National Aeronautics and Space Administration

Deep Space Network Updates

SCaN Space Communications and Navigation

Exploration, enabled.

Presented to:
Planetary Sciences Advisory Committee
Presented by:
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Discipline Scientist, Science Mission Directorate
On Detail to the Space Communications and Navigation (SCaN) organization
Space Operations Mission Directorate
National Aeronautics and Space Administration

November 14, 2023

Outline

1. About SCaN
2. DSN Status, Challenges, and Plans

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

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

Canberra

Goldstone

Madrid

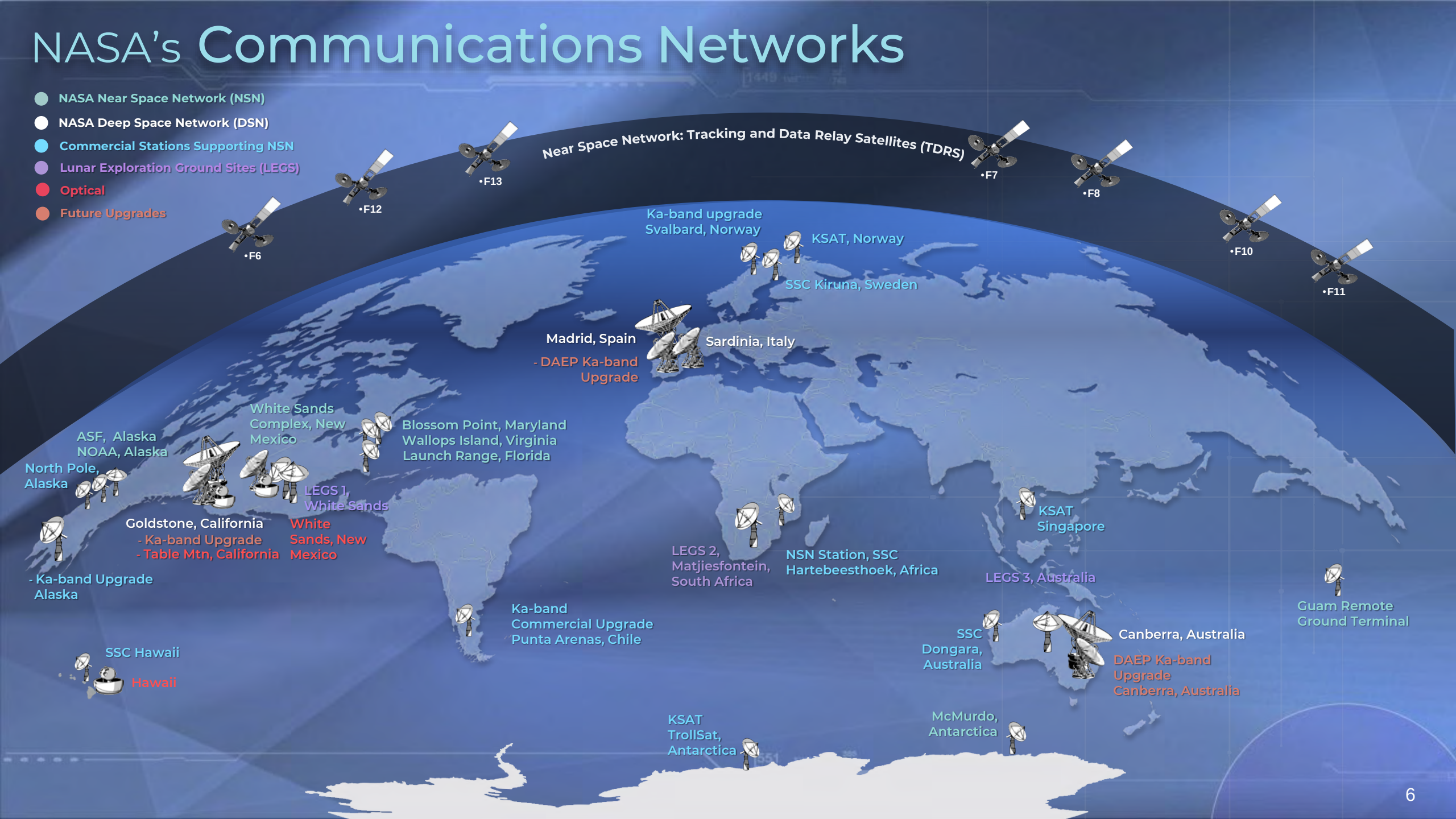
Deep Space Communications are Key to Agency Priorities

DSN Mission Dashboard October 2023 (*Updated Monthly -- Contact S. Asmar*)

#	Completed Since 2019	Current 20+22 = 42 Deep Space	Current 20+22 = 42 Cis-Lunar, Lagrange, ...	Future 15+26 = 41 Deep Space	Future 15+26 = 41 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)

ARTEMIS

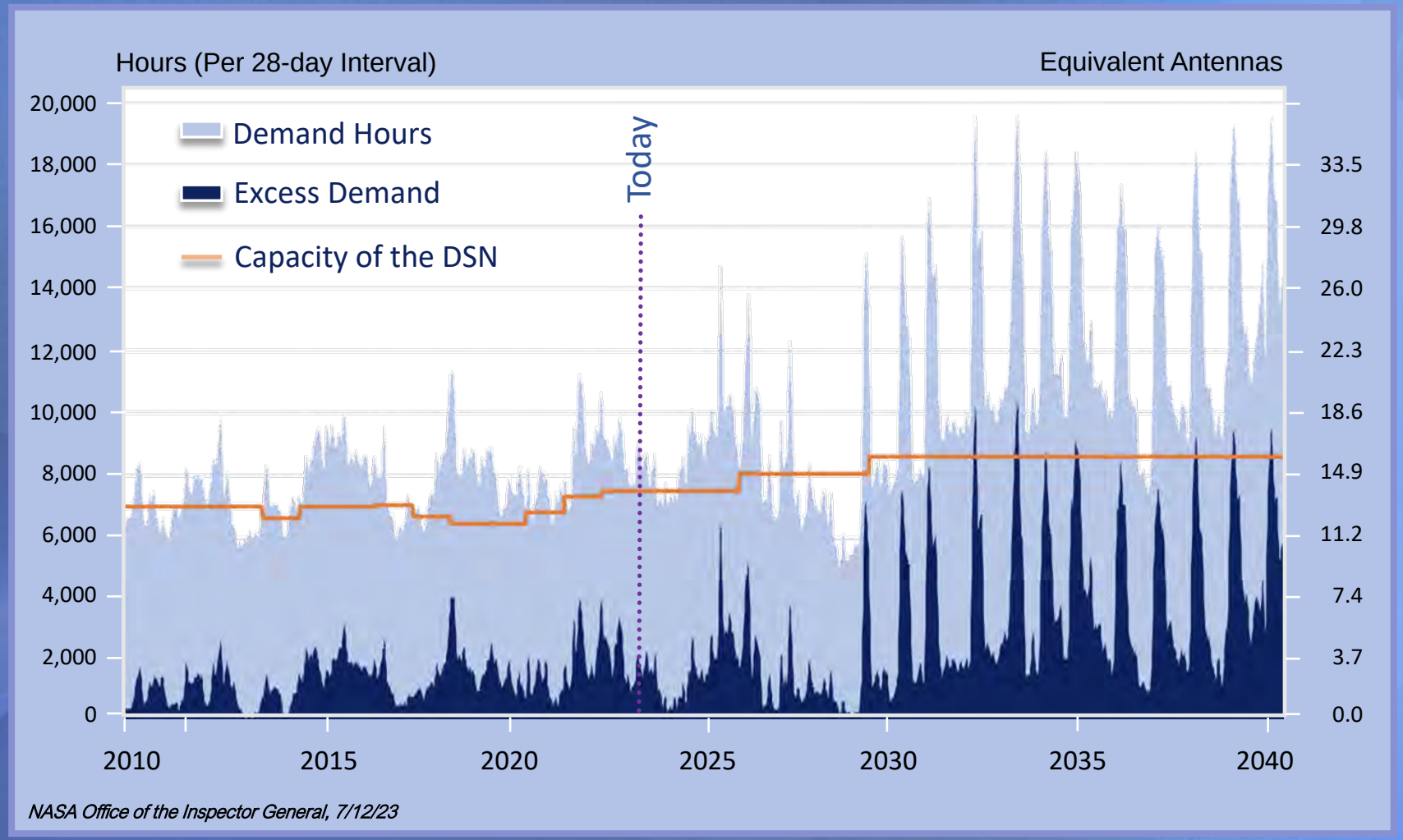
NASA's Communications Networks



The DSN Challenge: Rapidly Growing User Needs

Cadence and complexity of cis-lunar and SMD missions are creating a new level of network demand not seen in decades

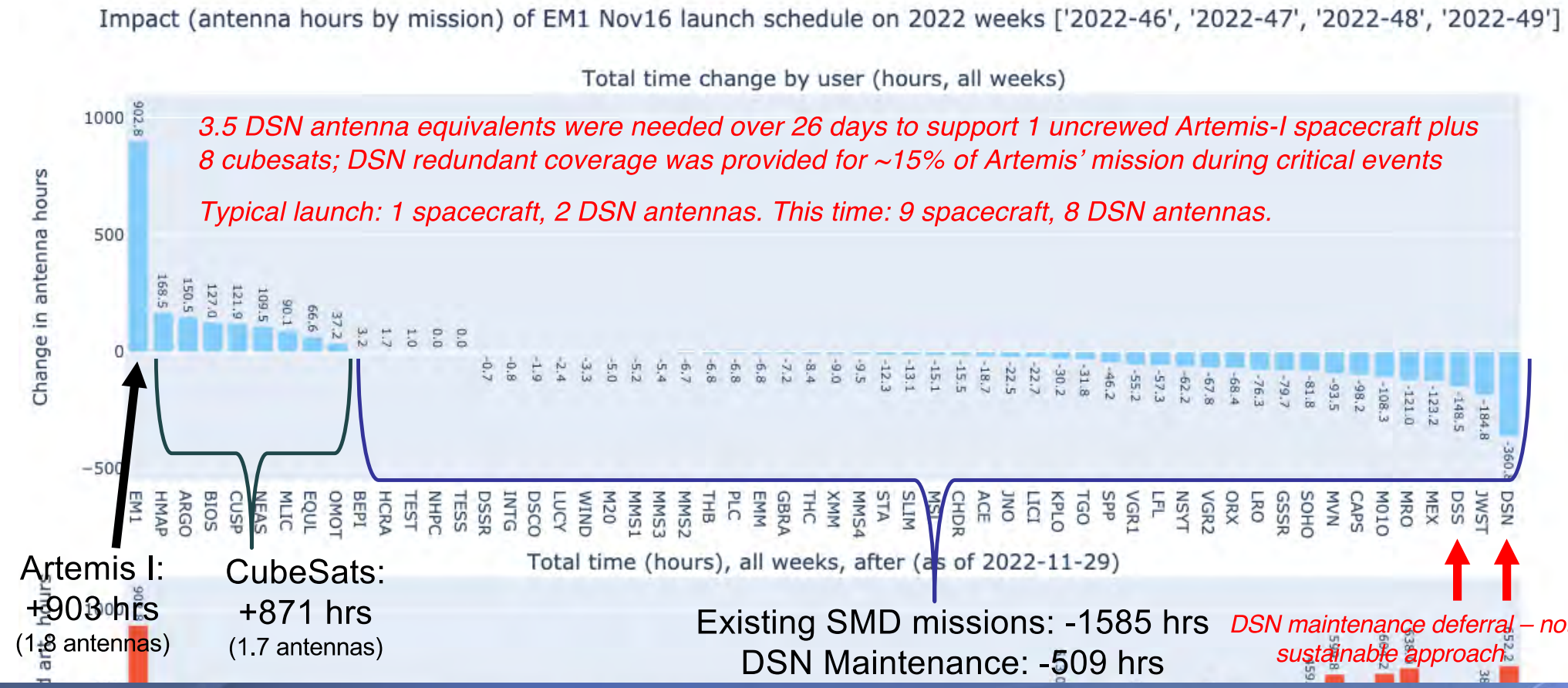
- New technologies to achieve Decadal Survey priorities are ever more data hungry
- JWST alone uses 10% of DSN capacity; sending back 25x the data of Hubble
- Infrastructure support has not kept up



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

DSN Challenge: Demand Spikes During Artemis

Artemis-I + Deep Space CubeSat Support: DSN Impacts



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How SCaN Plans to Support 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)

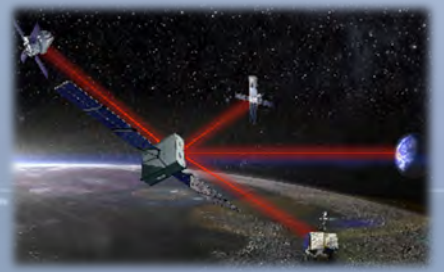
2

- 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 LEGS will add additional capacity as demand grows

Commercial and International Partners

3

- Further drawing upon commercial service procurement to devlelop lunar relays to reduce user PNT burden and remove DTE line-of-sight constraints (enabling South Pole and Far-Side operations)
- Seeking additional commercial and international contributions for both Earth based and Lunar C&N assets

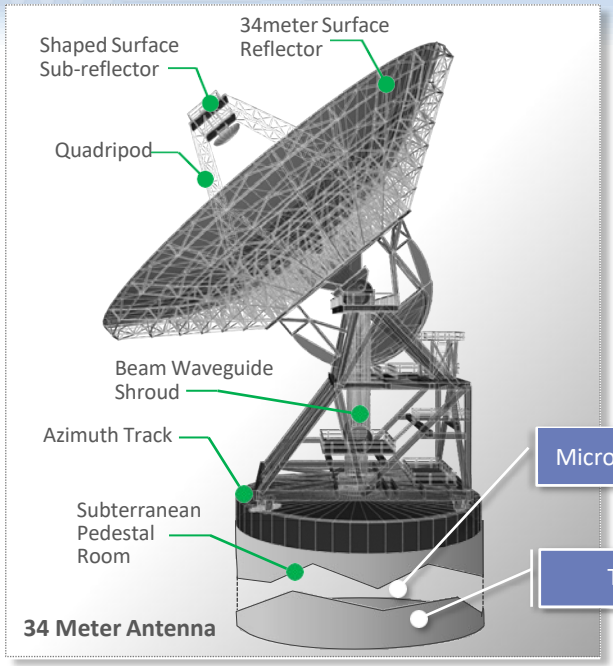


Optical and other New Technologies

4

- Optical will reduce burden on DSN alongside other technologies
- 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

DSN Upgrades: The Road to Green (R2G)



R2G examined DSN's state of health starting in 2020

R2G determined concreate steps to improve network reliability and robustness

Microwave Controller

Transmitter

Holography

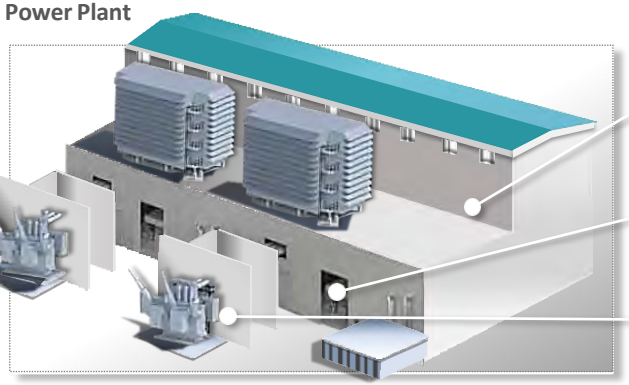
Antenna Spares

Water main and sewers

Fire Suppression

Underground fuel and oil tank (move to above ground)

Power Plant



Generators

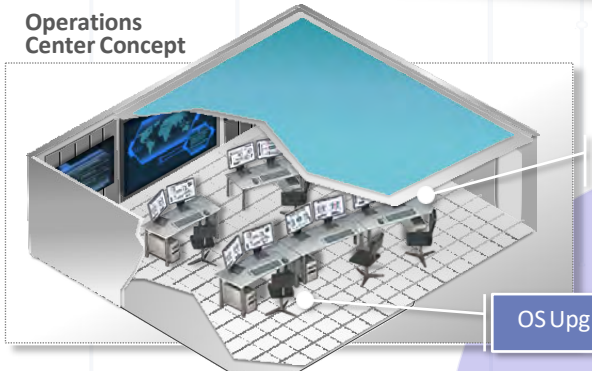
Uninterruptible Power Supply

Transformers and Switchgear

Funds prioritized to address:

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

Operations Center Concept

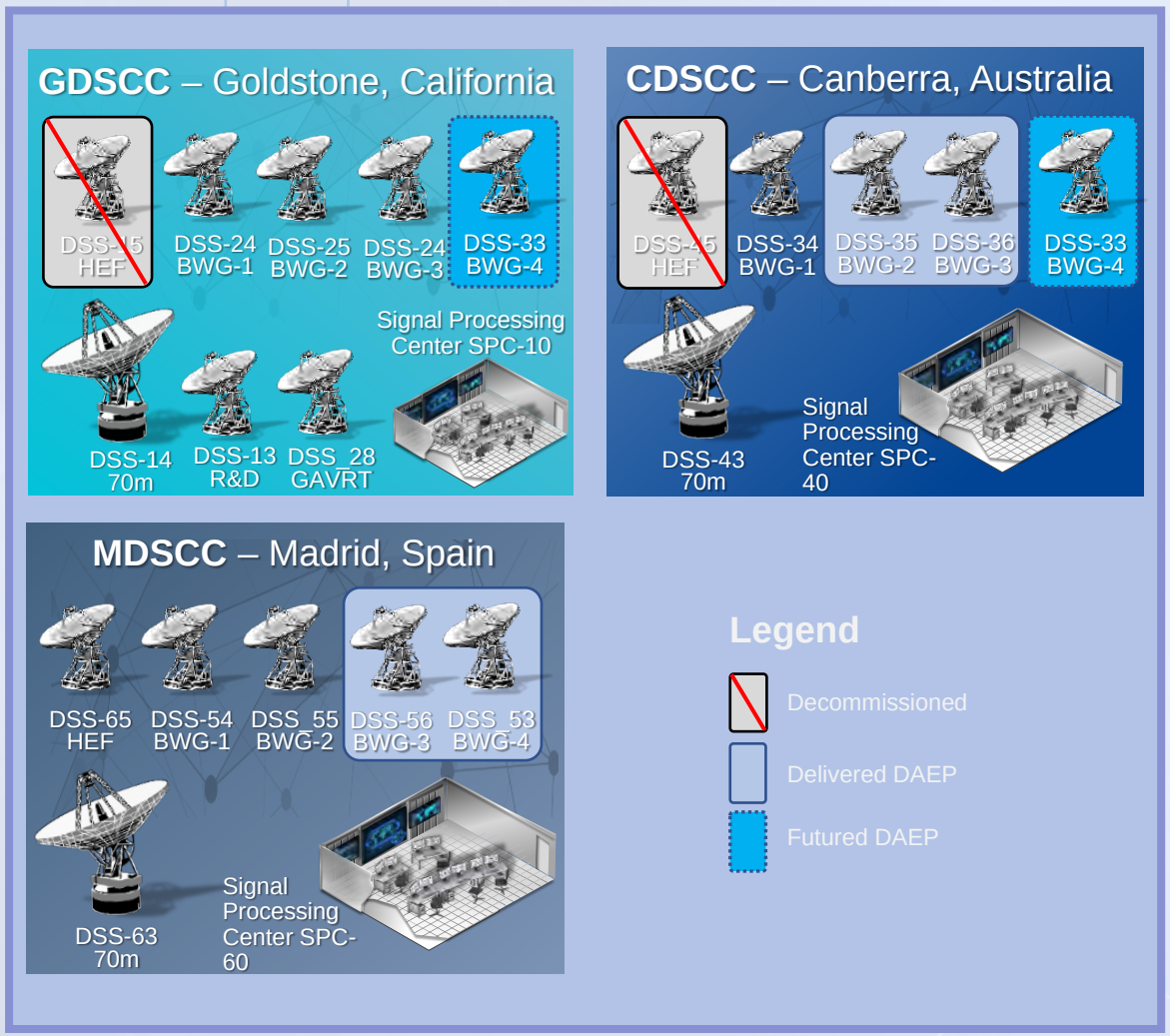


General Cyber Security

OS Upg rades

DSN Upgrades: 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,* 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 Upgrades: 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)

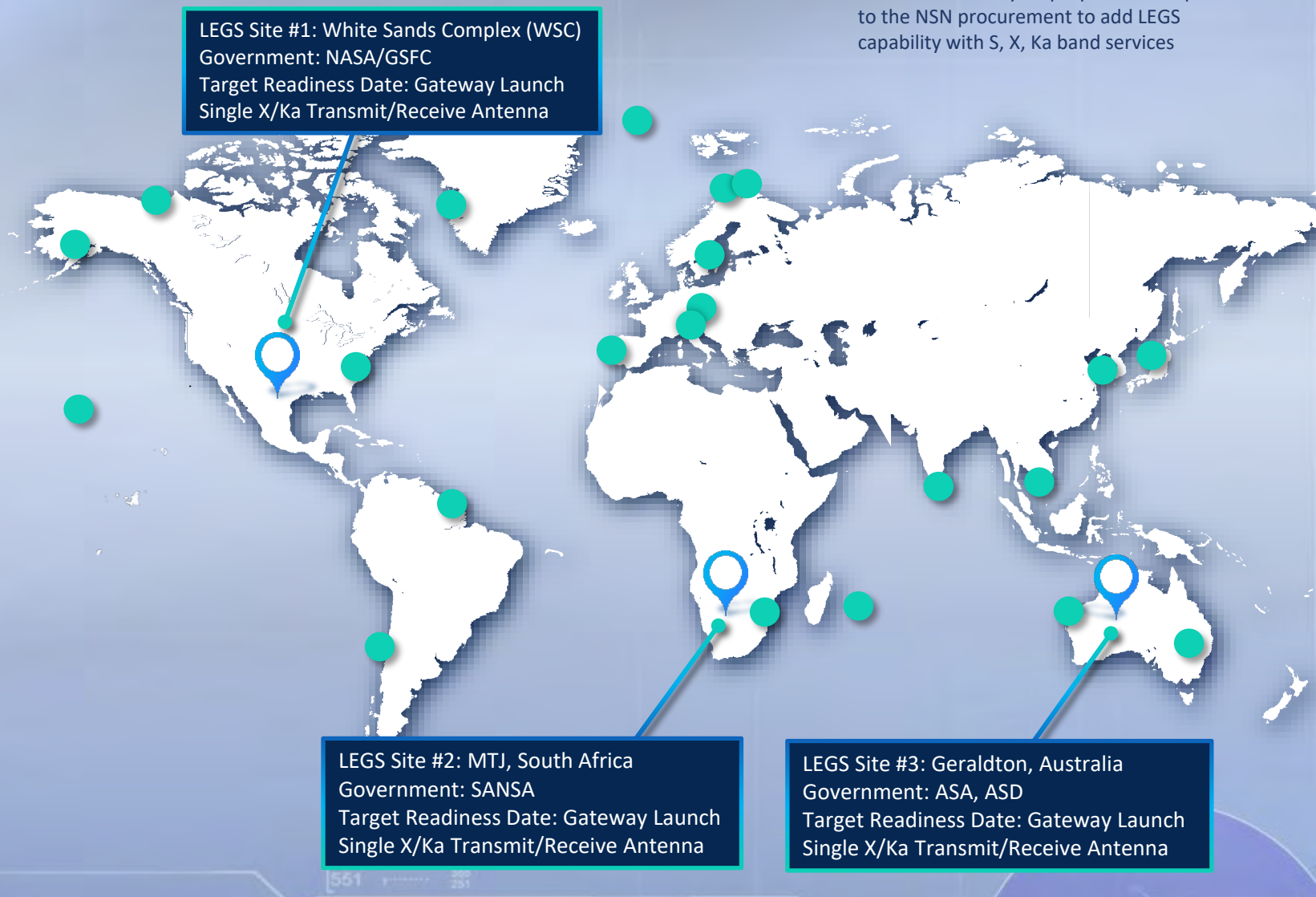
LEGS is a new network of DTE antennas that reduce contention for DSN by absorbing new Artemis demands

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



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

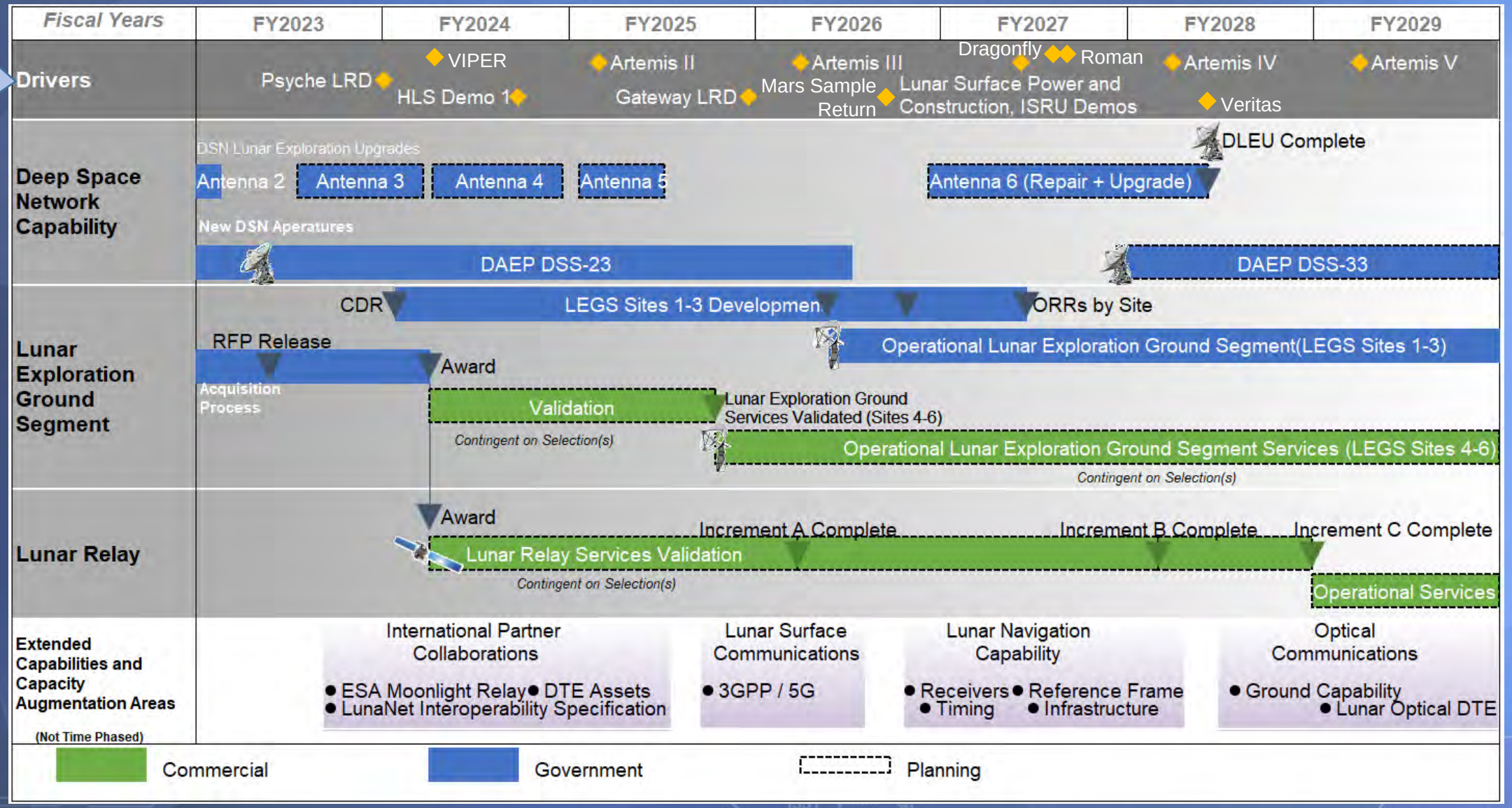
Incorporating SMD (Decadals) and ESDMD (Lunar and Mars architectures) as long-term planning inputs

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

Plan is to bring the final report to this board for review

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

Synopsis: The Future of SCaN

New Challenges and New Opportunities

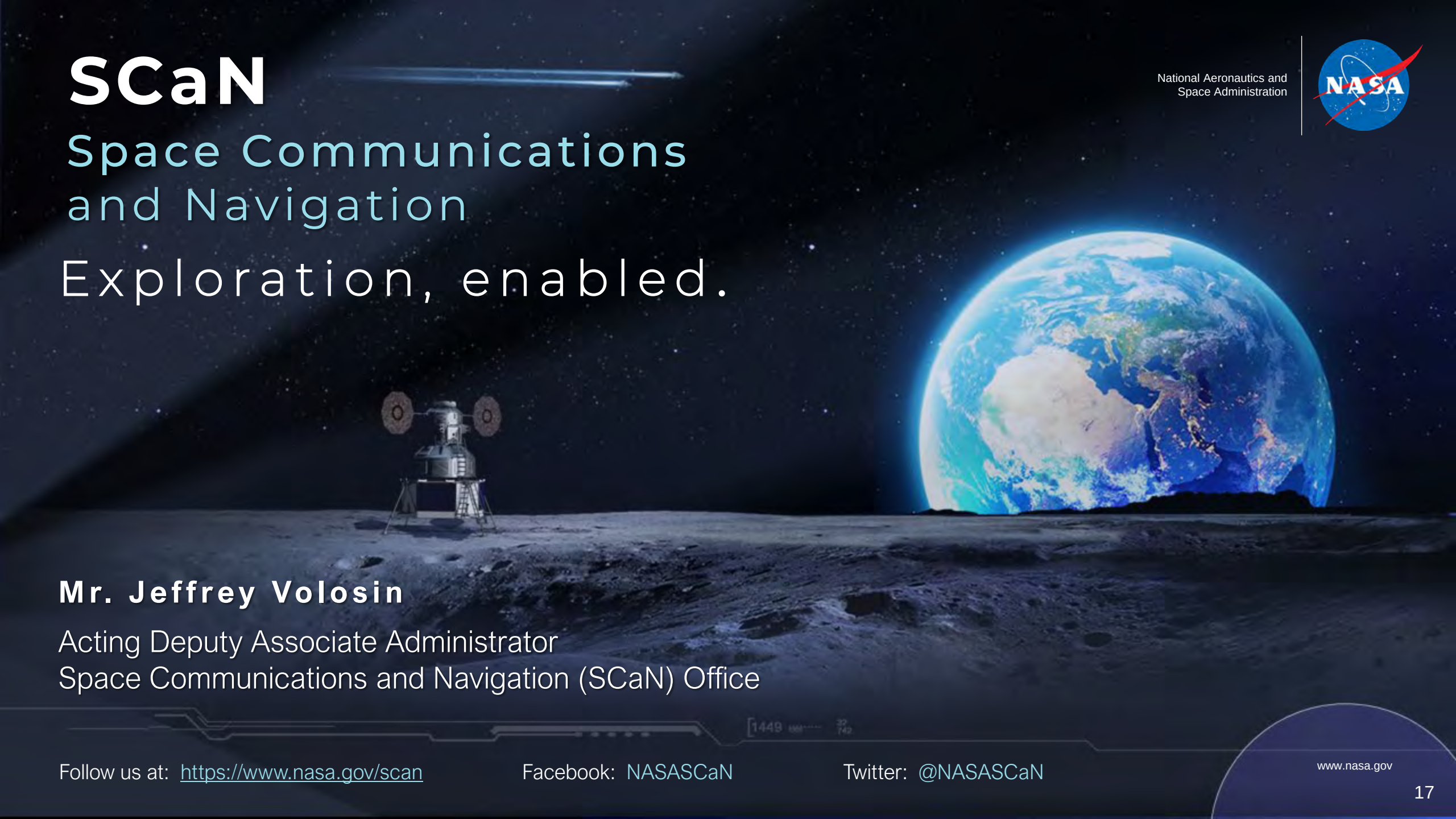
- Growing DSN demand is putting flagship SMD and SOMD missions at risk
- Investment in reliability, robustness, and capacity will be necessary to secure DSN's future
- LEGS government and commercial investments can also offload some Artemis and CLPS requirements from DSN, alongside international partnerships

SCaN

Space Communications and Navigation

Exploration, enabled.

National Aeronautics and Space Administration



Mr. Jeffrey Volosin

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