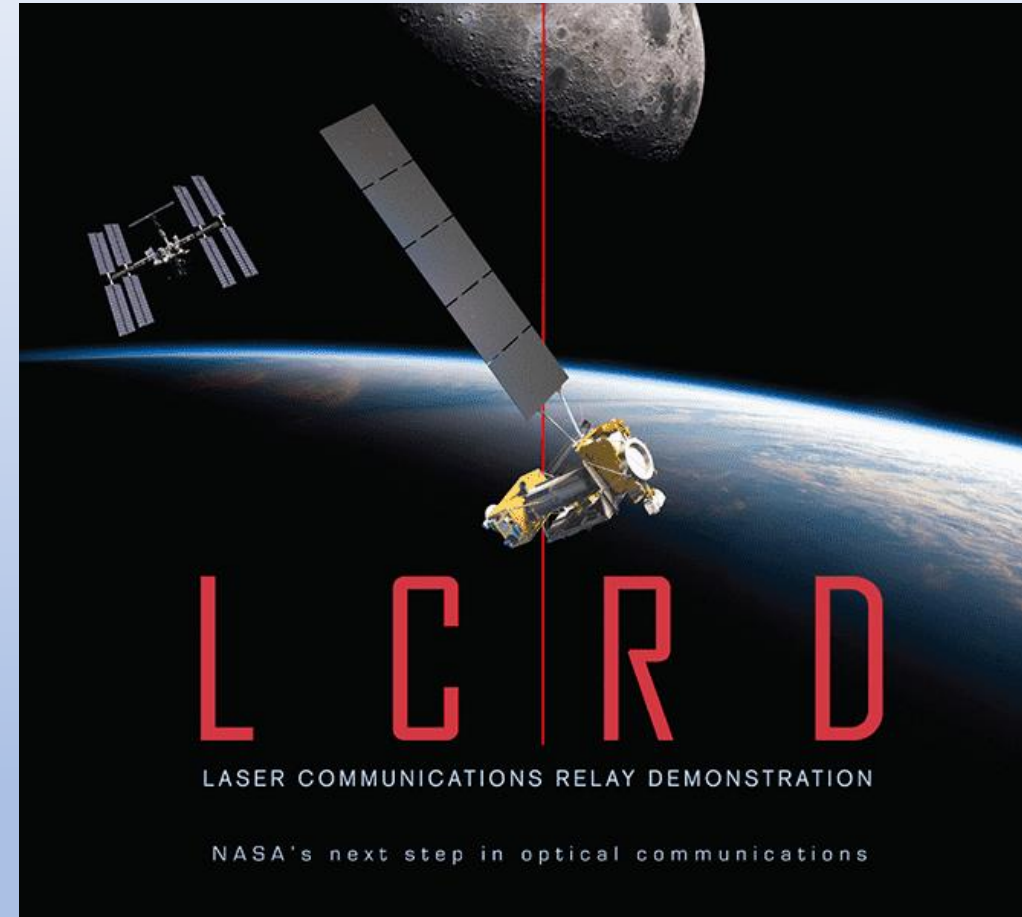
- In support of optical comm and networking



NASA JPL's new single-photon detector comprises 32 superconducting nanowires

Laser Communications Relay Demonstration

- LCRD showcases the unique capabilities of space-based optical communications
- Provides benefits for missions, including bandwidth increases of 10 to 100 times compared to RF systems
- Compared to RF, optical comm offers decreased system requirements on size, weight, and power; optical comm will supplement RF, giving most missions unparalleled communications capabilities
- Opportunity for experimentation with laser-comm functionality using LCRD:
(<https://esc.gsfc.nasa.gov/projects/LCRD?tab=opportunities%20for%20experimenters>)



[Laser Communications Relay Demonstration \(LCRD\) Overview - YouTube](#)



A vision for collaborative quantum-comm R&D/T centers



- Partnership among industry, government, academia and state
- Led by industry
- Funding, administration, and management modality [under study]
- Timeframe: Within 3-5 years
- The need for a new partnership modality for Quantum 2.0



Lessons and guidance, e.g., *Government-Industry Partnerships for the Development of New Technologies*, edited by C. W. WESSNER, NRC (2003); <http://nap.edu/10584>



Sample areas for potential collaboration

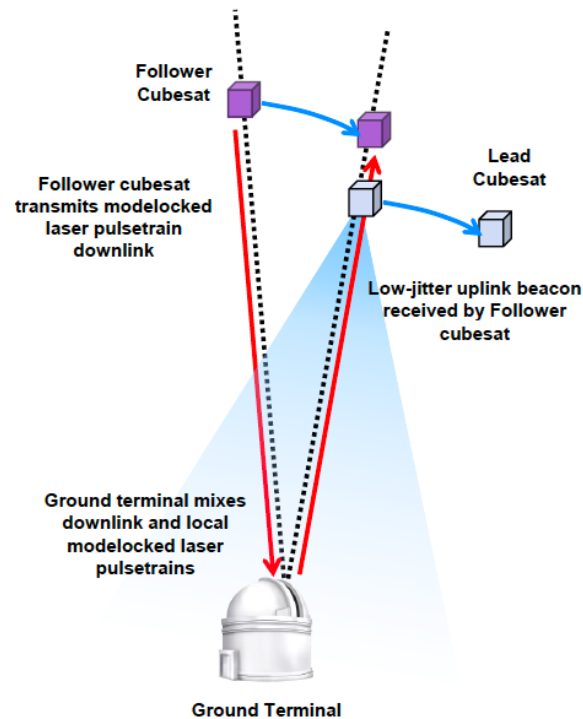


- Development of pre-competition (low TRL) technologies and applications
- Infrastructure building
- Testing and characterization at specialized facilities; components to systems
- Testing and validation using the new space-based testbed; new technologies (at the ground stations), new QIS protocols...
- Work force development and training; creation of specialized STEM programs at the local, state, and national levels

Nominal Roadmap

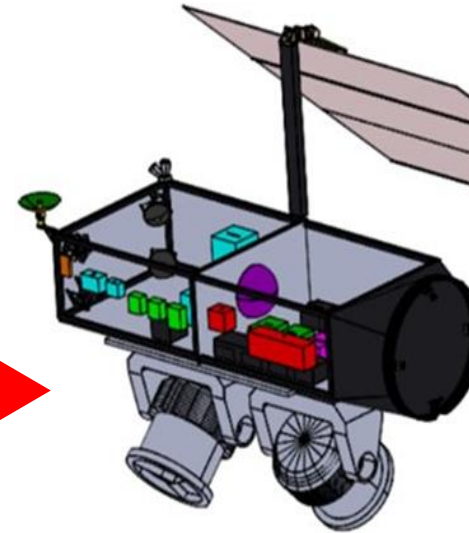
- First step is a 'warm' LEO testbed capable of ~ 100 -Km Baseline - makes use of an uplink architecture that supports narrowband sources based on emission memory at 737 nm and a wideband 780 nm SPDC source, with Bell state measurement (BSM) in space
- Second step (M2.0) is optimized for 5000-Km (inter-continental), MEO, high performance

LEO Testbed
Up to ~ 100 s-Km
Baseline
Warm (no Cryo),
Uplink Only,
 ~ 1 -m telescope



~ 2026

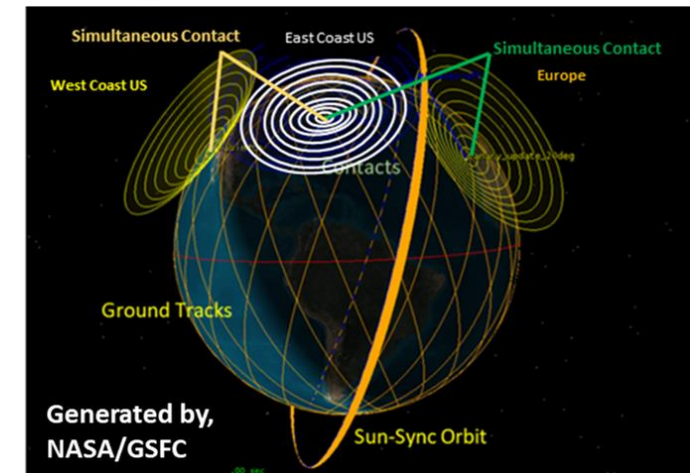
Quantum Testbed in LEO



~ 2031

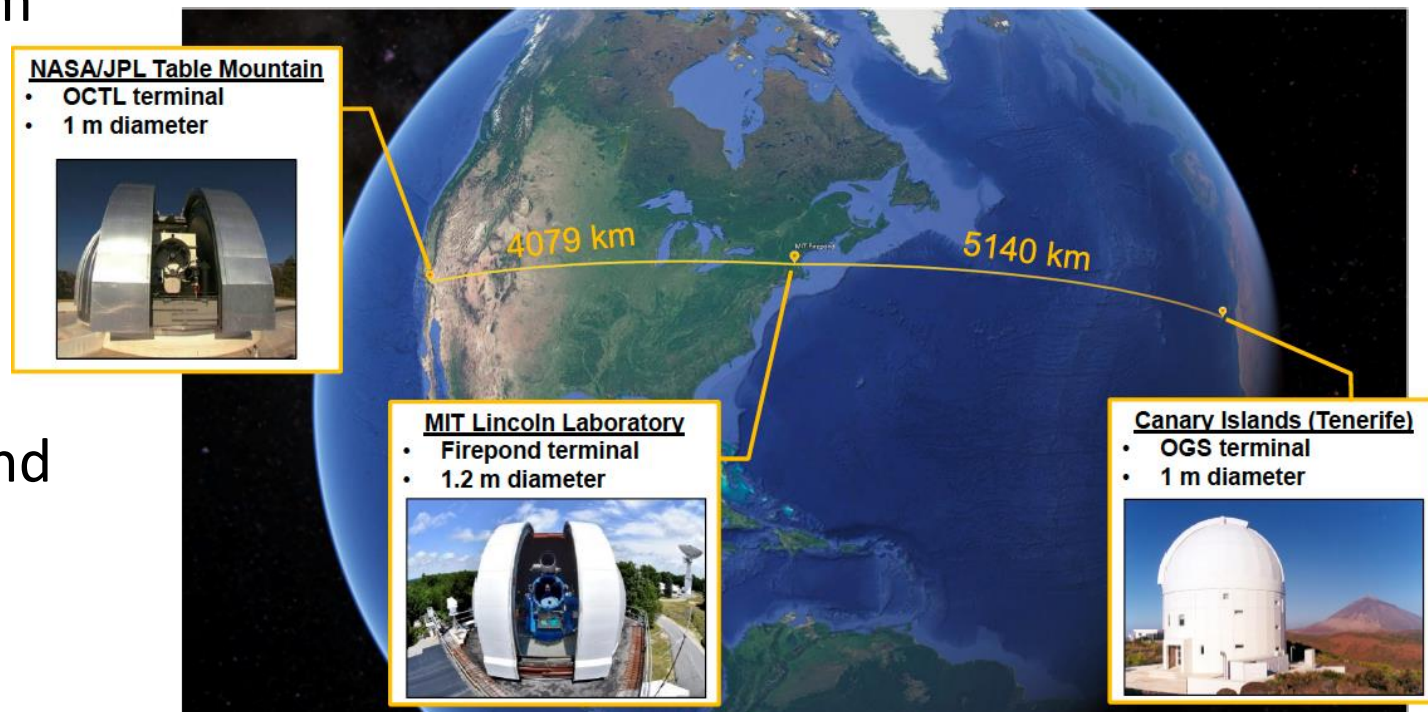
Quantum Mission (M2.0) in MEO

MEO M2.0 (Study)
Up to 5000-Km Baseline
 ~ 1 -m telescopes, Cryo



The vision: “M2.0”

- ✓ High-rate and high-fidelity quantum entanglement distribution capability across continental and trans-Atlantic/Pacific distances
- ✓ A unique and enabling space-ground platform for future space and terrestrial quantum networks
- ✓ The need for a space-based testbed



Testbed will test and mature quantum technologies that thread many applications: from science, to computing, to networking and communications



SCaN HQ 'Quantum Team'



- Lead: Nasser Barghouty
nasser.barghouty@nasa.gov
- Program Scientist: Babak Saif
babak.n.saif@nasa.gov
- PoC: Alex Sullivan
alexander.s.sullivan@nasa.gov