SCaN Next Generation Communications Capabilities

a Beacon of Light into NASA's Future

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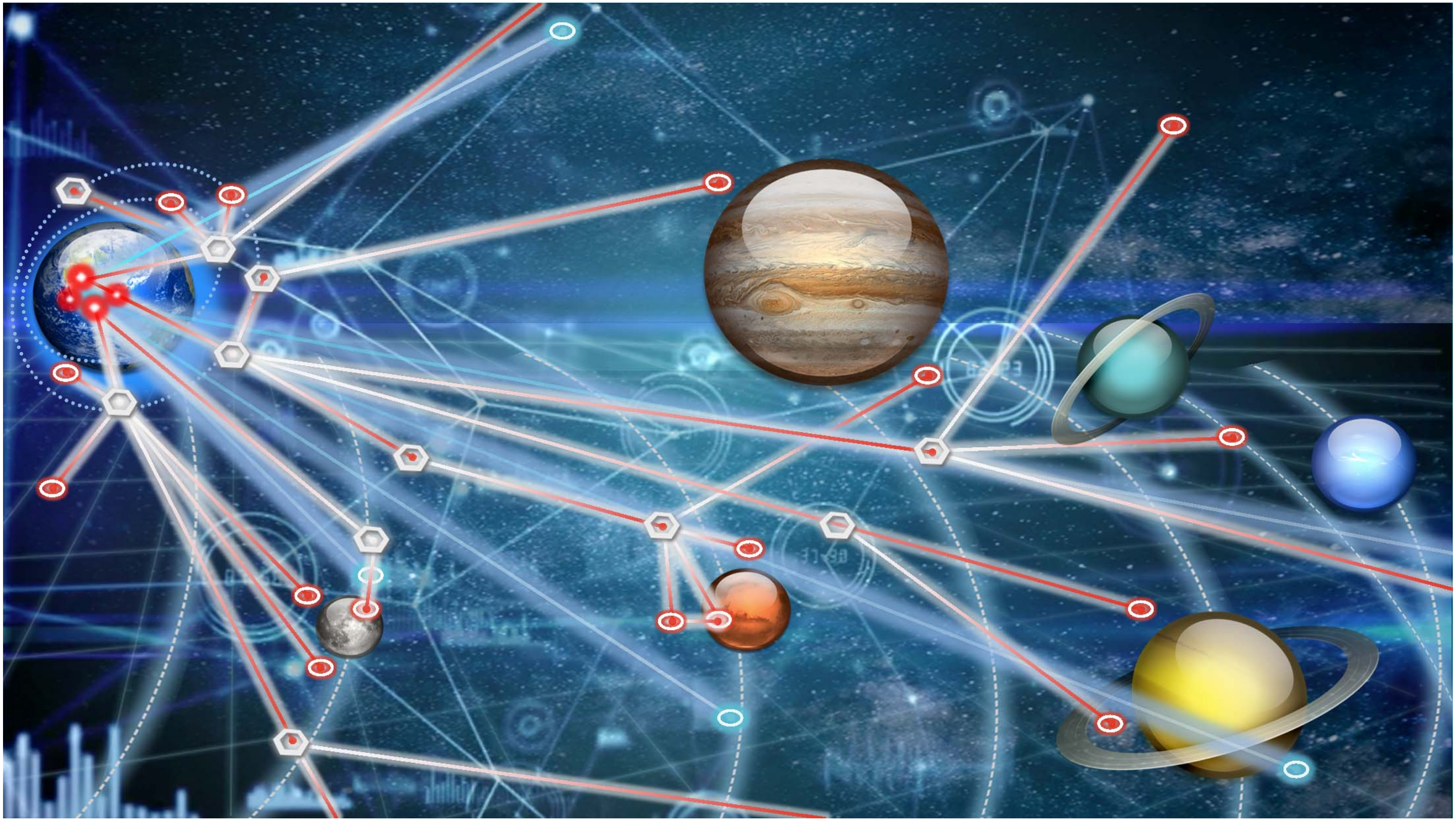
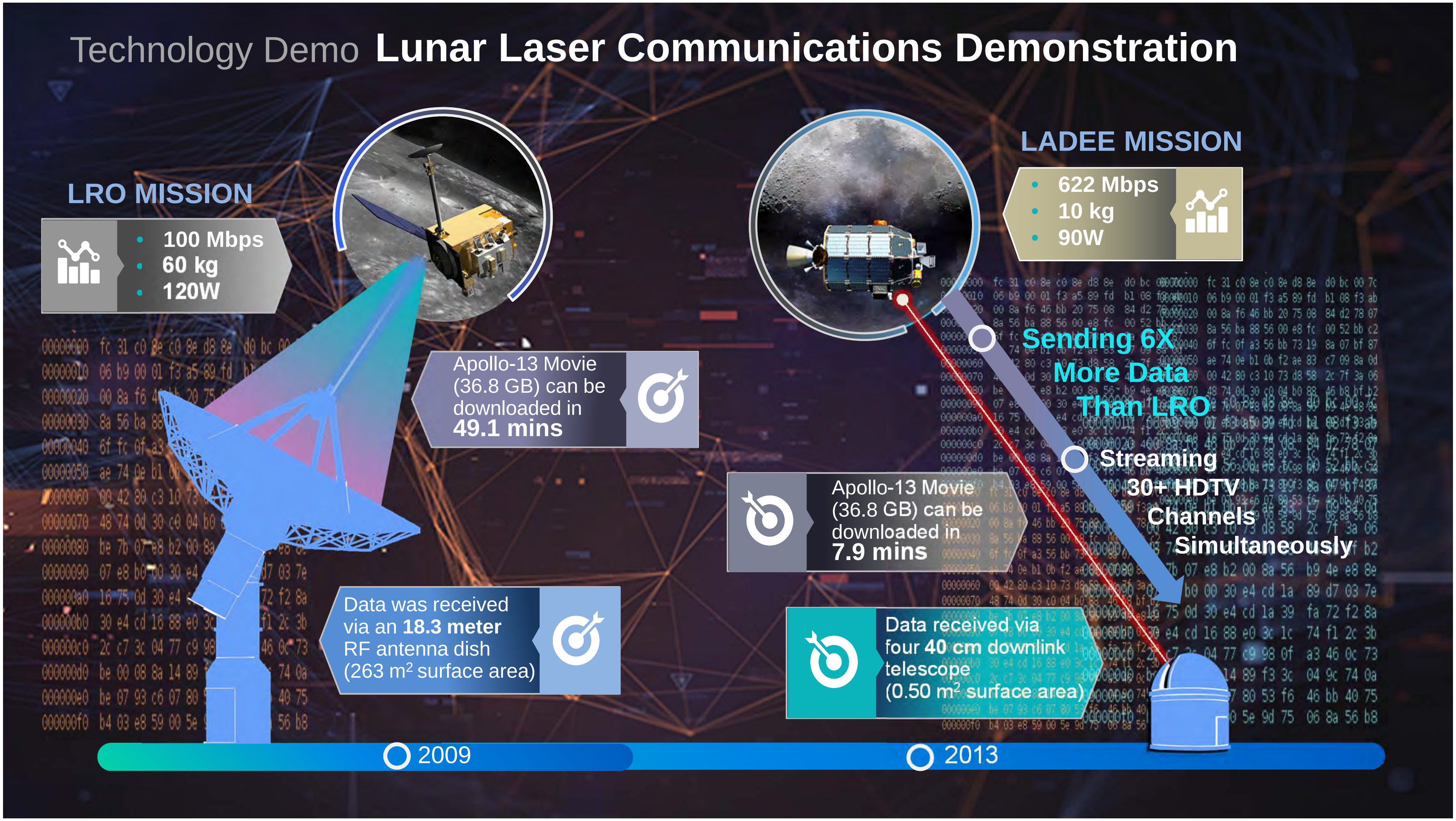
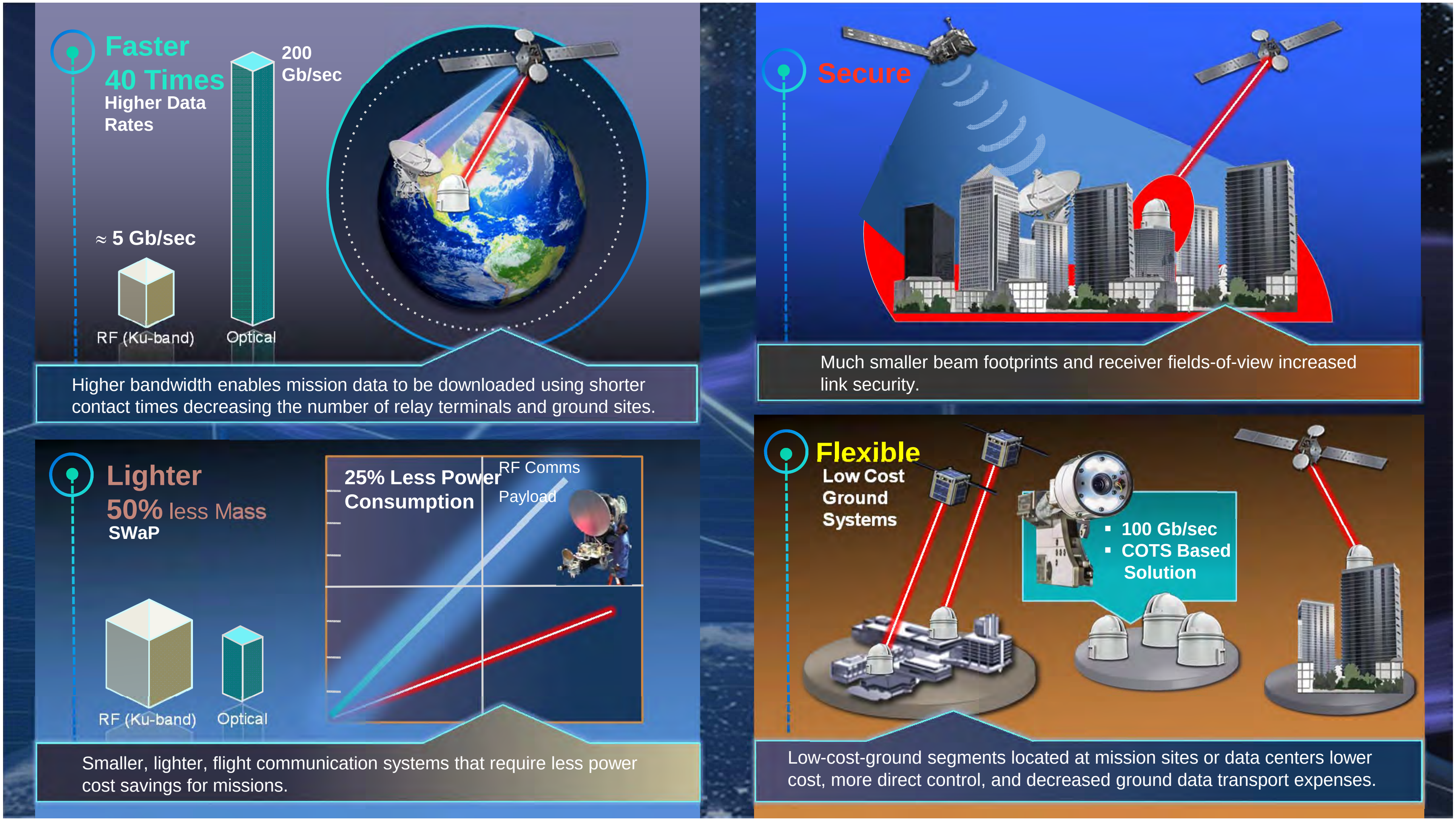
Decade of LIGHT




Technology Demo Lunar Laser Communications Demonstration
LRO MISSION
100 Mbps
60 kg
120W
Apollo-13 Movie (36.8 GB) can be downloaded in 49.1 mins
Data was received via an 18.3 meter RF antenna dish (263 m² surface area)
LADEE MISSION
622 Mbps
10 kg
90W
Sending 6X More Data Than LRO
Streaming 30+ HDTV Channels Simultaneously
Apollo-13 Movie (36.8 GB) can be downloaded in 7.9 mins
Data received via four 40 cm downlink telescope (0.50 m² surface area)
2009
2013


Faster
40 Times
Higher Data Rates
200 Gb/sec
≈ 5 Gb/sec
RF (Ku-band)
Optical
Higher bandwidth enables mission data to be downloaded using shorter contact times decreasing the number of relay terminals and ground sites.
Secure
Much smaller beam footprints and receiver fields-of-view increased link security.
Lighter
50% less Mass
SWaP
25% Less Power Consumption
RF Comms Payload
RF (Ku-band)
Optical
Smaller, lighter, flight communication systems that require less power cost savings for missions.
Flexible
Low Cost Ground Systems
▪ 100 Gb/sec
▪ COTS Based Solution
Low-cost-ground segments located at mission sites or data centers lower cost, more direct control, and decreased ground data transport expenses.

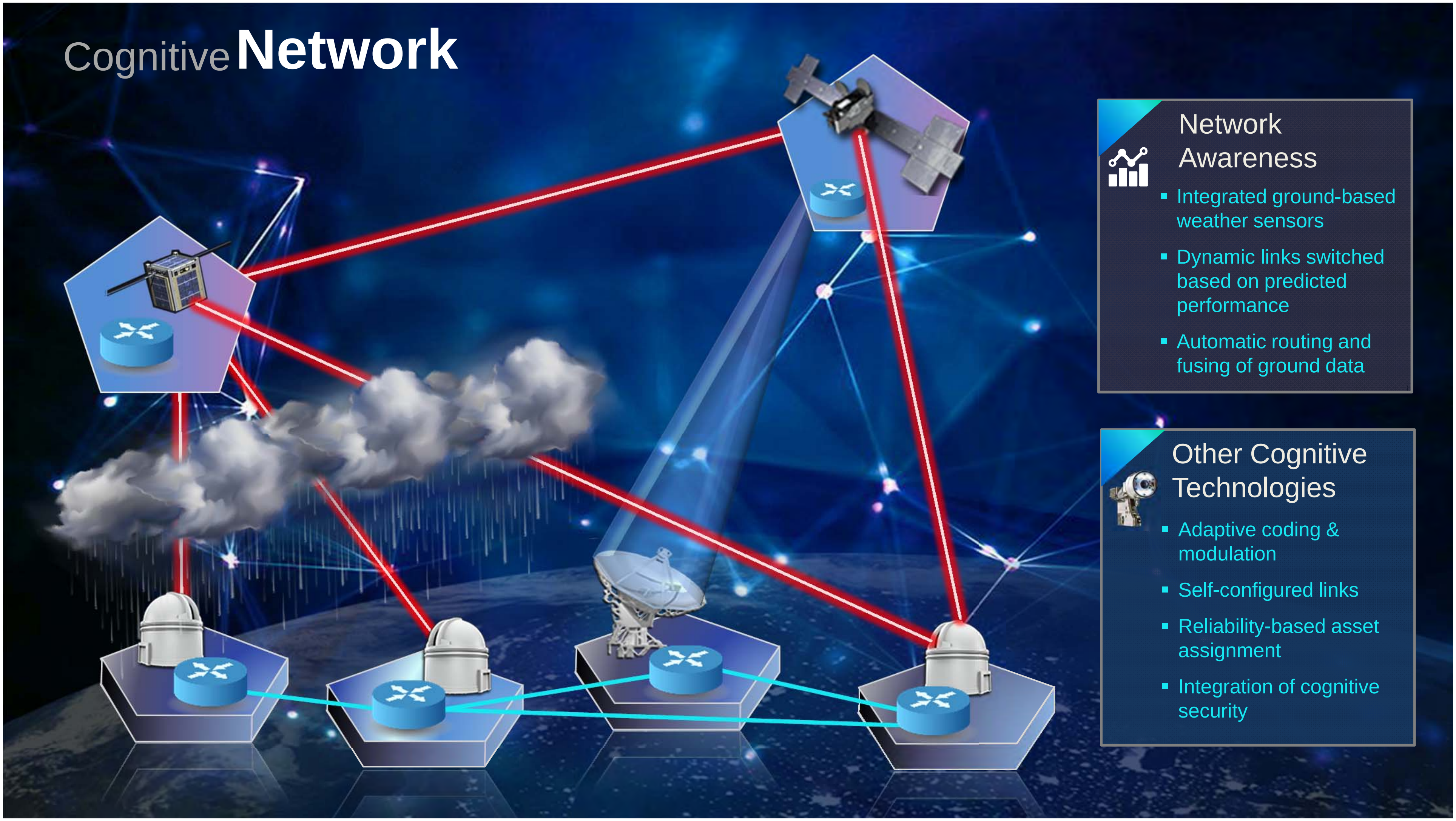
Concept of Operations


RF Network


RF Network
Near Earth DTE


RF Network
Near Earth DTE
Near Earth Relay


RF Network
Near Earth DTE
Near Earth Relay
Deep Space DTE


Cognitive Network
Network Awareness
▪ Integrated ground-based weather sensors
▪ Dynamic links switched based on predicted performance
▪ Automatic routing and fusing of ground data
Other Cognitive Technologies
▪ Adaptive coding & modulation
▪ Self-configured links
▪ Reliability-based asset assignment
▪ Integration of cognitive security

Technology**Timeline**

Recent Successes

LADEE/LLCD (2013)

- First two-way space optical communications from the moon and first demonstration of "space internet" over a laser link

SCaN Testbed on ISS (2012)

- Cognitive radio step forward

2012 - 2013

Near Earth Direct-to-Earth

Technologies in the pipeline include:

- 100 Gbps user terminal
- 100 Gbps low cost ground station
- Cognitive algorithms development

2019

Near Earth Relay

Technologies in the pipeline include:

- 2.88 Gbps GEO relay & two ground stations (2019)
- 2.88 Gbps user terminal(2021)
- 100 Gbps GEO relay, user and ground station (2023)
- Cognitive networking development

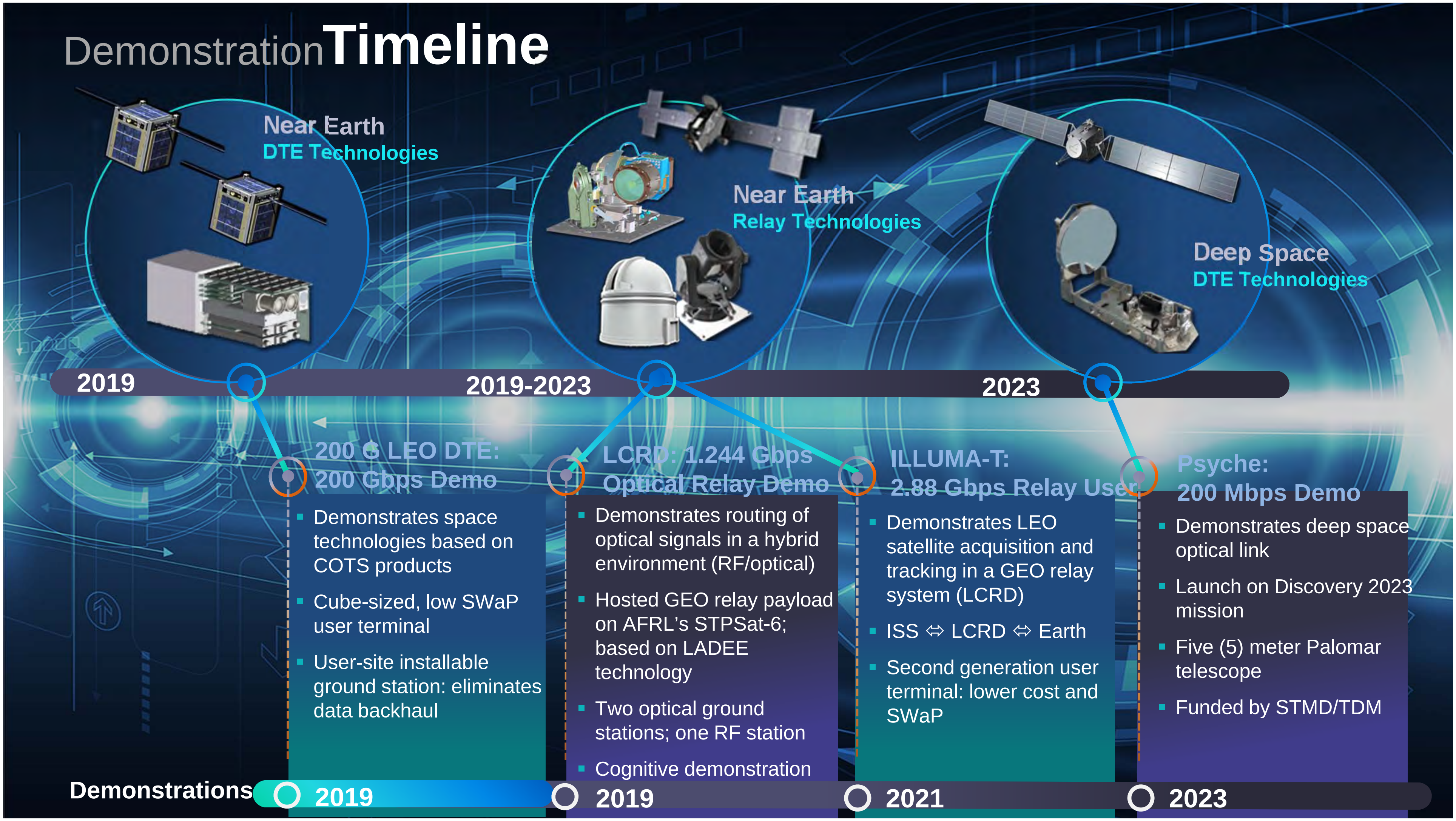
2019 - 2023

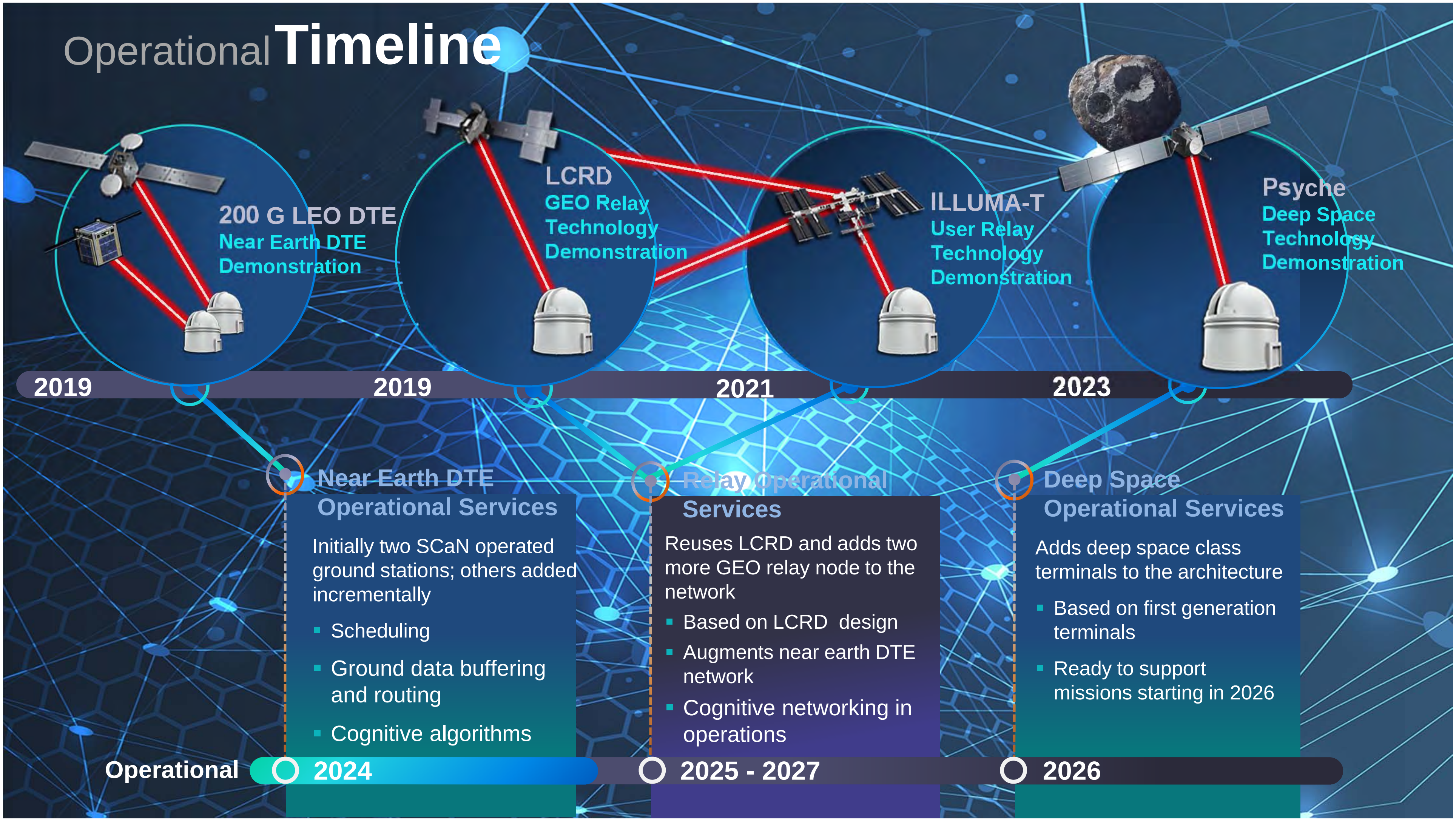
Deep Space DTE

Technologies in the pipeline include:

- 200 Mbps ground station
- 200 Mbps user terminal
- Cognitive Network to the edge of the solar system

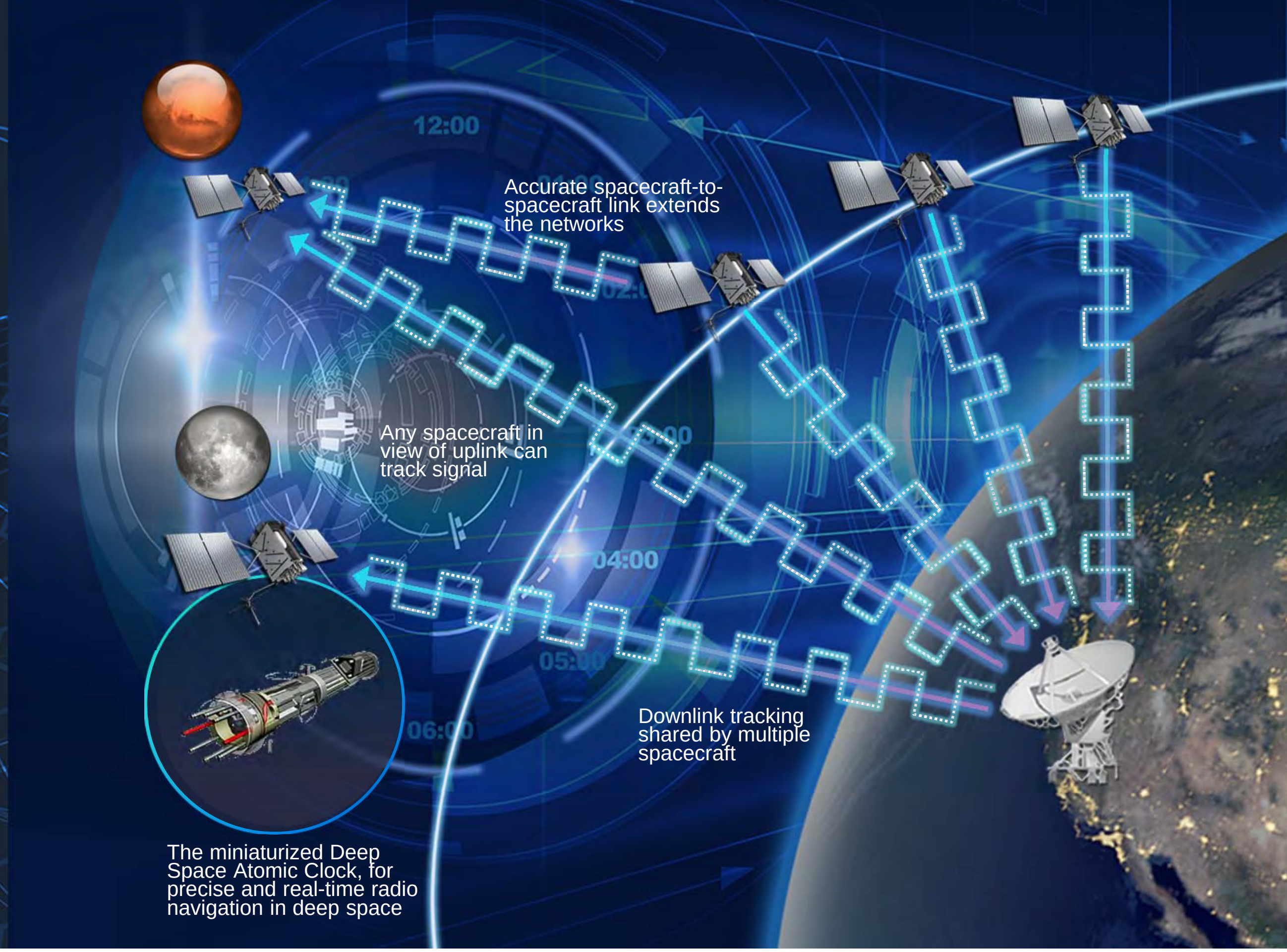
2023


Demonstration Timeline
Near Earth
DTE Technologies
Near Earth
Relay Technologies
Deep Space
DTE Technologies
2019
2019-2023
2023
200 G LEO DTE:
200 Gbps Demo
Demonstrates space technologies based on COTS products
Cube-sized, low SWaP user terminal
User-site installable ground station: eliminates data backhaul
LCRD: 1.244 Gbps
Optical Relay Demo
Demonstrates routing of optical signals in a hybrid environment (RF/optical)
Hosted GEO relay payload on AFRL's STPSat-6; based on LADEE technology
Two optical ground stations; one RF station
Cognitive demonstration
ILLUMA-T:
2.88 Gbps Relay User
Demonstrates LEO satellite acquisition and tracking in a GEO relay system (LCRD)
ISS ⇔ LCRD ⇔ Earth
Second generation user terminal: lower cost and SWaP
Psyche:
200 Mbps Demo
Demonstrates deep space optical link
Launch on Discovery 2023 mission
Five (5) meter Palomar telescope
Funded by STMD/TDM
Demonstrations
2019
2019
2021
2023


Operational Timeline
200 G LEO DTE
Near Earth DTE Demonstration
LCRD
GEO Relay Technology Demonstration
ILLUMA-T
User Relay Technology Demonstration
Psyche
Deep Space Technology Demonstration
2019
2019
2021
2023
Near Earth DTE Operational Services
Initially two SCaN operated ground stations; others added incrementally
Scheduling
Ground data buffering and routing
Cognitive algorithms
Relay Operational Services
Reuses LCRD and adds two more GEO relay node to the network
Based on LCRD design
Augments near earth DTE network
Cognitive networking in operations
Deep Space Operational Services
Adds deep space class terminals to the architecture
Based on first generation terminals
Ready to support missions starting in 2026
Operational
2024
2025 - 2027
2026

Deep Space **Atomic Clock**

Deep Space **Atomic Clock**



Features & Benefits

- Miniaturized, ultra-precise mercury-ion atomic clock
- Orders of magnitude more stable than existing navigation clocks
- No lasers, cryogenics, microwave cavity
- Low sensitivity to temperatures, magnetics, voltages
- Precise radio navigation in deep space

Performance

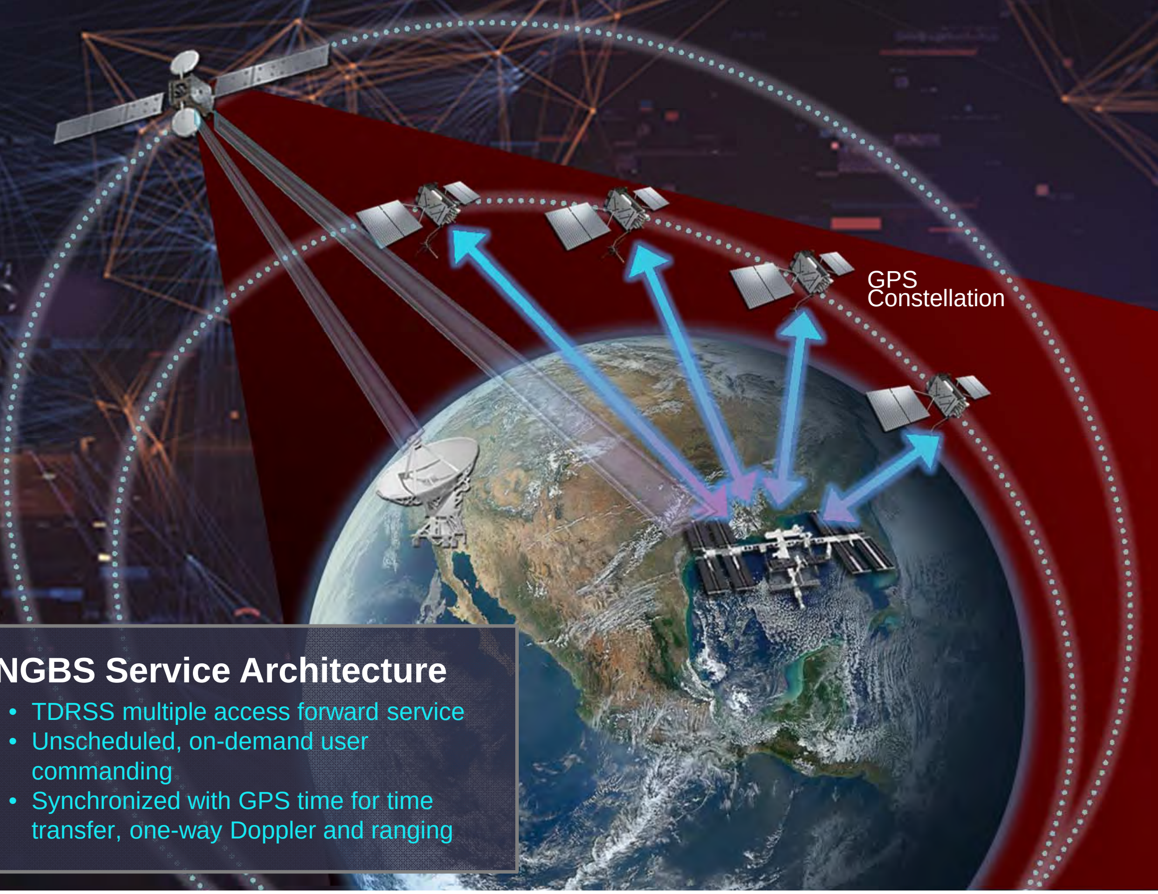
- Short term stability: 1 – 10 sec (Depends on Local Oscillator. DSAC selected USO 2e-13 at 1 second)
- Longer term stability: greater than 10 sec. Allan Deviation < 3.e-15 at 1 day

Next Step

- Year-long demonstration in space; advances technology to TRL 7
- Focused on maturing new technology (Ion trap and optical systems)

Next Generation **Broadcast Service**

Under Development: Next Generation **Broadcast Service (NGBS)**



NGBS Service Architecture

- TDRSS multiple access forward service
- Unscheduled, on-demand user commanding
- Synchronized with GPS time for time transfer, one-way Doppler and ranging

Features & Benefits

- Reduces time interval for coordinating Target-of-Opportunity observations across multiple spacecraft
- Facilitates autonomous or MOC-in-the-loop re-pointing
- Provides common information for situational awareness including space weather
- Provides unscheduled, continuously-available alternative (or supplement) to GPS navigation
- Provides resiliency to GPS solution

Time Line

- **2000:** Global differential GPS (GDGPS) operational
- **2006-2007**: Demo of early beacon concept on TDRS-1
- **2016:** Re-scoped to NGBS; Demo on TDRS-12 to validate beacon pattern


Decade of LIGHT
https://www.nasa.gov/directorates/heo/scan/index.html