National Aeronautics and Space Administration

SCaN Updates

Presented to:
NASA Advisory Council –
Human Exploration and Operations

Presented by:
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SCaN Space Communications and Navigation
Exploration, enabled.

Enabling Human Space Exploration and Science

1 Develop, operate and manage all NASA space communications capabilities

2 Develop technologies to enable and enhance future mission experience

3 Manage NASA spectrum; represent NASA on national and international spectrum management forums

4 Develop space communication standards as well as positioning, navigation, and timing policies

5 Represent and negotiate on behalf of NASA on all matters related to space communications and navigation

Space Communications and Navigation (SCaN) serves as the Program Office for all of NASA's space communications activities

24/7 Global Near Earth and Deep Space Communications and Navigation Services

100+ Missions currently supported by SCaN

SCaN is Adapting to Rapid Changes in the Space Sector

Commercialization

- Growth of commercial space sector has created robust non-governmental demand for space support services like communications
- Office of Management and Budget and National Space Policy encourage NASA SCaN to draw upon these commercial services wherever possible

Cis-Lunar Developments

- Growth in lunar exploration will dramatically increase network demand
- Deep Space Network upgrades are in process
- Commercial services will be part of the solution for fulfilling mission needs

2022 Satellite Service Industry Trends*

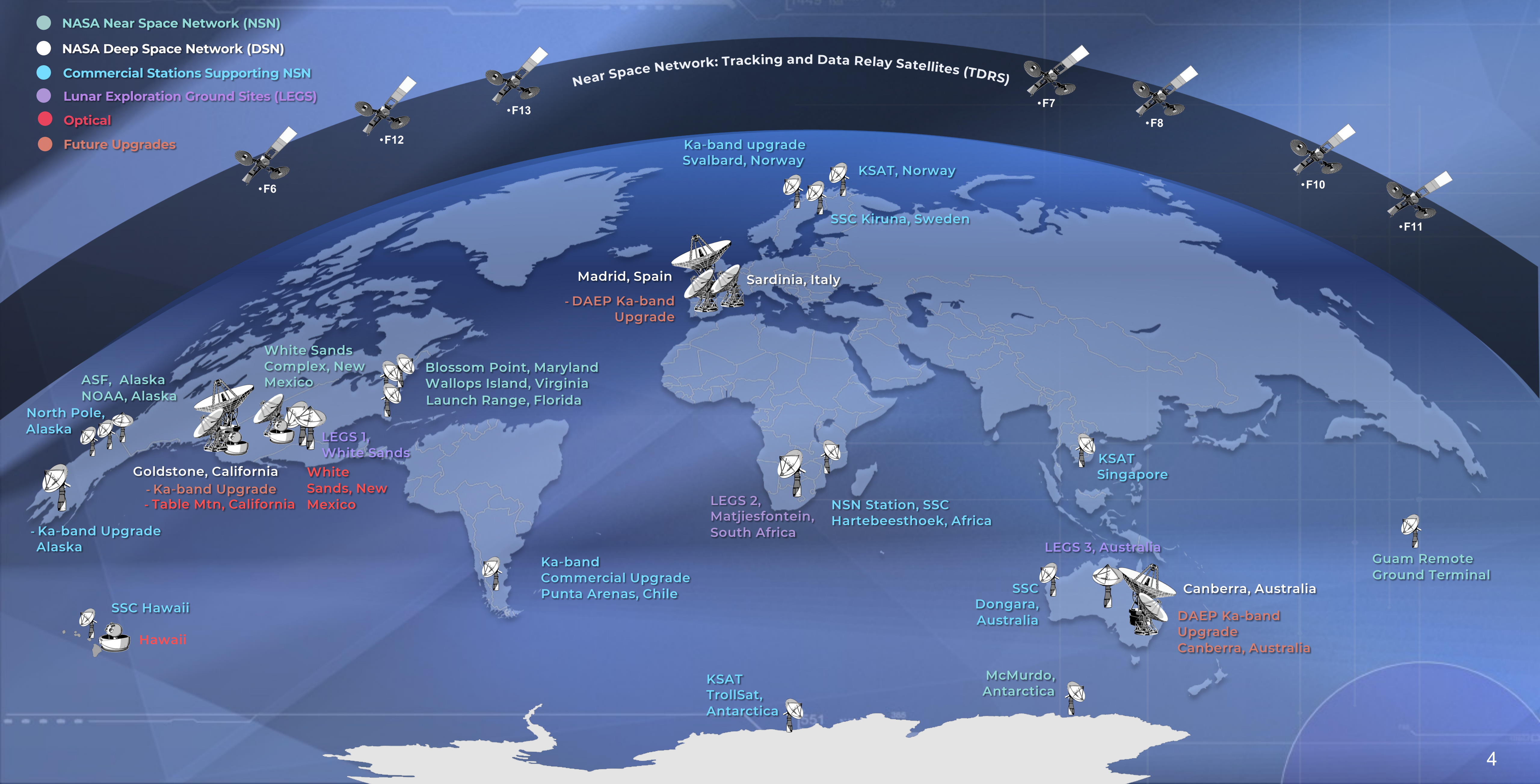
Mobile voice and data revenue

Managed network services revenue increased

High Throughput Satellite capacity increasingly available

*Satellite Industry Association 2022 Report

NASA's Communications Networks

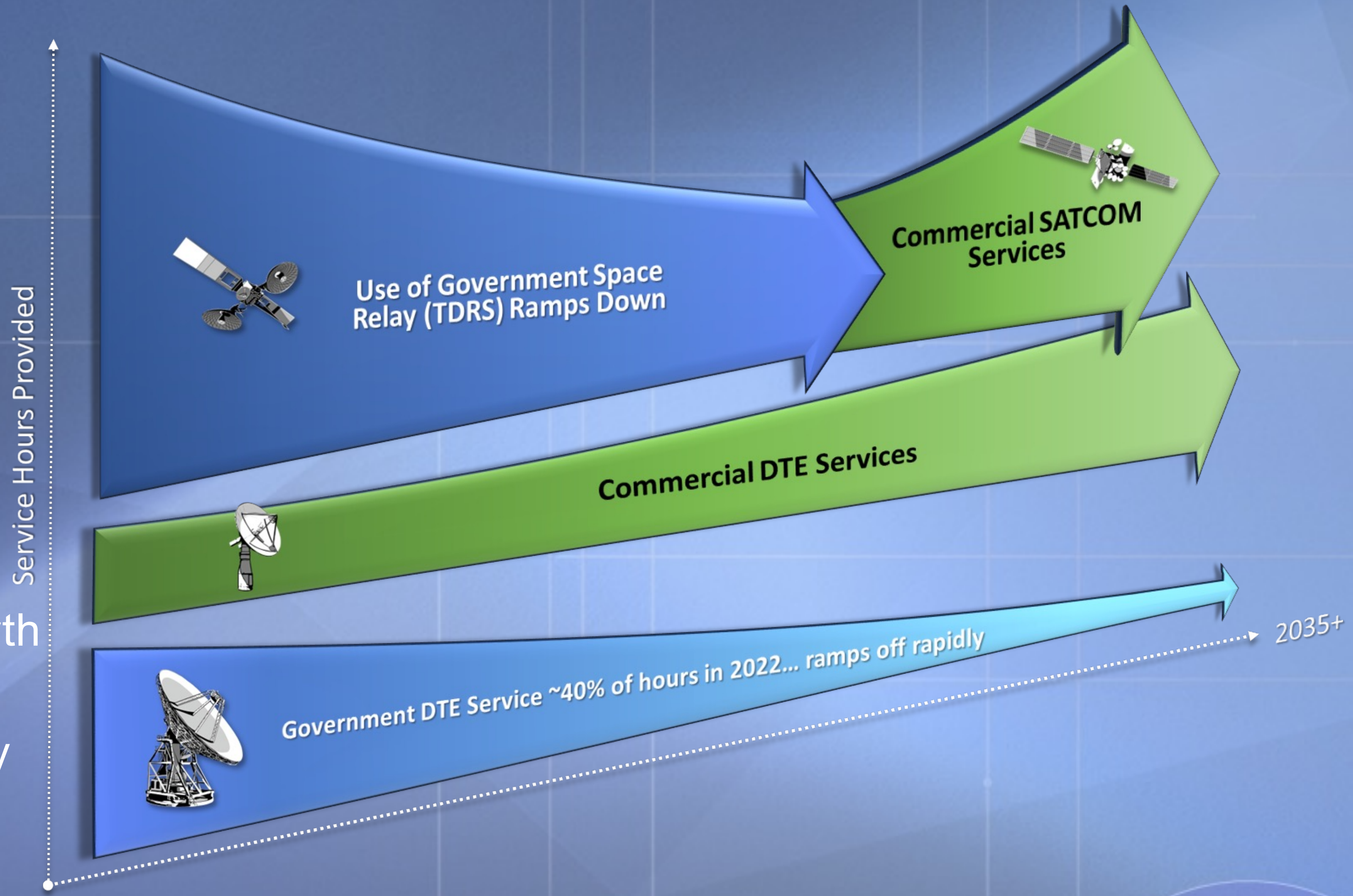


Commercial Transition Strategy

In 2020, SCaN defined a strategy to transition NASA's LEO user community to commercial services

This strategy identified two swim lanes of effort based on assessments of technical risk and market maturity:

- ☐ Rapid transition of direct-to-Earth (DTE) services
- ☐ Gradual transition of Earth relay services



Growth in Commercial DTE Services

Kongsberg Satellite Services (KSAT) has provided TT&C services support from its Svalbard, TrollSat, and Singapore sites

NASA also has a long history of procuring services from the Swedish Space Corporation (SSC), beginning with support from the Universal Space Network (USN) in the early 2000's

KSAT KONGSBERG SATELLITE SERVICES

1997 1998
Svalbard Satellite Station Opened. NASA installed SG1 antenna to support EOS.
SG1 Government Owned / Contractor Operated.
SG2 Commercially owned / operated

2000
NASA begins to receive support from the USN Hawaii and Australia stations for missions including GOES, FAST, FUSE, GLAST…

2003 2006
SG3 added to the network - is Commercially owned / operated.
SG4 installed- is Partner owned / operated

SSC

2009
SSC purchases the USN. NASA obtains LRO support from SSC/USN

As of 2012, the NASA no longer owned or operated any antennas at commercial locations

2012
New KSAT owned SG1 antenna declared operational for NEN support. Aqua and Aura first missions supported

2015
Support through SSC grows to include THEMIS, MMS, and launch support

As of 2022, ~60% of all DTE Services to NASA missions are commercially provided

RFP Released in 2023 with goal to expand level of commercial services to near 100%

NASA tapping into a growing market of commercial DTE comms vendors

aws
RBC SIGNALS
LEAFSPACE
ATLAS SPACE OPERATIONS
Infostellar

1990's | 2000-2010 | 2010's | 2020's

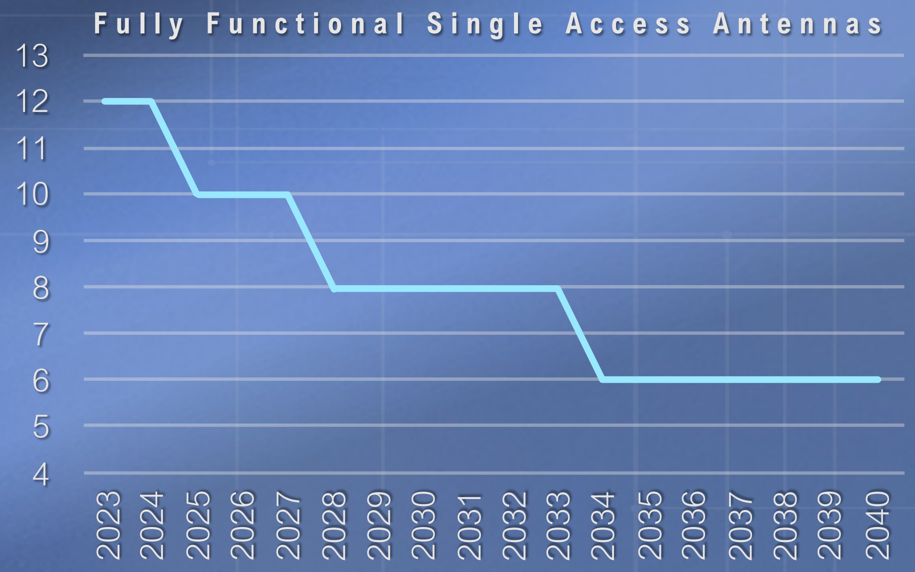
History of Events

**Companies listed are illustrative of market activity, not indicative of NASA preference or commitments*

Near Earth Relay: NASA Must Phase Out TDRSS

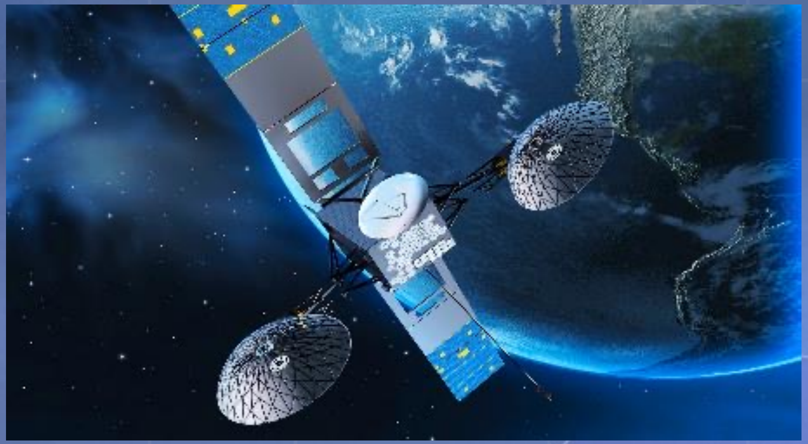
NASA does not have budgetary, political or policy support to launch replacement satellites for the Tracking and Data Relay Satellite System (TDRSS

- Option for final 3rd generation spacecraft (TDRS-N) was rejected by the OMB and Congress
- OMB has communicated that NASA should transition away from TDRSS and towards commercial, aligning with National Space Policy



NASA expects to operate TDRSS into the 2040's

- The last TDRS was launched in 2017, and nine remain operational or in storage
- SCaN will maintain and fly out the constellation to support existing missions
- TDRS retirements will be driven by spacecraft health
- TDRS 11, 12, and 13 are projected to last into the 2040s



Progress in Pursuing Commercial Services

- Commercial Geosynchronous Orbit (GEO) **L-band** relay network — inmarsat
- **Optical** Low Earth Orbit (LEO) network — amazon | project kuiper
- GEO **C-band** and Medium Earth Orbit (MEO) **Ka-band networks** — SES GOVERNMENT SOLUTIONS
- **Optical** LEO network — SPACEX
- RF relay networks offering **C-band and Ka-band** services — TELESAT
- GEO **Ka-band** relay network — Viasat

Communications Services Project

June 2022, six NASA CSP Funded Space Act Agreement awards were made totaling

$278.5 million

- Commercial vendors will offer NASA users a variety of capabilities
- SCaN is working toward a 2024 Agency Program Management Council review to decide on future mission commitments, including TDRS flyout

Wideband Multilingual Terminal

NASA is supporting the Applied Physics Lab (APL) development of a wideband/multilingual user terminal to unlock interoperability across commercial SATCOM systems

Supports government and commercial Ka-band allocations (17.7 – 31.0 GHz)

Key Milestones:

- ◻ APL was selected (end of FY21) to proceed to flight demonstration activity
- ◻ A flight demonstration terminal has been integrated into a York Space Systems S-Class bus for launch on Transporter-11 in 2024
- ◻ Flight demo operations to last ~6 months

Post flight demo actions:

- ◻ Leverage existing partnerships to transfer wideband design / technology to industry
- ◻ Include resultant wideband terminal options in NSN services catalog

Inmarsat Global Xpress

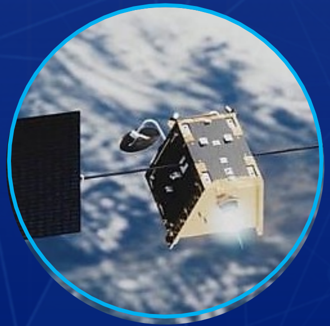
- GEO Constellation
- 28 Steerable Antennas in orbit
- 7 new satellites

O3b mPOWER

- MEO Constellation
- Thousands of beams per satellite
- 11 satellites

Telesat Blackjack

- LEO Constellation
- 2 steerable antennas per satellite
- 2 satellites in DARPA mission



Deep Space Network (DSN)

DSN's Role and Structure

DSN is the only US network dedicated to providing telecommunications services for missions beyond LEO

DSN also supports international spacecraft and scientific investigations (radar, radio astronomy and radio science)

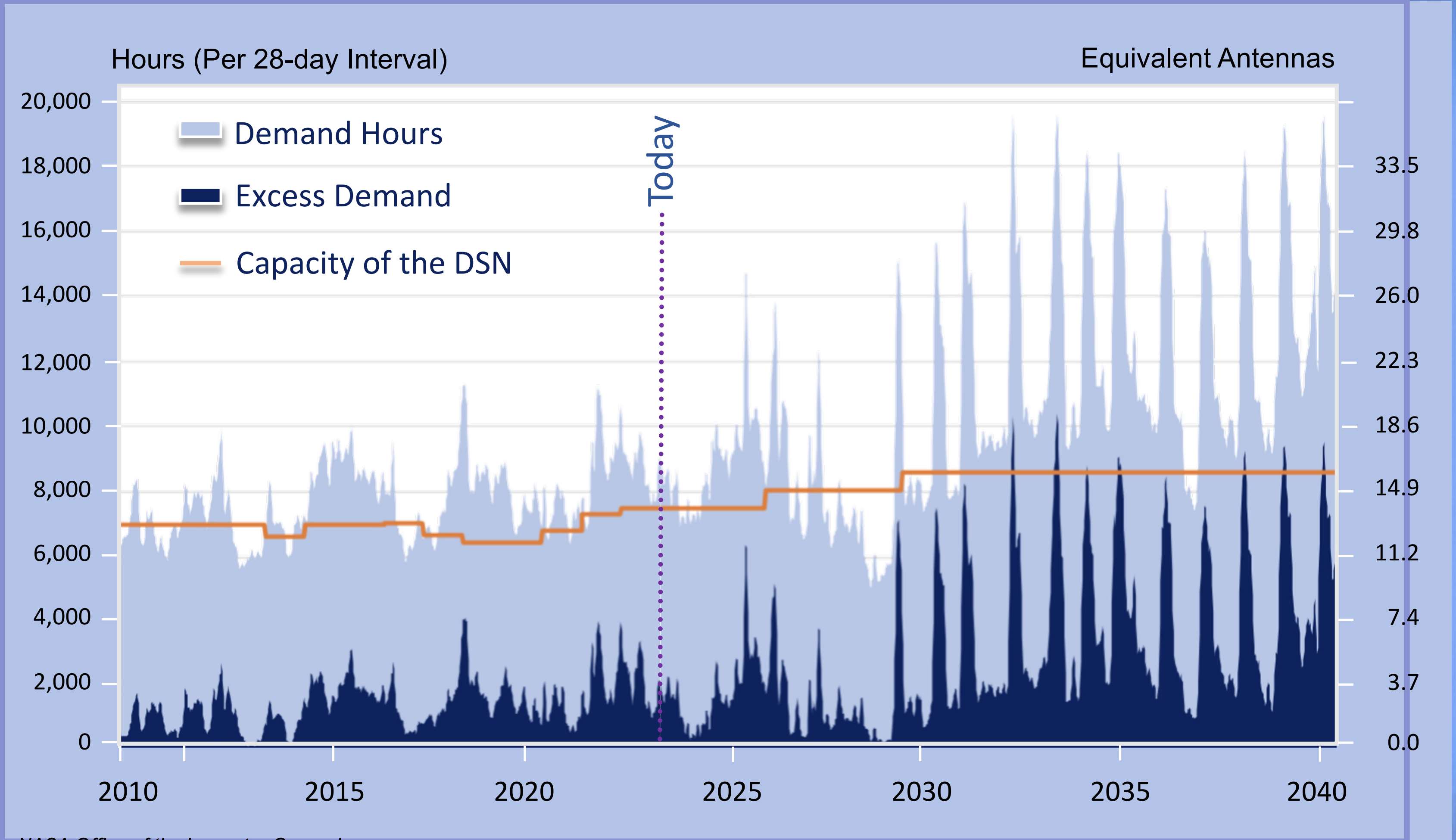
DSN has three complexes, spread across the world to ensure 24/7 coverage

The NASA Jet Propulsion Laboratory (JPL) develops, operates, and manages DSN

Deep Space Network Missions

#	DSN	Mission Dashboard	October 2023	(*Updated Monthly -- Contact S. Asmar*)	
#	Completed Since 2019	Current 20+22 = 42 Deep Space	Cis-Lunar, Lagrange, ...	Future 15+26 = 41 Deep Space	Cis-Lunar, Lagrange, ...
1	InSight *Mars*	Juno *Jupiter*	Lunar Recon. Orb. *Lunar*	VERITAS *Venus*	SunRISE
2	Mars Cube One *InSight Cube*	Lucy *Asteroids*	SOHO *Helio L1 NASA-ESA*	DAVINCI+ *Venus*	GOES U
3	DART *Asteroid*	Perseverance Mars	ACE *Helio L1*	Dragonfly *Titan*	SWFO *L1*
4	LICIA (ASI) *DART Cube*	Mars Odyssey Mars	Wind *Helio L1*	Europa Clipper *Jupiter 2024*	IMAP *L1*
5	GOES T	Mars Recon. Orb. *Mars*	MMS 1 *Earth Ellip. Orb.*	ESCAPADE Blue *Mars*	Carruthers *L1*
6	Geotail	MAVEN *Mars*	MMS 2 *Earth Ellip. Orb.*	ESCAPADE Gold *Mars*	Astrobotic Peregrine *Lunar*
7	Artemis 1 *Lunar*	Curiosity *Mars*	MMS 3 *Earth Ellip. Orb.*	Sample Return Land. *Mars*	Astrobotic Griffin *Lunar*
8	NEA Scout *Cube*	New Horizons	MMS 4 *Earth Ellip. Orb.*	Earth Return Orb. (ESA) *Mar*	Lunar Node-1 CLPS *Lunar*
9	CuSP Cube	OSIRIS-REx (APEX)	Themis B *Helio L1*	Rosalind Franklin (ESA) *Mars*	Lunar Trail Blazer *Mar 2024*
10	LunaHMAP *Cube*	Parker Solar Probe *Helio*	Themis C *Helio L2*	EnVision (ESA) *Venus*	VIPER *Lunar*
11	Lunar Ice Cube	Voyager 1 *Helio*	DSCOVR *L1*	HERA (ESA) *Asteroid*	Artemis-2 Orion
12	Team Miles *Cube*	Voyager 2 *Helio*	Chandra *HEO*	DESTINY+ (JAXA) *Asteroid*	Artemis-3 Orion
13	ArgoMoon (ASI) *Cube*	STEREO A *Helio*	JWST *L2*	MMX (JAXA) *Mars (L 2024)*	Exploration Upper Stage
14	Omotenashi (JAXA) *Cube*	Akatsuki (JAXA) *Venus*	TESS *Earth Ellip. Orb.*	Emiratres Asteroid (UAE)	Gateway *Lunar*
15	Equuleus (JAXA) *Cube*	Hayabusa-2 Ext (JAXA) *Astero*	CAPSTONE *Cube*	Rocket Lab Venus	Human Landing Sys 1
16	INTEGRAL (ESA)	BepiColombo (ESA)	TDRS 6-13 *emergency*		Human Landing Sys 2
17	Hayabusa-2 Prime (JAXA)	Trace Gas Orb. (ESA) *Mars*	Biosentinel *Cube*		Human Landing Sys 3
18	Beresheet (Israel) *Lunar*	Mars Express (ESA)	Lunar Flash Light *Cube*		Blue Origin Mark-1 SN-1
19	Mars Orb. Mission (ISRO)	Emirates Mars (UAE)	XMM (ESA) *Earth Ellip. Orb.*		Blue Origin Mark-1 SN-2
20	Chandrayaan 2 Land. (ISRO)	Psyche *Asteroid*	Gaia (ESA) *L2*		Lunar Terrain Vehicles
21	Chandrayaan 2 Orb. (ISRO)		KPLO (KARI) *Lunar*		Beresheet-2 (Israel) *Lunar*
22	Chandrayaan 3 Land. (ISRO)		SLIM & LEV (JAXA) *Lunar*		Roman Telescope *L2 2027*
23					NEO Surveyor *L1 2027*
24					Oracle-P Air Force *L1 2025*
25					Astrobotic third lander
26					LUPEX (JAXA/USRO)

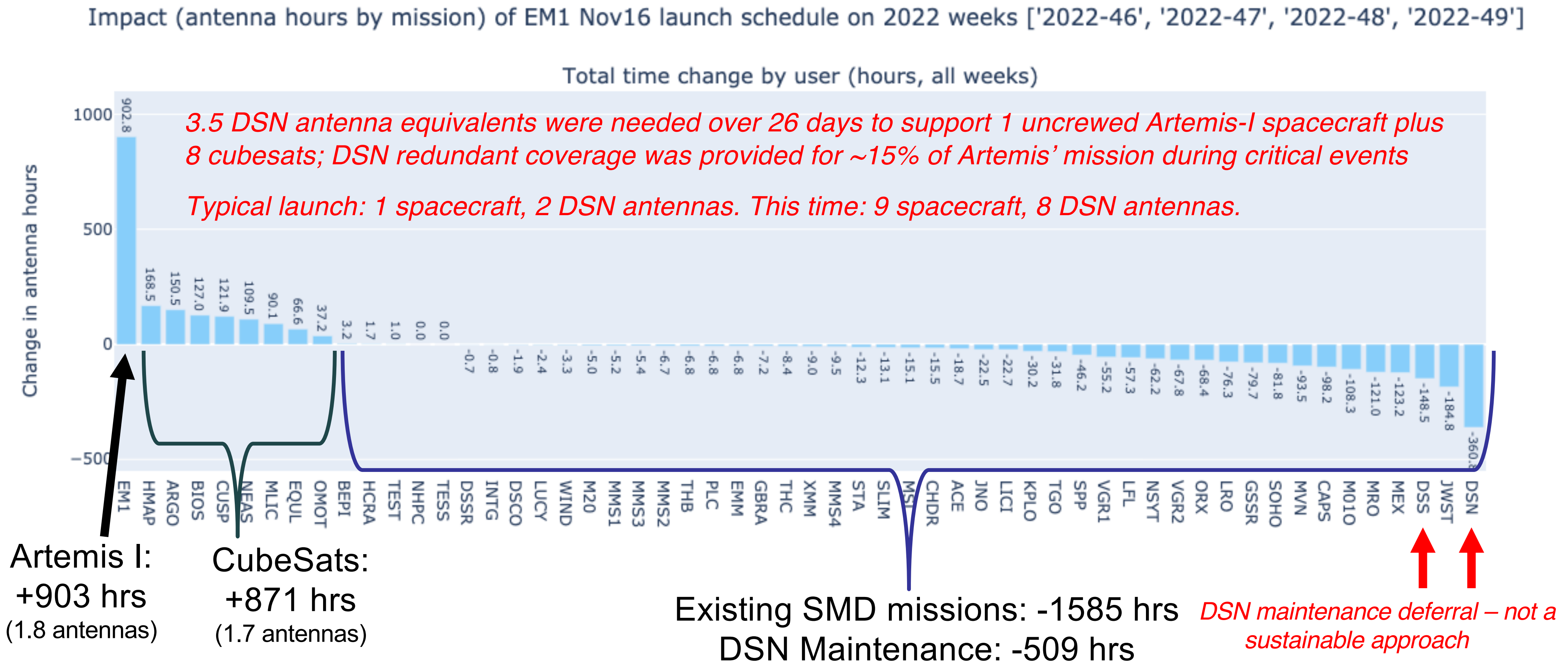
DSN Challenge: Growing User Needs



NASA Office of the Inspector General, 7/12/23

Artemis 1 and Cubesat Experience

Artemis-I + Deep Space CubeSat Support: DSN Impacts



How SCaN Plans to Support Lunar Demand and DSN Users

New Deep Space Network (DSN) Capacity & Upgrades

1

- Building six 34m antennas across all three DSN complexes
- Upgrading two DSN antennas at each complex to enable simultaneous operations, enhance uplinks, and increase data rates

Lunar Exploration Ground Segment (LEGS)

2

- Network of new 18-meter class antennas to support lunar missions
- Starting with three government owned, commercial operated sites around the Earth, offering continuous coverage
- Commercial services will add additional capacity as demand grows

Lunar Communications and Navigation Relay Services

3

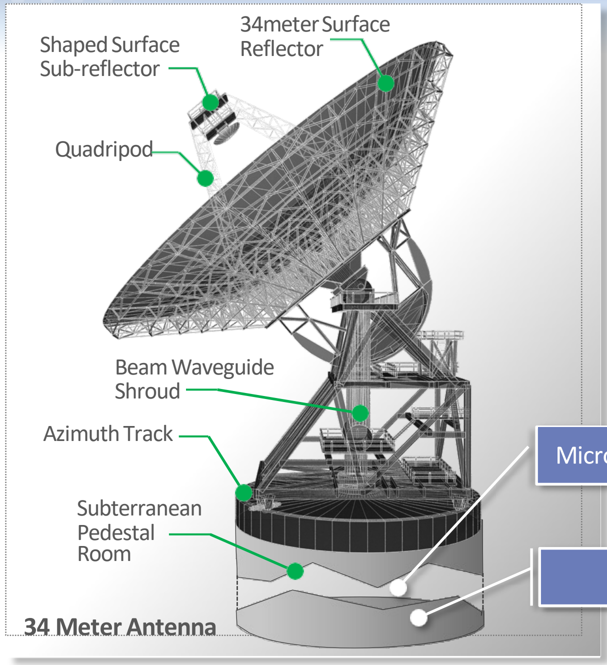
- Creating lunar relays to reduce user PNT burden and remove DTE line-of-sight constraints (enabling South Pole and Far-Side operations)
- Using a commercial service procurement approach

International Partnerships and Contributions

4

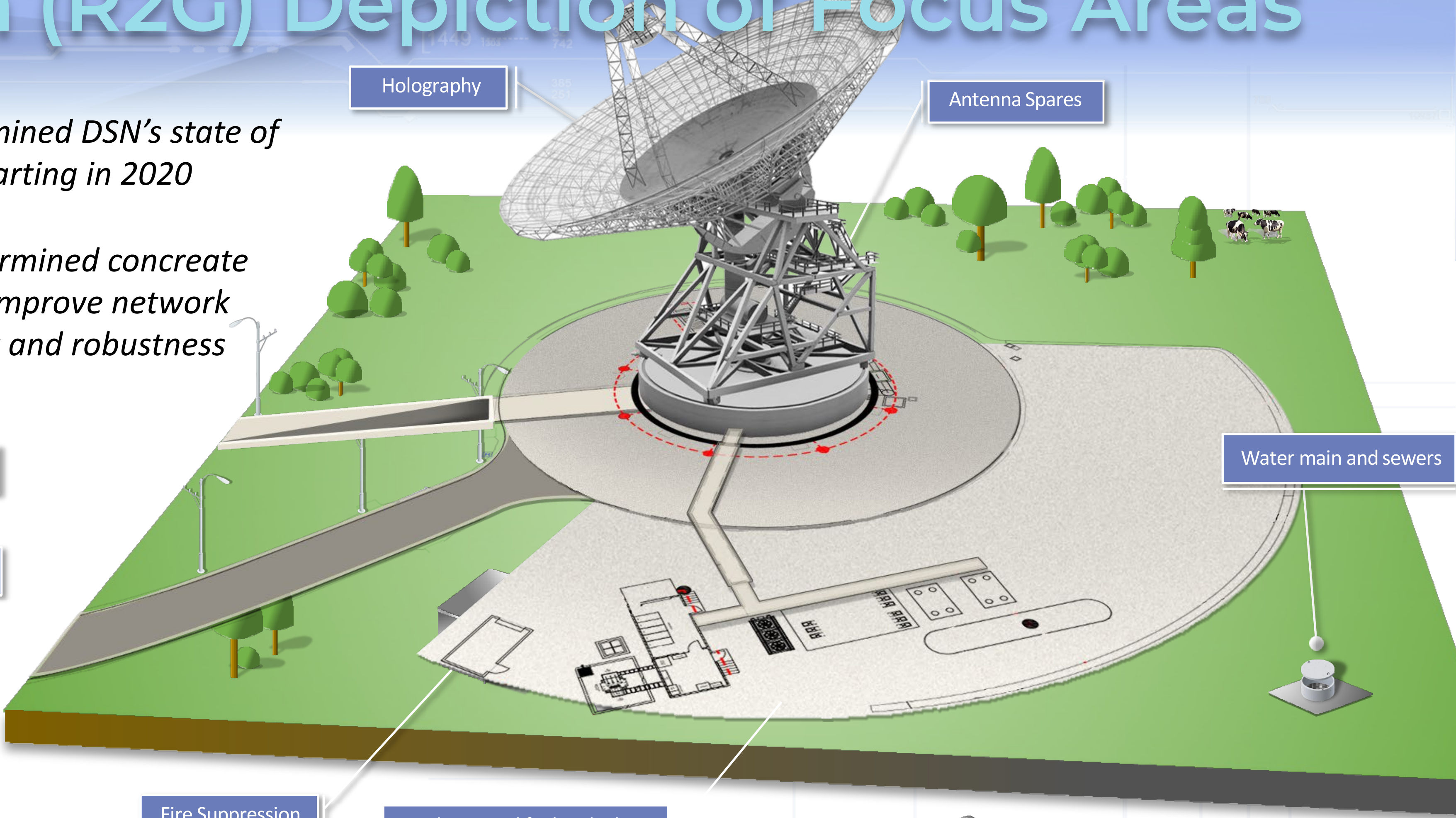
- Seeking contributions for both Earth based and Lunar C&N assets
- Priority 1: Direct-to-Earth assets that meet or exceed LEGS performance
- Priority 2: Lunar relay comm and PNT services
- Priority 3: Lunar surface comm and PNT capabilities

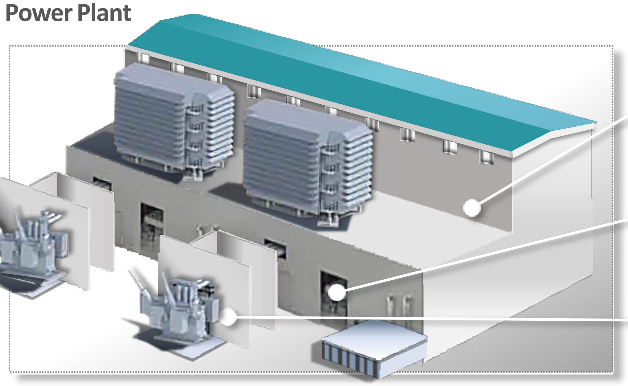
Road to Green (R2G) Depiction of Focus Areas



R2G examined DSN's state of health starting in 2020

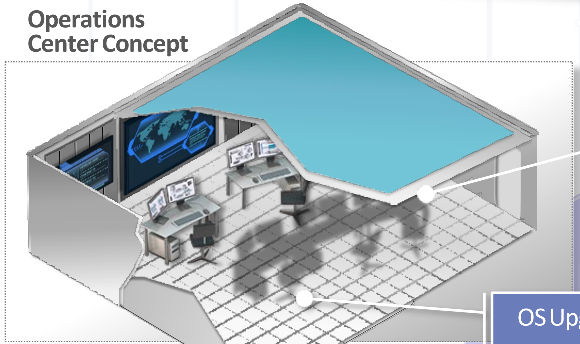
R2G determined concreate steps to improve network reliability and robustness





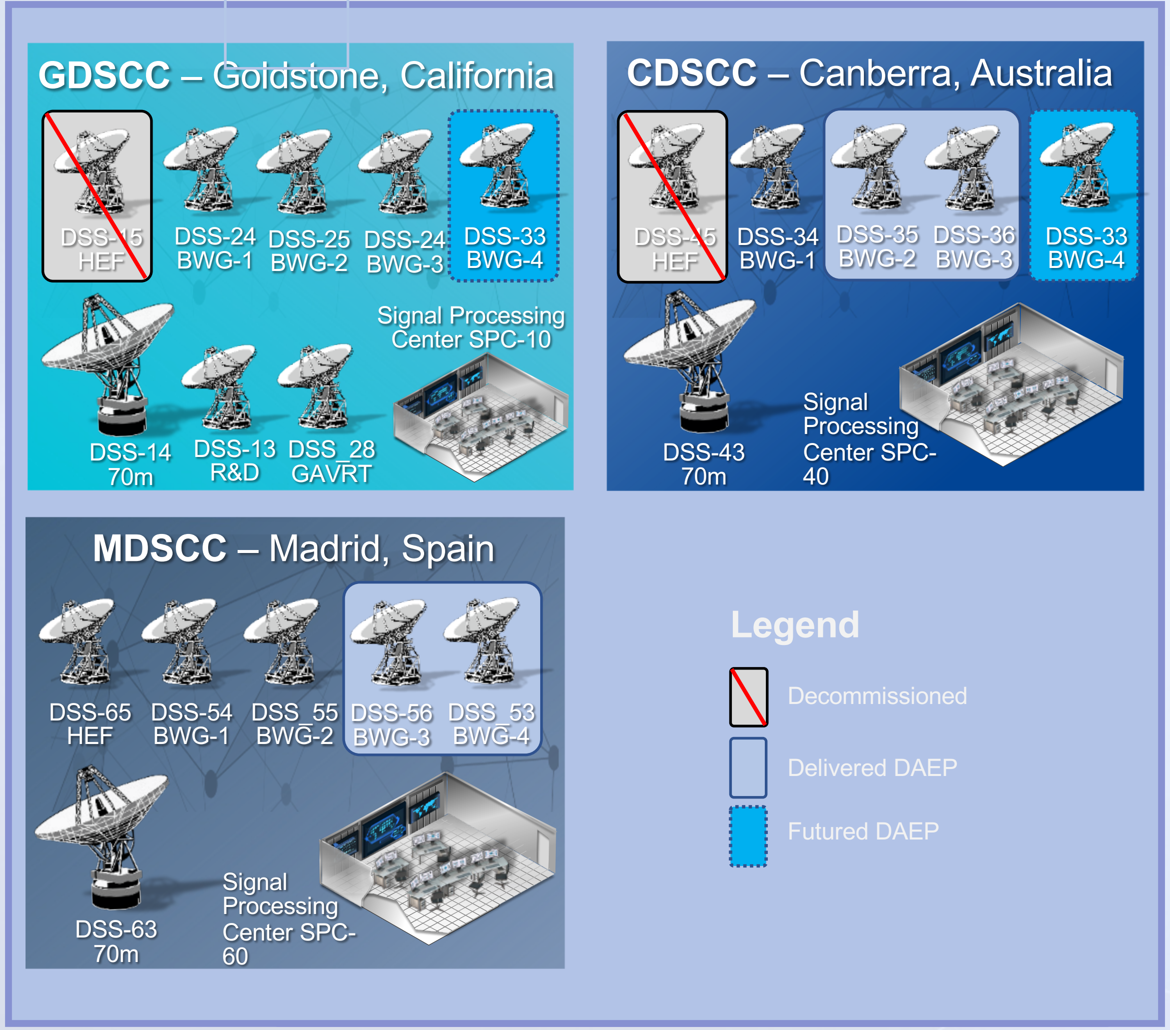
Funds prioritized to address:

- *Health and safety*
- *IT security*
- *Facility infrastructure*
- *Vulnerable antenna components*



Capacity Increases: DSN Aperture Enhancement Project (DAEP)

- DAEP is building six 34m Beam Wave Guide (BWG) antennas across all three DSN complexes to provide additional capacity
- FY2024 DAEP STATUS SNAPSHOT:
  - Four 34m BWG deliveries completed (Two in Canberra and two in Madrid)
  - One 34m BWG in process in Goldstone; Delivery to service April 2026
  - One 34m BWG in the future at Canberra; Delivery to service expected October 2029
- Further expansion after FY30 will be based on a *DSN Futures Study* and Agency requirements, and available support
  - May include higher power transmitters, HEF antenna refurbishments, and site diversity measures
  - Post-FY30 development work is funding dependent



DSN Lunar Exploration Upgrades (DLEU)

Upgrading six DSN antennas; two at each of the three complexes

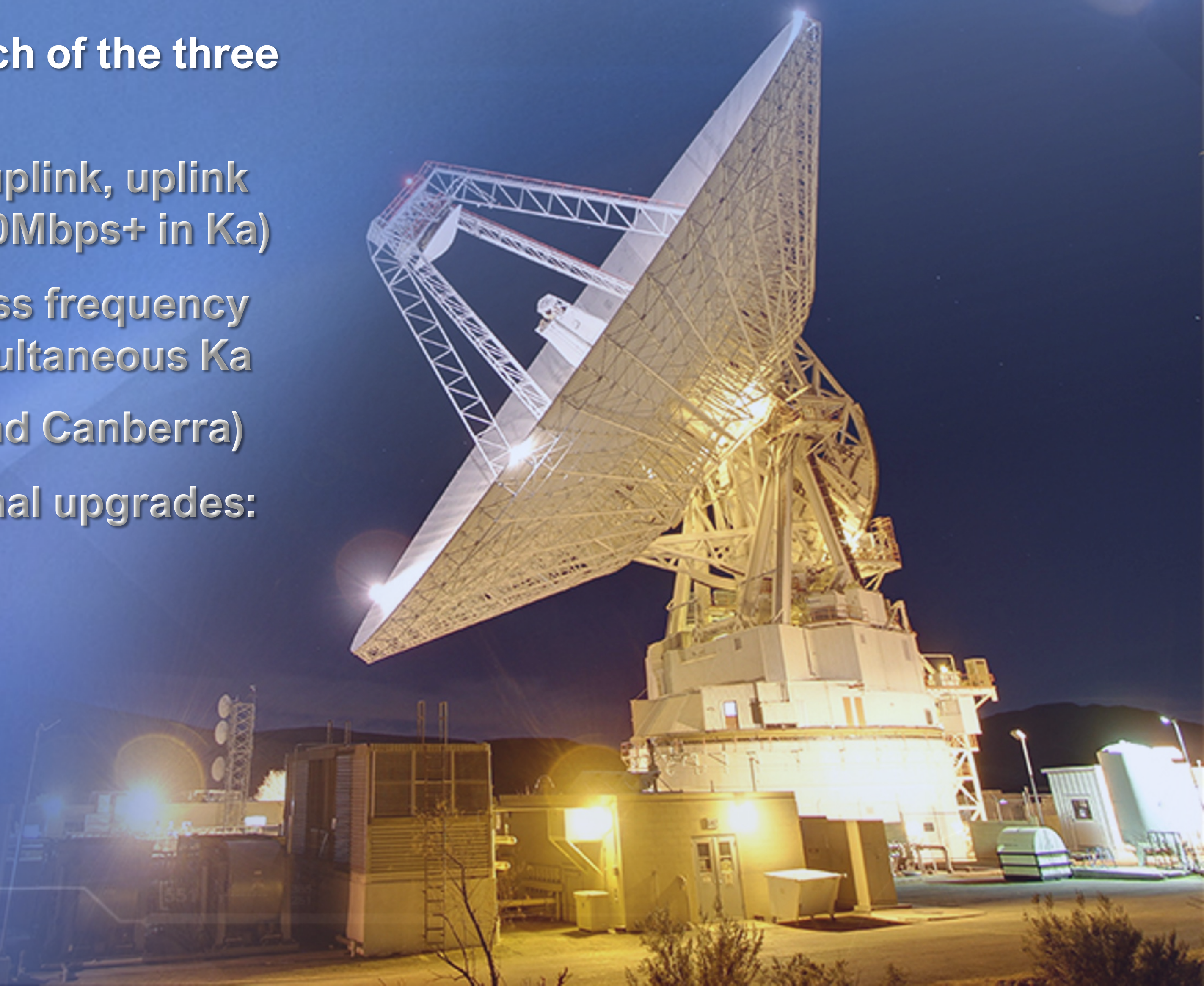
Adds capability for near-earth K-band uplink, uplink encoding, and increased data rates (100Mbps+ in Ka)

Provides simultaneous operations across frequency bands – S+Ka-band, X+Ka-band, or simultaneous Ka

Two upgrades completed (Goldstone and Canberra)

Estimated completion dates for additional upgrades:

- ☐ Goldstone: December 2023
- ☐ Canberra: July 2024
- ☐ Spain (DSS-56): April 2025
- ☐ Spain (DSS-54): March 2028



Lunar Exploration Ground Segment (LEGS)

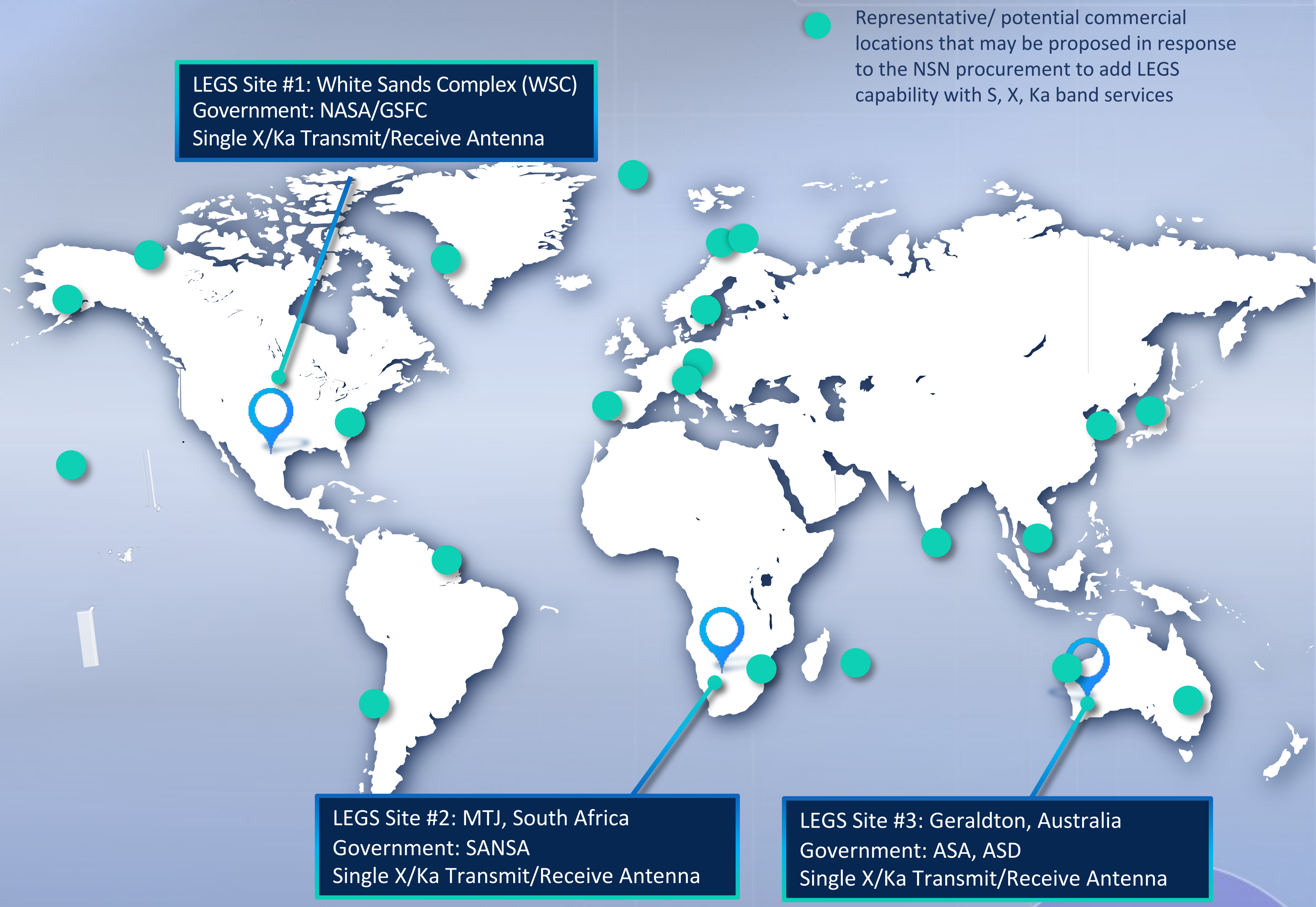
LEGS is a new network of DTE antennas that reduce contention for DSN by absorbing new Artemis demands

LEGS 1 to 3:

- ☐ Cover three geographically diverse sites, offering continuous lunar coverage
- ☐ 18-meter class performance in X and Ka
- ☐ Government-owned / contractor operated

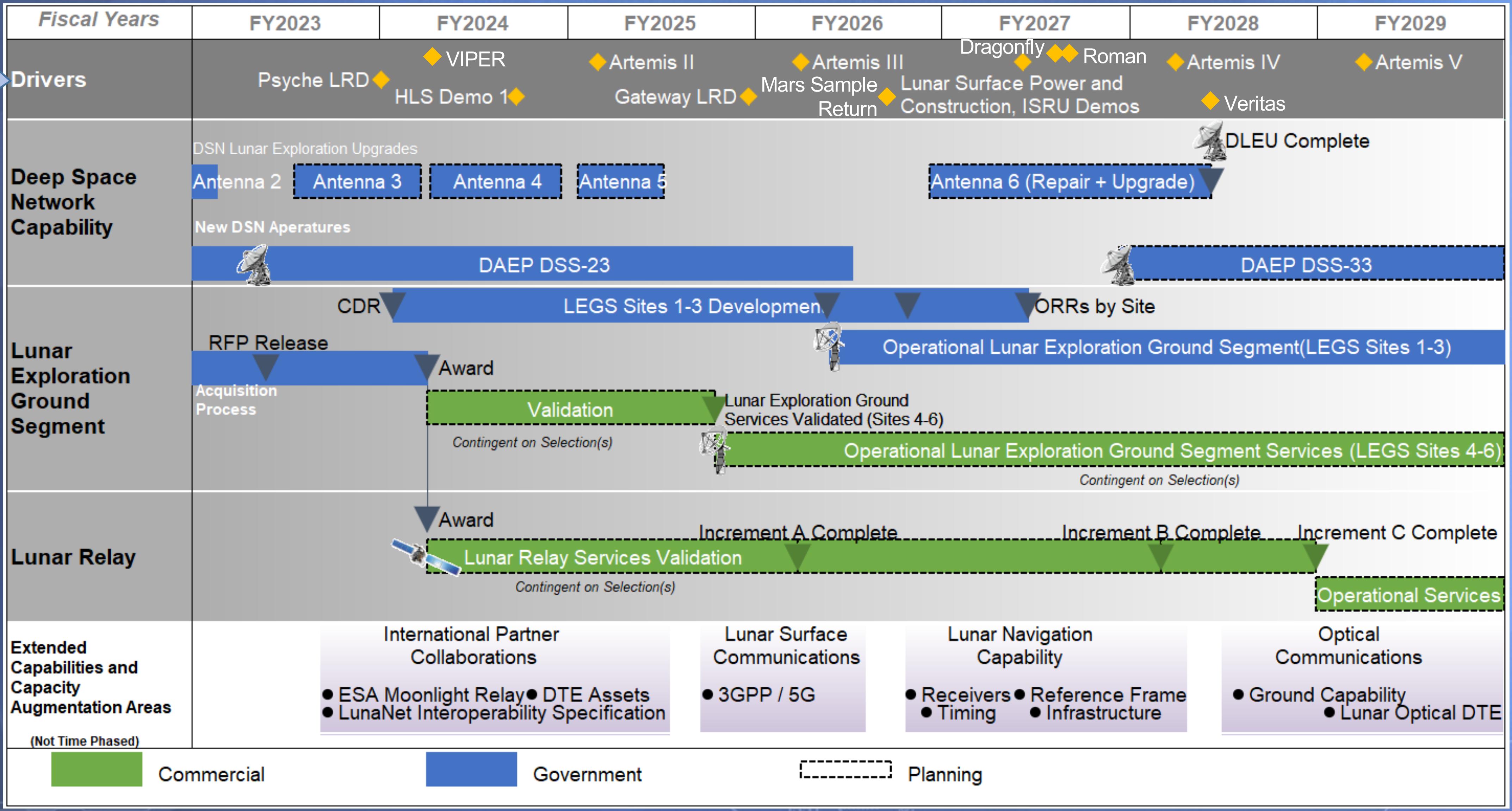
LEGS 4+:

- ☐ Locations TBD
- ☐ 18-meter class performance in X, Ka **and S**
- ☐ Being pursued under full commercial services procurement



Orchestration of Supply

Examples only… critical event list is significant



O&M and sustainment must be orchestrated around mission demands and capability variance is 1:1 with funding variance

DSN Futures Study

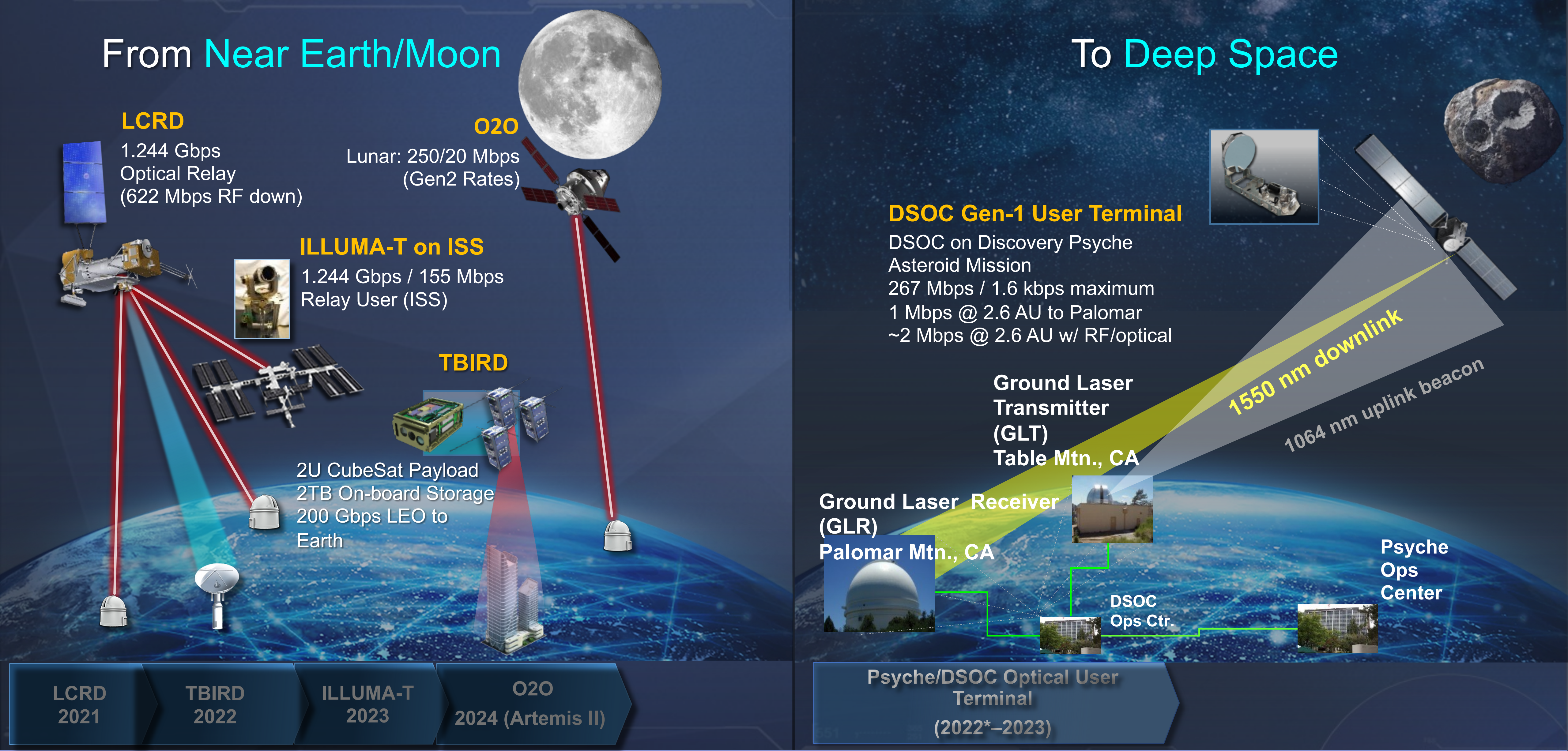
DSN Futures Study objectives:

- Look at near-term issues (network scheduling efficiency, network and element brittleness, and fragility), and projected capability needs though 2050
- Understand what probable technology will be available, when it could be infused into the DSN, and the required costs

Incorporating SMD (Decadals) and ESDMD (Lunar and Mars architectures) as long-term planning inputs

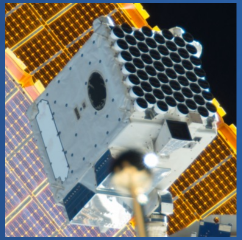
Study Team members include NASA stakeholders from ESDMD, SMD, and SOMD that are asked to review study progress on a quarterly basis

Optical Communications Technology Demonstrations



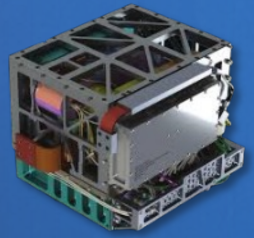
SCaN Technology Investments Driven by Mission Needs

Galactic Positioning System: XNAV



- Autonomous navigation and timing via X-ray emitting Millisecond Pulsars (XNAV)
- Enables long-duration independent operations and reduces Earth-based tracking
- Autonomous navigation and timing anywhere in the Solar System and beyond

Deep Space Atomic Clock



- Advanced prototype mercury-ion (Hg+) atomic clock (TRL 7) demonstrated in space
- Enables next gen space navigation, radio science, and navigation autonomy
- 50x better long-term stability than GPS clocks
- Reduces DSN tracking burden

Lunar Surface 3GPP

- Build on Nokia 4G lunar demo tipping point award
- Leverage existing 3GPP/5G commercial standards to accelerate deployment of lunar surface capabilities

Lunar Weak-Signal GNSS: NavCube3 Mini

- Leverage always-on, Earth-based radiometric navigation and timing signals in cislunar space and at the Moon
- Reduces DSN tracking burden
- Enables autonomous PNT
- Small-sat form factor

SCaN is reviewing technology investments; priorities are being identified based on customer needs

Synopsis: New Challenges and New Opportunities

Use of Commercial Vendors for Communication and Navigation Services

- Success in commercialization of DTE services since the 1990s provides roadmap
- Phasing out of TDRS services over the coming decades provides opportunities for commercial LEO, MEO, GEO relay services
- Through lunar relay service procurements and18m class DTE LEGS, commercial providers can also support lunar activities

Human Spaceflight Beyond LEO:

- Growing DSN demand is putting flagship SMD and SOMD missions at risk
- Investment in reliability, robustness, and capacity will be necessary to secure DSN's future
- LEGS government and commercial investments can also offload some Artemis and CLPS requirements from DSN, alongside international partnerships
- Lunar relay is necessary to send crewed missions to the South Pole region

Technology Infusion of Optical Communication

- Current demonstrations cover LEO DTE, LEO/GEO relay, Lunar and Deep Space, applications
- Future optical infrastructure investments will require commitment by Human Spaceflight and Science Missions

Future Technology Investments

- Focus on establishing user driven technology investments and priorities

Closing: New Challenges and New Opportunities

Use of Commercial Communication and Navigation Services

- ☐ Success in commercialization of DTE services since the 1990s provides roadmap
- ☐ Phasing out of TDRS services over the coming decades provides opportunities for diverse commercial offerings
- ☐ Commercial providers can also support lunar activities

Human Spaceflight Beyond LEO:

- ☐ Growing DSN demand is putting flagship SMD and SOMD missions at risk
- ☐ Investment in reliability, robustness, and capacity will be necessary to secure DSN’s future
- ☐ LEGS investments, along with international partnerships, can offload some of the demand
- ☐ Lunar relay is necessary to send crewed missions to the South Pole region

Technology Infusion

- ☐ Current optical demonstrations cover LEO DTE, LEO/GEO relay, Lunar and Deep Space, applications
- ☐ Future optical infrastructure investments will require commitment by Human Spaceflight and Science Missions
- ☐ Technology efforts in general will focus on establishing user driven investments and priorities

SCaN

Space Communications and Navigation

Exploration, enabled.

National Aeronautics and Space Administration

Ms. Susan Chang

Acting Assistant Deputy Associate Administrator
Space Communications and Navigation (SCaN) Office

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