

DSN Status and Implications

The Mars Exploration Program Analysis Group

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DPM and ADAA
Space Communications and Navigation (SCaN)

05 01 2025

Science and Exploration Enabled



SCaN is the essential connection to our human explorers, our science missions, and our partners.

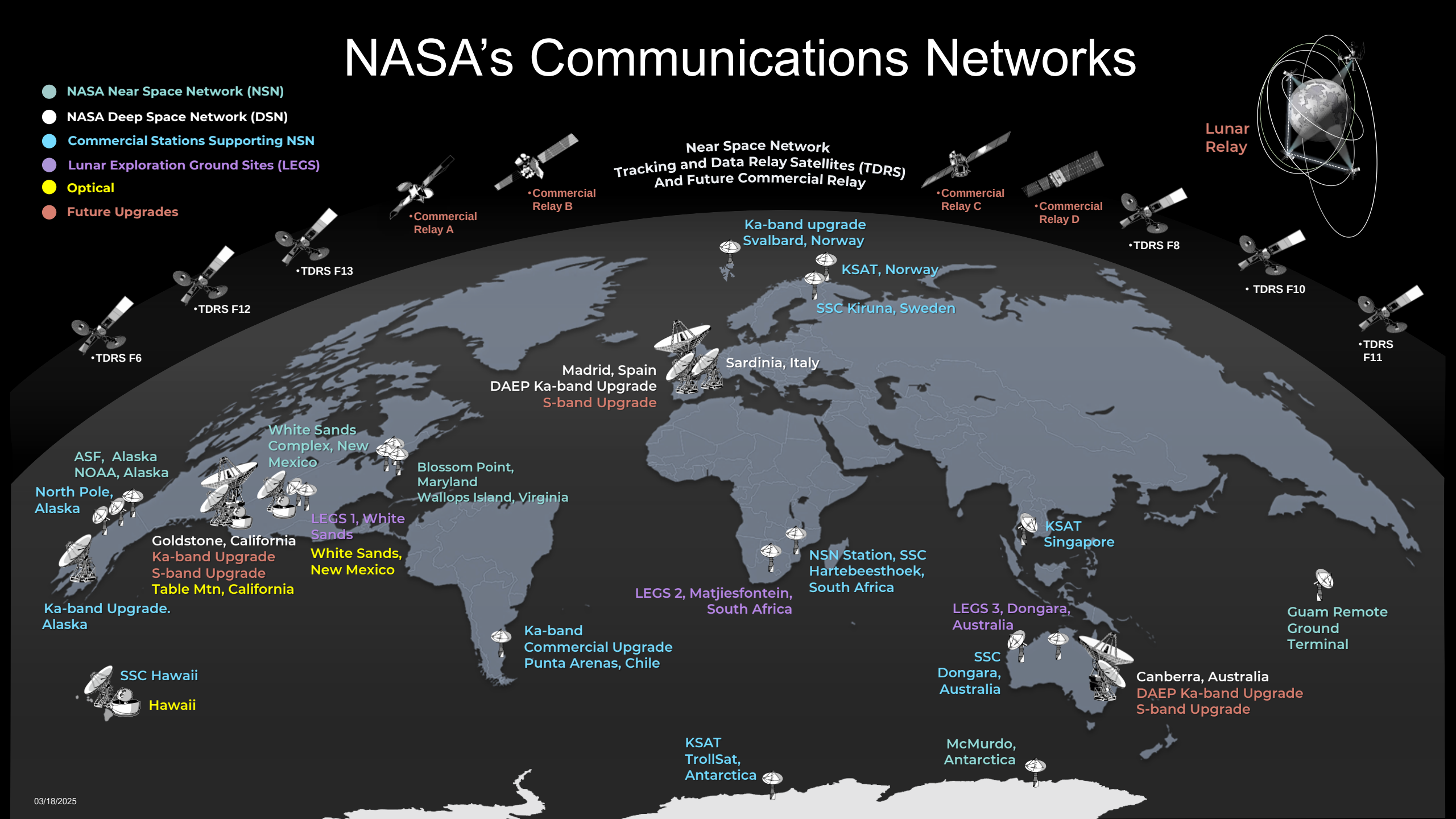
Space Communications and Navigation (SCaN)

- Serves as the enterprise responsible for all NASA's space communications activities
- 24/7 Global Near Earth and Deep Space Communications and Navigation Services
- 100+ Missions currently enabled by SCaN

Focal Points for Change: Strategic Evolution

- **Engage** as one team, one mission, one network
- **Execute** with sound technical and programmatic fundamentals
- **Evolve** the network to satisfy mission customer needs of the future
- **Empower** our science and exploration partners

NASA's Communications Networks



SCaN's Deep Space Network (DSN) is our Connection to Mars

DSN'S ROLE AND STRUCTURE

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

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

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

4. On behalf of SCaN, the NASA Jet Propulsion Laboratory (JPL) develops, operates, and manages DSN

COMPLEXES







Deep Space Communications are Key to Agency Priorities

DSN Mission Dashboard May 2024			(Updated Monthly -- Contact S. Asmar)	
Completed Since 2019	Current = 40 Deep Space	Cis-Lunar, Lagrange, ..	Future = 42 Deep Space	Cis-Lunar, Lagrange, ...
InSight *Mars*	Juno *Jupiter*	Lunar Recon. Orb. *Lunar*	2024 or 2025	2024 or 2025
Mars Cube One	Lucy *Asteroids*	SOHO *Helio L1 NASA-ESA*	Europa Clipper *Jupiter*	SunRISE *cluster 1*
DART *Asteroid*	Perseverance *Mars*	ACE *Helio L1*	ESCAPADE Blue *Mars*	SunRISE *cluster 2*
LICIA (ASI) *DART Cube*	Mars Odyssey Mars	Wind *Helio L1*	ESCAPADE Gold *Mars*	GOES U
GOES T	Mars Recon. Orbiter *Mars*	MMS 1 *Earth Ellip. Orb.*	HERA (ESA) *Asteroid*	SWFO *L1*
Geotail	MAVEN *Mars*	MMS 2 *Earth Ellip. Orb.*	Rocket Lab Venus	IMAP *L1*
Artemis 1 *Lunar*	Curiosity *Mars*	MMS 3 *Earth Ellip. Orb.*	AstroForge Odin *emergency*	Carruthers *L1*
NEA Scout *Cube*	New Horizons	MMS 4 *Earth Ellip. Orb.*	2026 or later	Astrobotic Griffin *Lunar*
CuSP Cube	OSIRIS-REx (APEX)	Themis B *Helio L1*	Sample Return Lander	Lunar Trail Blazer
LunaHMAP *Cube*	Parker Solar Probe	Themis C *Helio L2*	Earth Return Orb. (ESA)	VIPER *Lunar*
Lunar Ice Cube	Voyager 1 *Helio*	DSCOVR *L1*	Rosalind Franklin (ESA)	Artemis-2 Orion
Team Miles *Cube*	Voyager 2 *Helio*	Chandra *HEO*	EnVision (ESA) *Venus*	Oracle-P Air Force *L1*
ArgoMoon (ASI) *Cube*	STEREO A *Helio*	JWST *L2*	DESTINY+ (JAXA) *Aster.*	Blue Orig Mark-1 SN-1
Omotenashi (JAXA) *Cube*	Akatsuki (JAXA) *Venus*	TESS *Earth Ellip. Orb.*	MMX (JAXA) *Mars*	Blue Orig Mark-1 SN-2
Equuleus (JAXA) *Cube*	Hayabusa-2E (JAXA)	CAPSTONE *Cube*	Emirates Asteroid (UAE)	2026 or later
INTEGRAL (ESA)	BepiColombo (ESA)	TDRS 6-13 *emergency*	JUICE *Jupiter* (ESA)	Exploration Upper Stage
Hayabusa-2 (JAXA)	Trace Gas Orb. (ESA)	Biosentinel *Cube*	VERITAS *Venus*	Gateway *Lunar*
Beresheet (Israel) *Lunar*	Mars Express (ESA)	XMM (ESA) *Ellip. Orb.*	DAVINCI+ *Venus*	Human Landing Sys 1
Mars Orbiter (ISRO)	Emirates Mars (UAE)	Gaia (ESA) *L2*	Dragonfly *Titan*	Human Landing Sys 2
Chandrayaan 2 Land (ISRO)	Psyche *Asteroid*	KPLO (KARI) *Lunar*		Human Landing Sys 3
Chandrayaan 2 Orb (ISRO)				Lunar Terrain Vehicles
Chandrayaan 3 Land (ISRO)				Beresheet-2 (Israel)
Lunar Flash Light *Cube*				Roman Telescope *L2*
SLIM & LEV (JAXA) Lunar				NEO Surveyor *L1*
Astrobotic Peregrine				Artemis-3 Orion
Lunar Node-1 CLPS				HelioSwarm
Intuitive Machines 1				LUPEX (JAXA/ISRO)

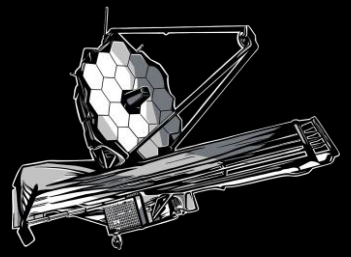
USER COMMUNITIES



DSN Demand is Rising

High-demand missions are already impacting the DSN

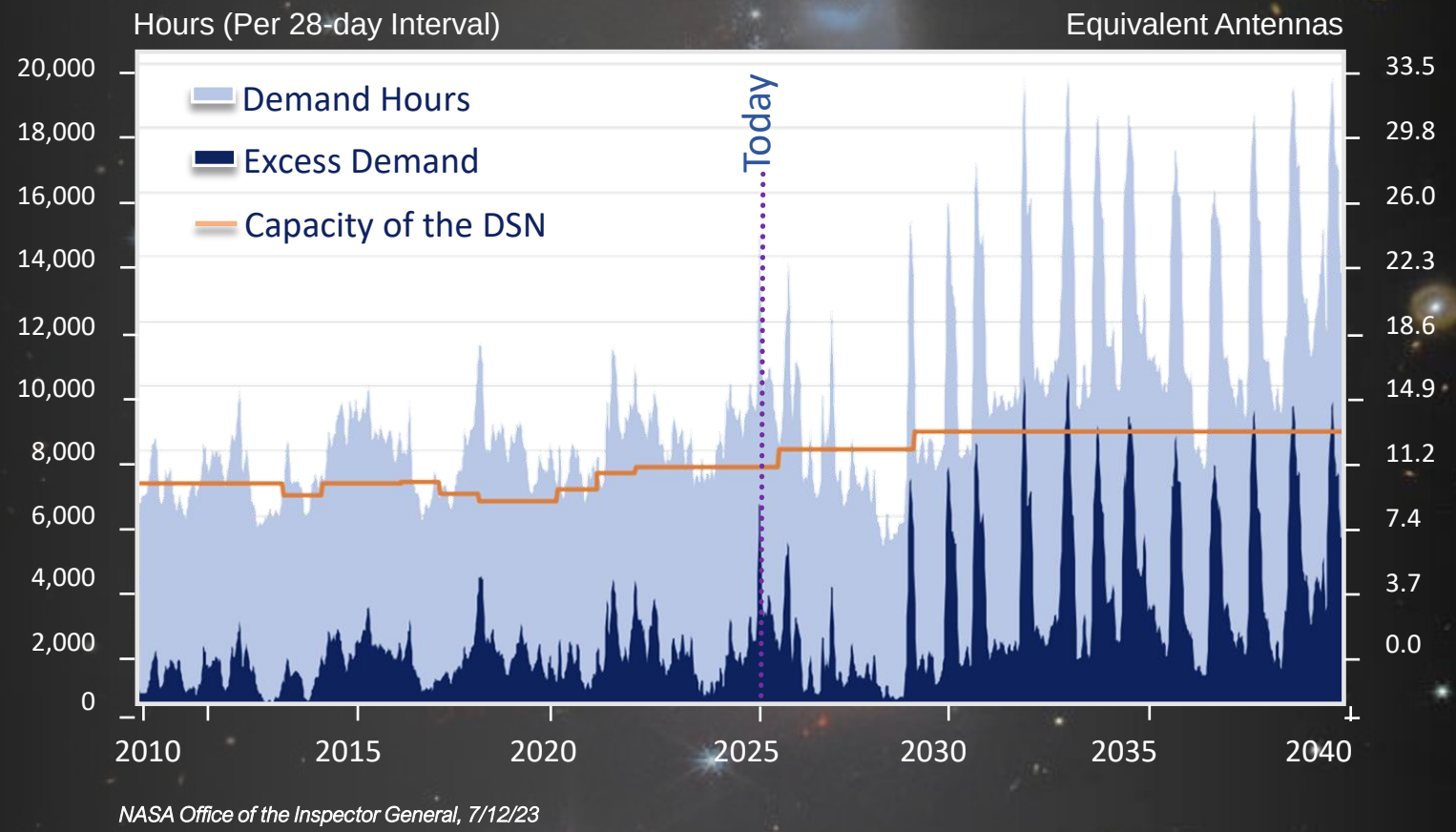
- Each Artemis launch leads to a major demand spike; these challenges grow with later missions
- Infrastructure support has not kept up
- New antenna builds to be completed by 2030 will alleviate some load



JWST

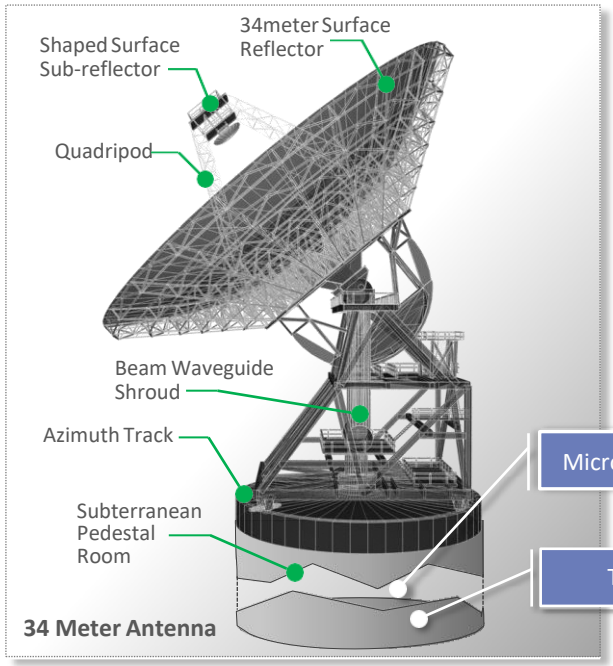


SLS



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

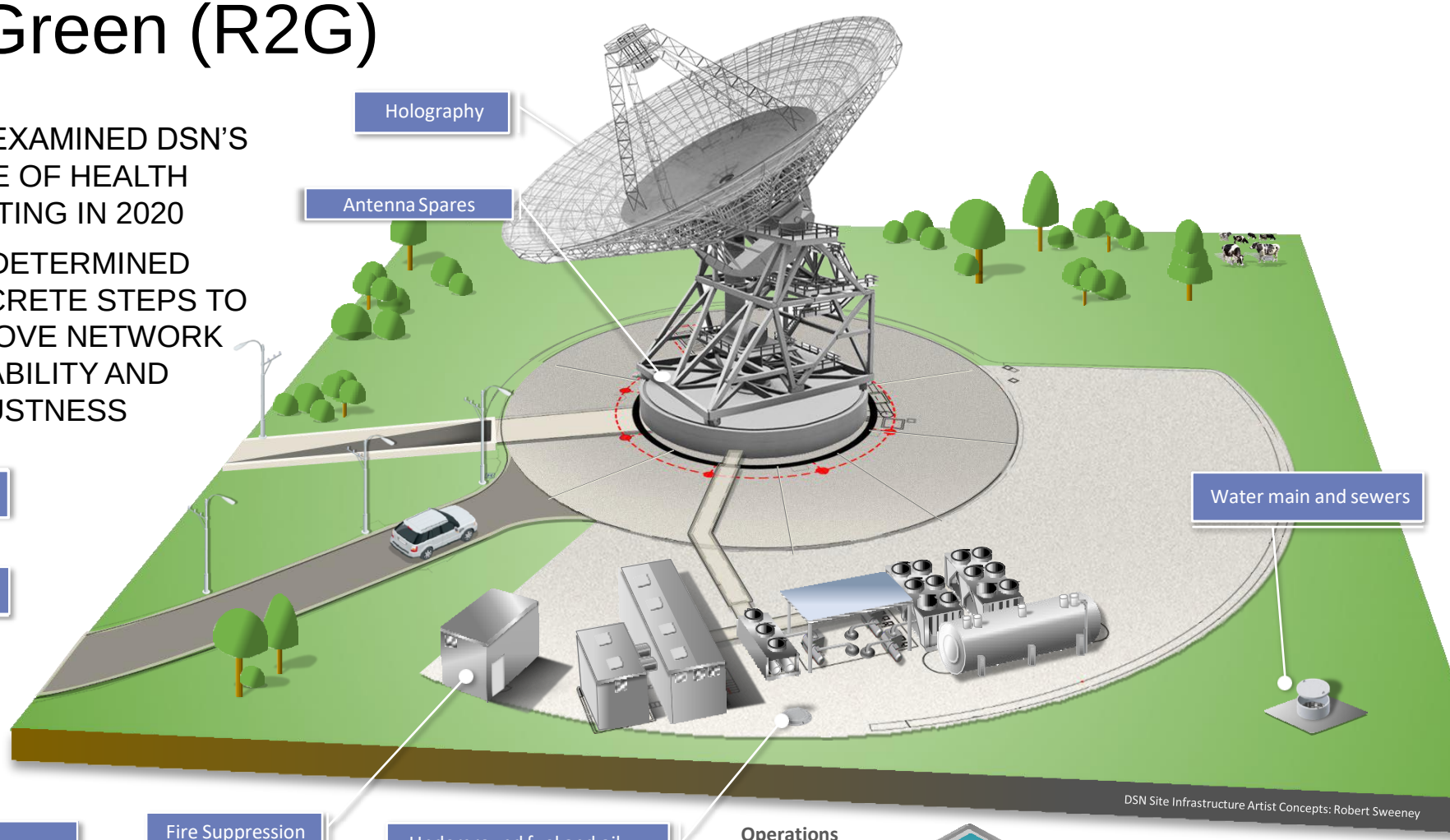
DSN: The Road to Green (R2G)



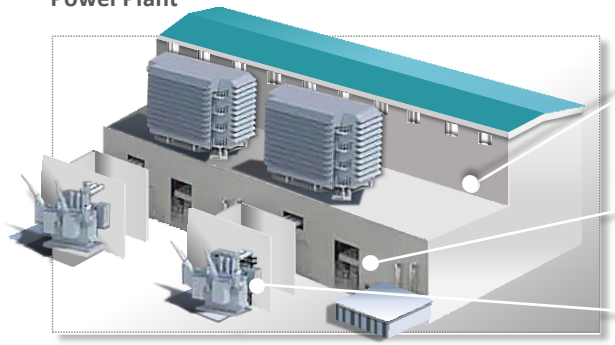
- R2G EXAMINED DSN'S STATE OF HEALTH STARTING IN 2020
- R2G DETERMINED CONCRETE STEPS TO IMPROVE NETWORK RELIABILITY AND ROBUSTNESS

Microwave Controller

Transmitter



Power Plant

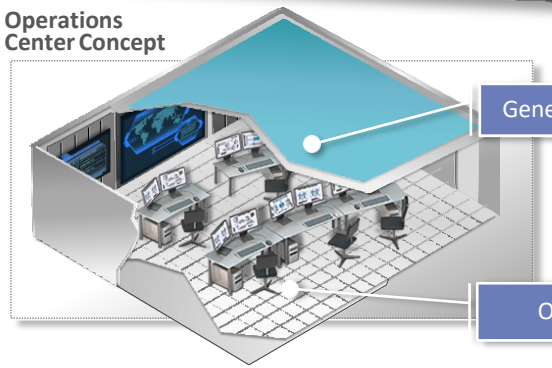


Generators

Uninterruptible Power Supply

Transformers and Switchgear

Operations Center Concept



General Cyber Security

OS Upgrades

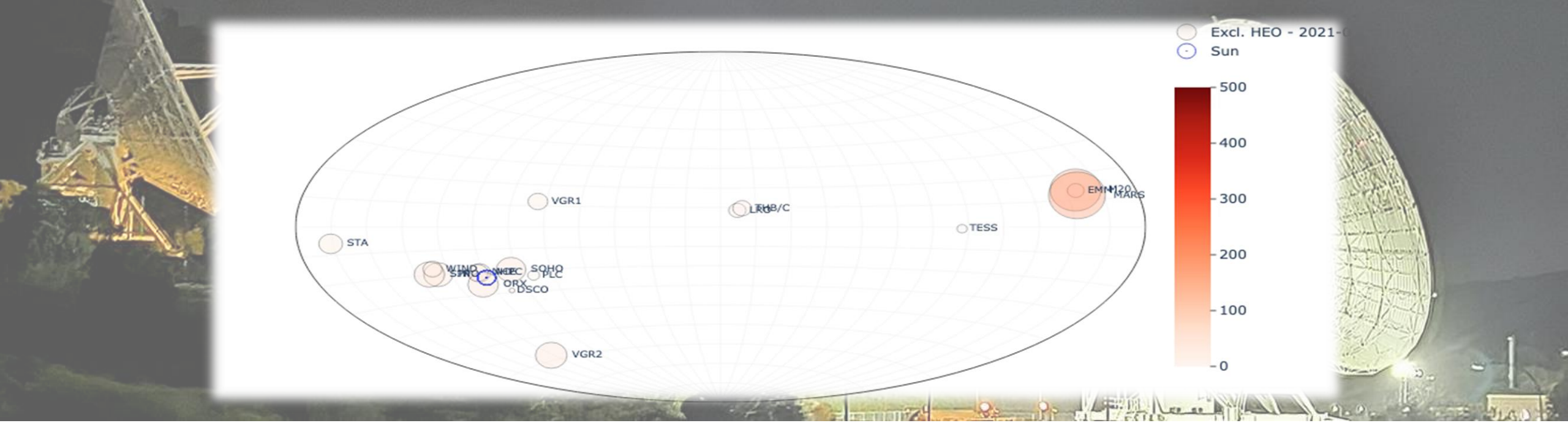
Sustainment and Maintenance: R2G and Beyond

- Funds are prioritized to address critical personnel safety issues first, e.g., fire detection and protection, asbestos abatement, fall protection
- DSN is also upgrading a pedestal for 34m Beam Wave Guide (BWG) antenna DSS-54 in Madrid
- Ongoing updates and subsequent planned replacement of Private Cloud Appliances (PCAs) – will reduce operational risk. (PCA failure was the cause of DSN site wide outage during Artemis I)
- Efforts are ongoing across other key areas:
  - IT security
  - Facility infrastructure
  - Vulnerable antenna components
- Full scope of work is at risk without full budgetary support

RECENTLY COMPLETED

R2G Work

1. Updated 57% of the backlogged operating systems with latest security updates
2. Replaced Goldstone Battery Backup “SWUPS”
3. Procured key long-lead items, including 70 m transmitter hardware and amplifier spares
4. Improved 34m antenna Ka-band efficiency by 52% through holography techniques



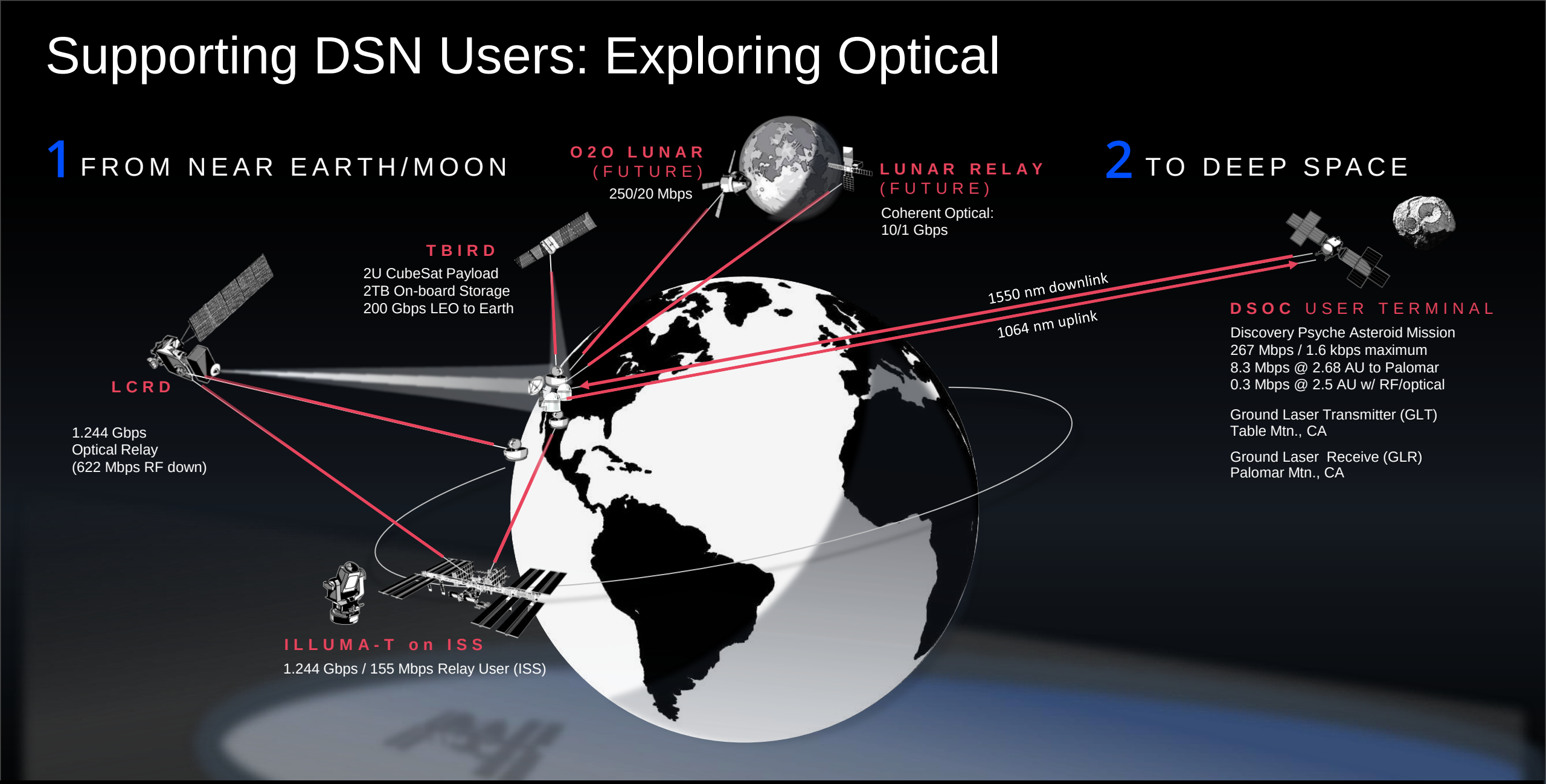
Supporting DSN Users: Scheduling and Prioritization

Applying lessons learned from JWST and Artemis 1 scheduling and prioritization techniques will also be key to SCaN's future approaches in support of planetary missions.

- A Multi-directorate working group has been formed to consider a new framework for DSN prioritization and scheduling
- Process improvements will include speeding up software, automation, collection of user preferences, and further definition of actions during spacecraft emergencies
- Evaluating the distributed nature of the scheduling teams to ensure efficiency and alignment
- Ultimately, there will be changes in how we provide missions with network support

WE INVITE YOU TO COLLABORATE WITH US TO GENERATE A ROBUST SCHEDULING PROCESS, CLEAR ARTICULATION OF MISSION NEEDS/PREFERENCES, ENABLE MORE DYNAMIC SCHEDULES SUPPORT IN THE ERA OF HUMAN SPACEFLIGHT

Supporting DSN Users: Exploring Optical



NASA HAS SUCCESSFULLY COMPLETED EXTENSIVE OPTICAL DEMONSTRATIONS.
OPERATIONALIZATION NEEDS TO BE DRIVEN BY MISSION COMMUNITY.

Supporting DSN Users: Addressing the Needs



1

Building Capacity with DAEP

The DSN Aperture Enhancement Project (DAEP) will result in the following at each site:

- Four BWG
- One 70 m backup
- One 80kw transmitter



2

Enhancing Capabilities with DLEU

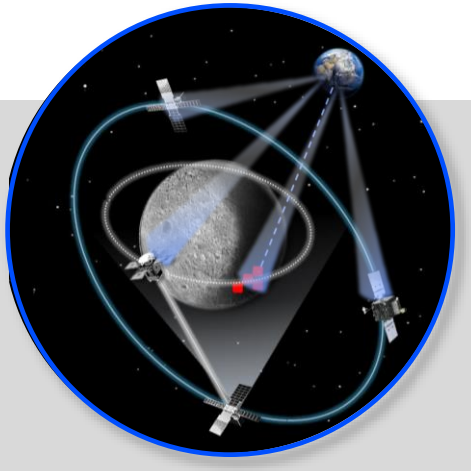
The DSN Lunar Exploration Upgrades (DLEU) will result in upgrading two DSN antennas at each complex, enabling simultaneous operations, enhanced uplinks, and increase data rates



3

Adding Support with LEGS

Lunar Exploration Ground Sites (LEGS) will “lighten” the load on DSN by shifting selected lunar missions to a network of new 18-meter class antennas



4

Increasing Efficiency with MSPA and Ka-band

Multiple Spacecraft per Aperture (MSPA) will unlock increasingly efficient asset utilization, while use of Ka-band will allow higher throughput links and reduce use-clock demand for new missions

THE USE of MSPA and KA-BAND on FUTURE MISSIONS WILL REDUCE DSN LOAD and ENHANCE PERFORMANCE for INDIVIDUAL MISSIONS AS WELL AS the NETWORK

NASA SCaN's plan for Lunar Relay Infrastructure can be a Model for Mars

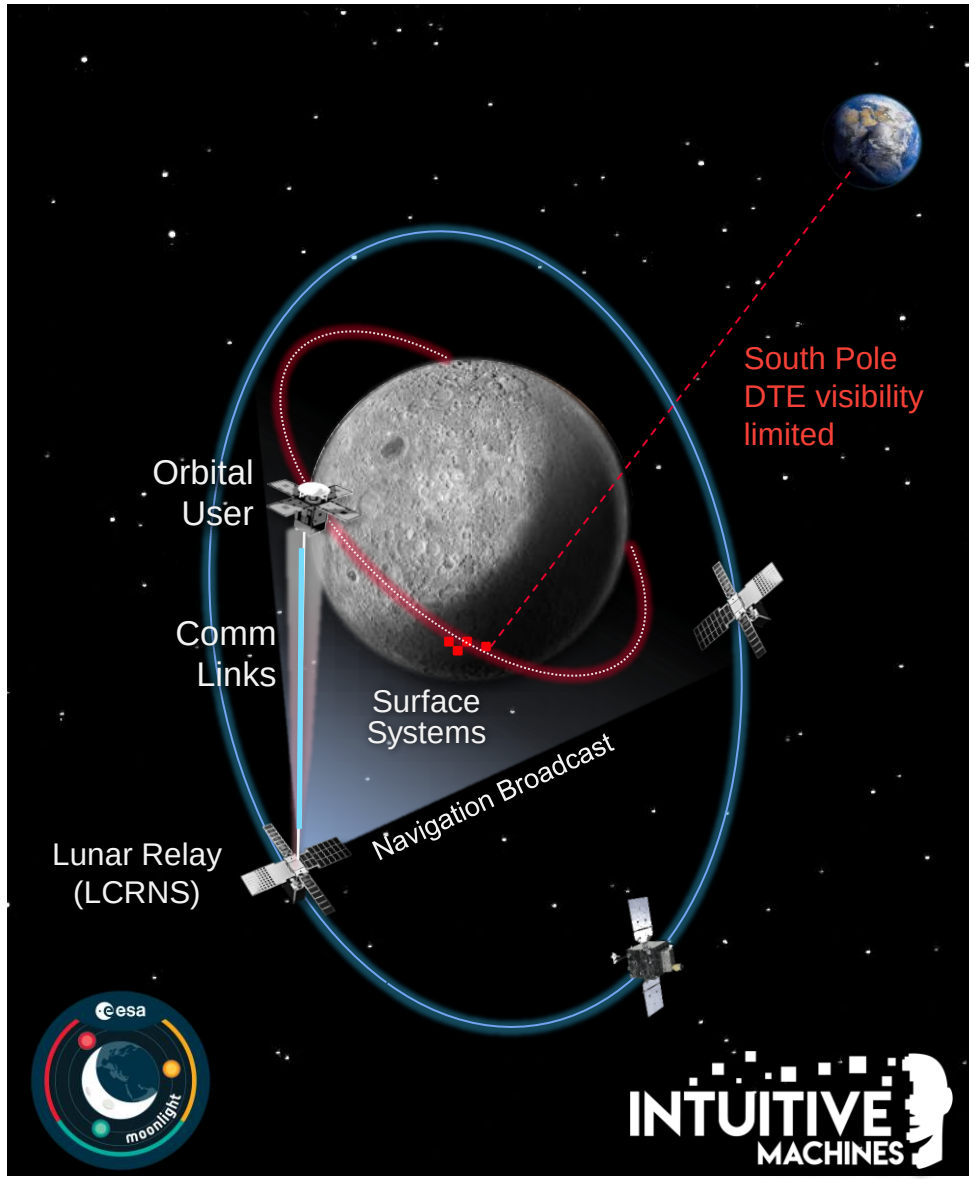
SCaN awarded Intuitive Machines a contract for Lunar Communications Relay and Navigation Systems (LCRNS)

SCaN is establishing standards (LunaNet Technical Baseline) for interoperable communications & position, navigation, and timing (C&PNT) for both its commercial and international partners (e.g., European Space Agency's Moonlight)

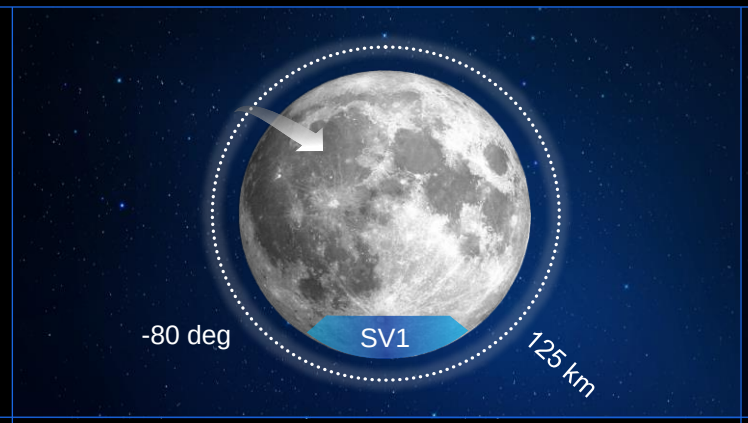
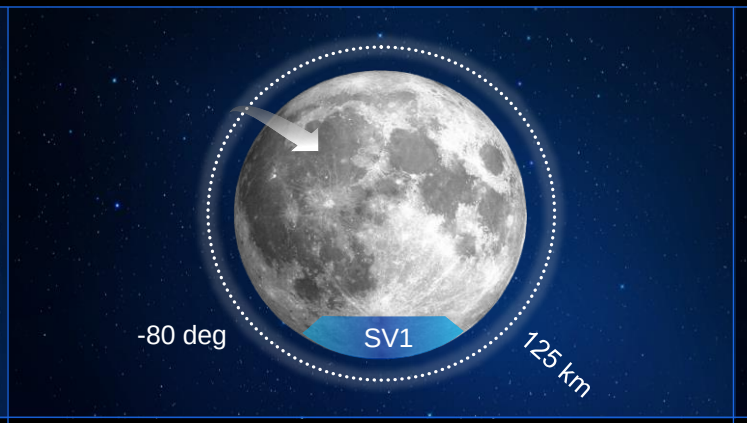
SCaN's plan for lunar relay will:

- Address lunar south pole coverage gap and navigation challenges
- Aggregate surface comms, reducing DTE load
- Reduce the user burden

Pre-validation services may be available directly via IM, or via the LCRNS project in a "test subject" capacity for flight-level checks



Jointly Approved LCRNS Requirements & Increments

Validation Task Order Increment	**Increment Alpha Q3 FY26** Services Ready: Artemis III	**Increment Bravo Q2 FY28** Services Ready: Artemis IV	**Increment Charlie Q2 FY29** Services Ready: Artemis V
Service Volume			
Capabilities	• Communication support • % Coverage of Earth Day – 70% (all bands) • RF and waveform compatibility with LunaNet Interoperability Specification • Single augmented forward signal (AFS) (position, navigation and timing (PNT))	• Enhanced communication support • % Coverage of Earth Day – 75% Ka-band, 90% S-band, 70% AFS (2 links) • RF and waveform compatibility with LunaNet Interoperability Specification • Multiple augmented forward signal (PNT)	• % Coverage - 75% Ka-band, 90% S-band, 40% AFS (4 links, max spatial GDOP<6) • Full set Lunar Communications Relay and Navigation Services (LCRNS) Services Requirements Document (SRD) and Initial Operating Capability (IOC) requirements
	Artemis III	*Artemis IV*	*Artemis V*
M2M Relay Comm Need	Demo Opportunity	Required	Required
M2M Relay PNT Need	Demo Opportunity	Demo Opportunity	Required

GDOP: Geometric Dilution of Precision

Mars Relay

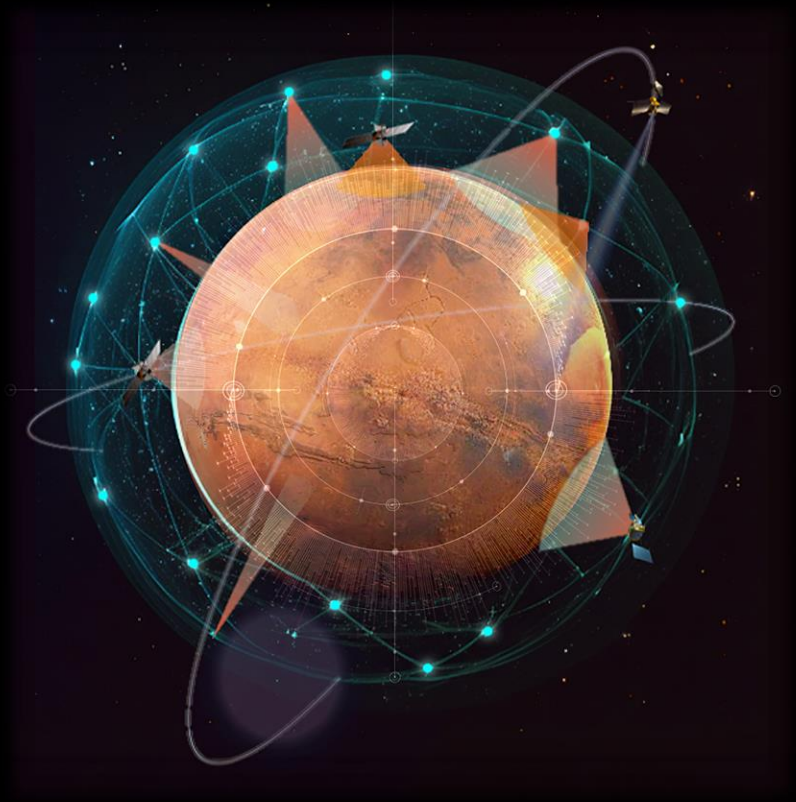
Current Mars Relay capability is provided by the SMD Mars Exploration Program

Delivered through a network of hybrid science/relay orbiters, and ground stations from DSN and ESA

Rudimentary capability is declining as orbiters age and **there is no formal plan to replenish the network**

SCaN is working to address this gap and reduce risk to future Mars mission support:

- Collating prior studies and gathering requirements – MEP studies in 2024, M2M high level C&PNT drivers for EDL, preparatory missions and eventual surface mobility
- Laying groundwork for systems engineering and pre-formulation work to move quickly toward subsequent acquisition



Summary

IF WE'RE SUCCESSFUL, SO ARE YOU

- Growing DSN demand is causing challenges to meeting science and exploration mission needs
- SCaN is working to enhance the capabilities, capacities, and efficiency of the DSN
- Major sustainment investments in the DSN are also helping improve reliability, robustness, and resiliency
- We need your help:
  - Scheduling and prioritization will be a collaborative effort with the science community
  - Future missions are encouraged to use Ka band and explore other mission efficiencies maximizing throughput (e.g., higher-order modulation and coding via ground system receiver and flight system transceiver upgrades)





SCaN

Science and exploration, enabled.

nasa.gov