National Aeronautics and Space Administration

Deep Space Network Updates

Presented to:
Planetary Sciences Advisory Committee

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National Aeronautics and Space Administration
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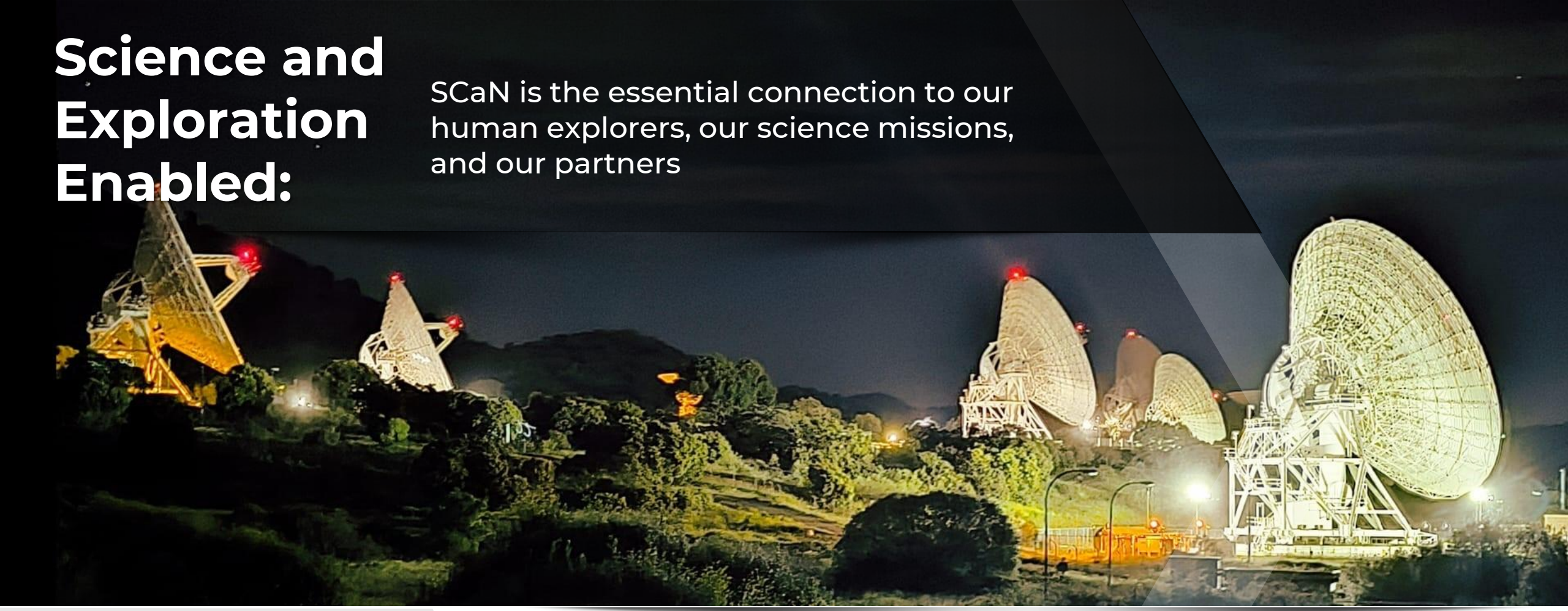
SCaN Space Communications and Navigation

Science and Exploration, Enabled. Together.

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 of NASA's space communications activities.

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

100+ Missions currently enabled by SCaN

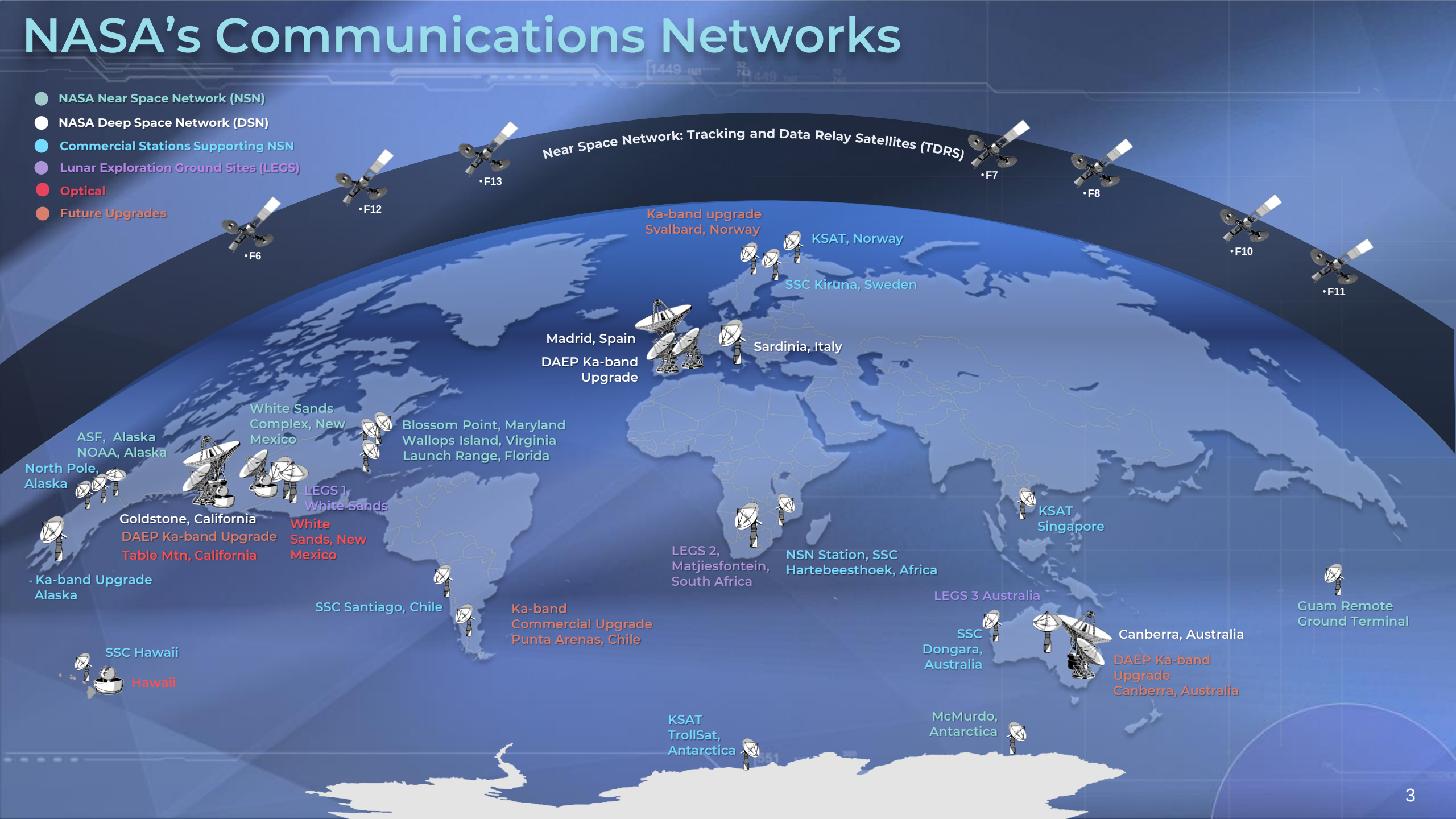
Focal Points for NASA SCaN

Provide reliable, robust, and resilient space communications and navigation capabilities to enable safe execution of NASA missions.

Architect, develop and partner to deliver the space communications and navigation capabilities of the future.

Demonstrate world-class leadership and teamwork, with our customers, and domestic and global mission partners.

NASA's Communications Networks



SCaN's Deep Space Network (DSN)

DSN's Role and Structure

DSN is the only US network dedicated to providing telecommunications services for missions in deep space

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

On behalf of SCaN, 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 May 2024				
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)**

ARTEMIS

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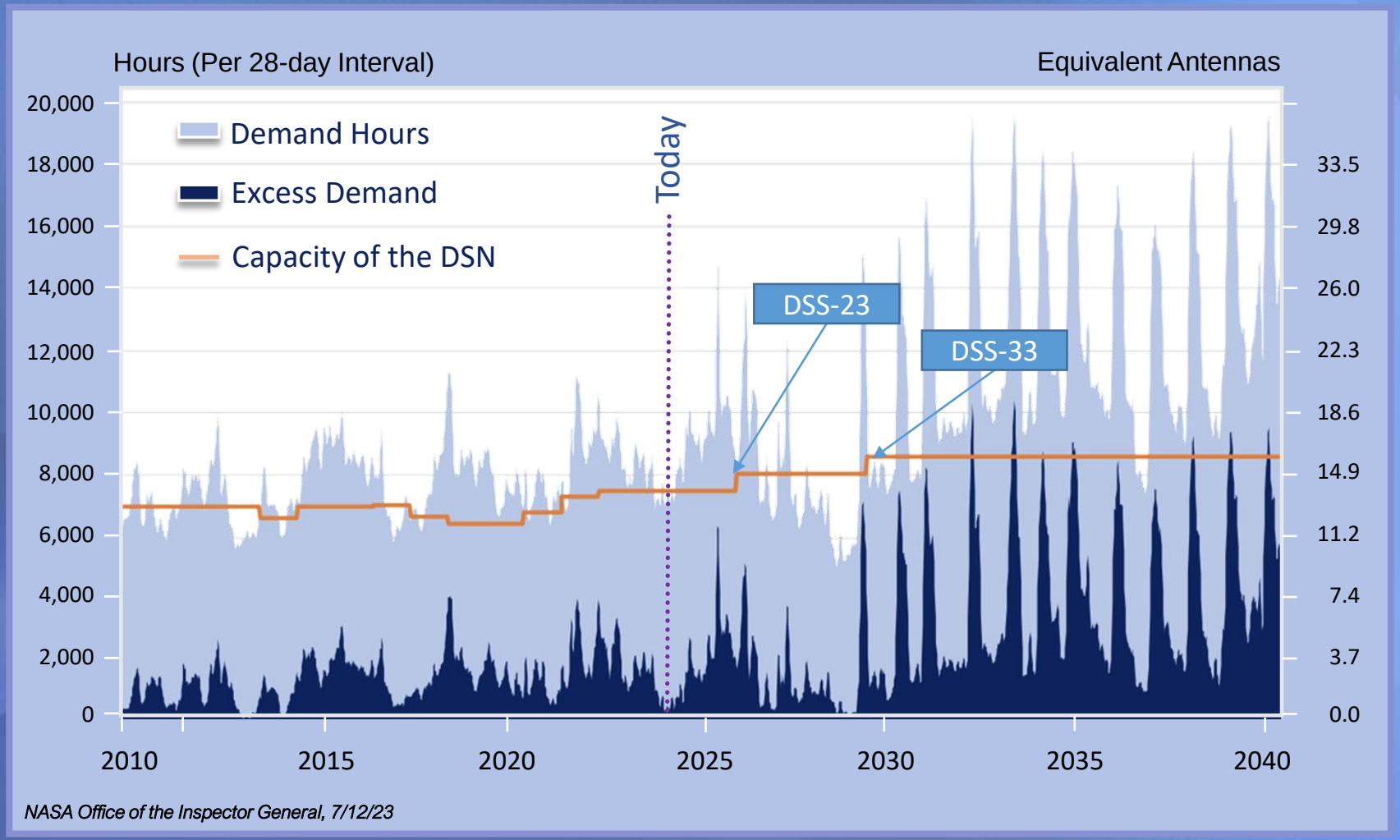
The DSN Challenge: Rapidly Growing User Needs

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

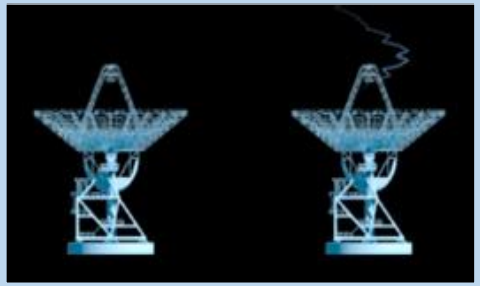
- New technologies to achieve Decadal Survey priorities are ever more data hungry
- JWST alone uses 10% of DSN capacity; sending back 25x the data of Hubble
- Infrastructure support has not kept up



Supporting DSN Users: Addressing the Needs

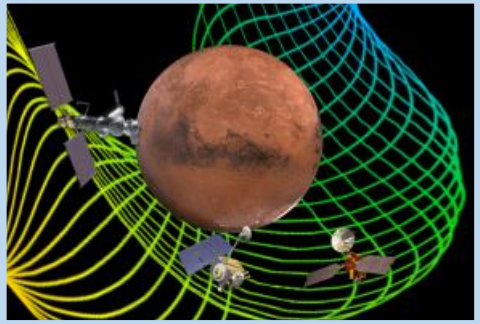
Building Capacity with DAEP
The DSN Aperture Enhancement Project (DAEP) will result in the following at each site:

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



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

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



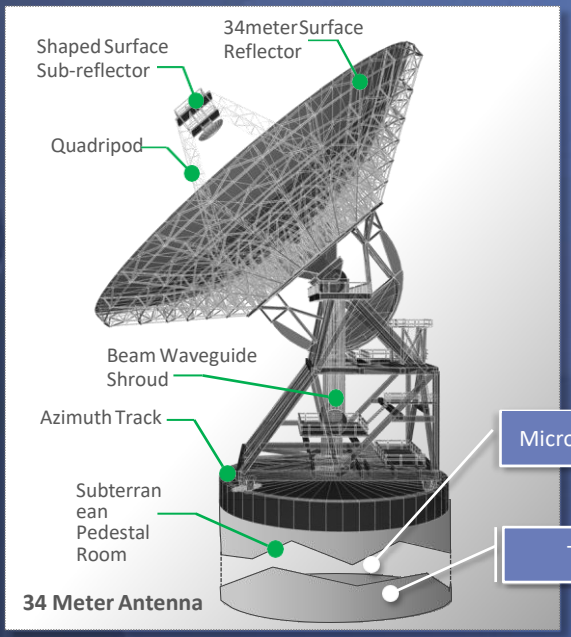
Increasing Efficiency with MSPA and Ka-band
Multiple Spacecraft per Aperture (MSPA) will unlock increasingly efficient asset utilization, while use of Ka-band will allow higher throughput links and reduce use-clock demand for new missions

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

Supporting DSN Users: Reliability, Robustness and Resiliency

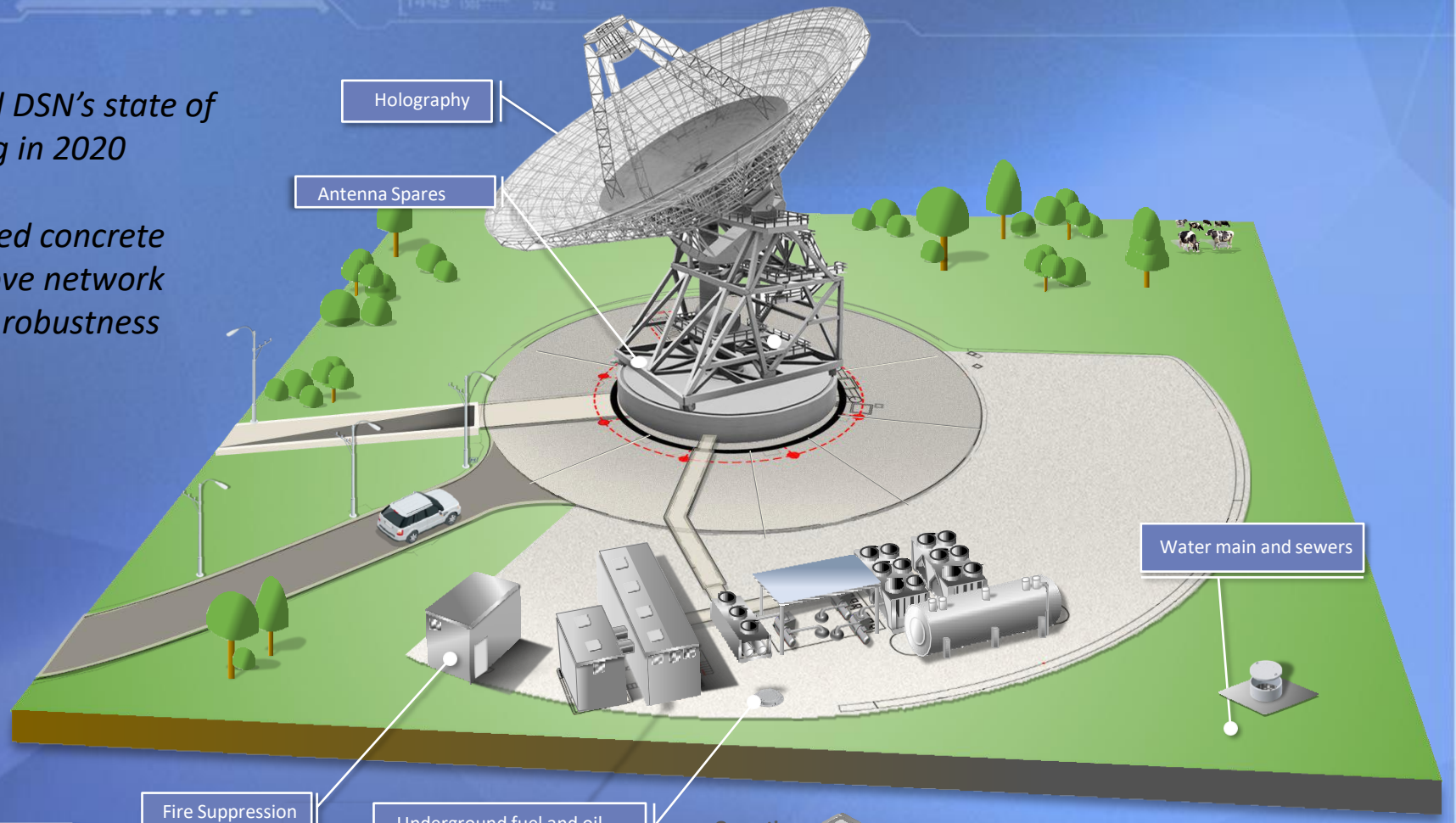
R2G examined DSN's state of health starting in 2020

R2G determined concrete steps to improve network reliability and robustness

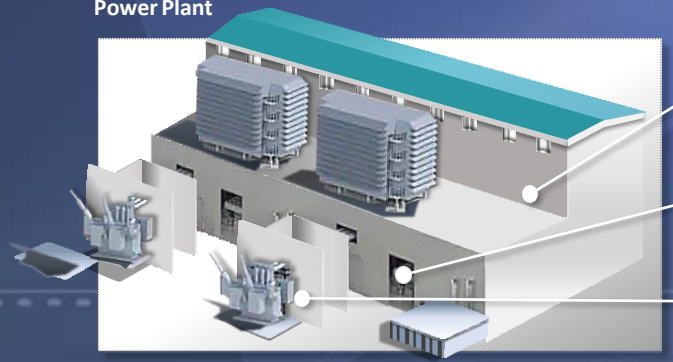


Microwave Controller

Transmitter



Power Plant



Generators

Uninterruptible Power Supply

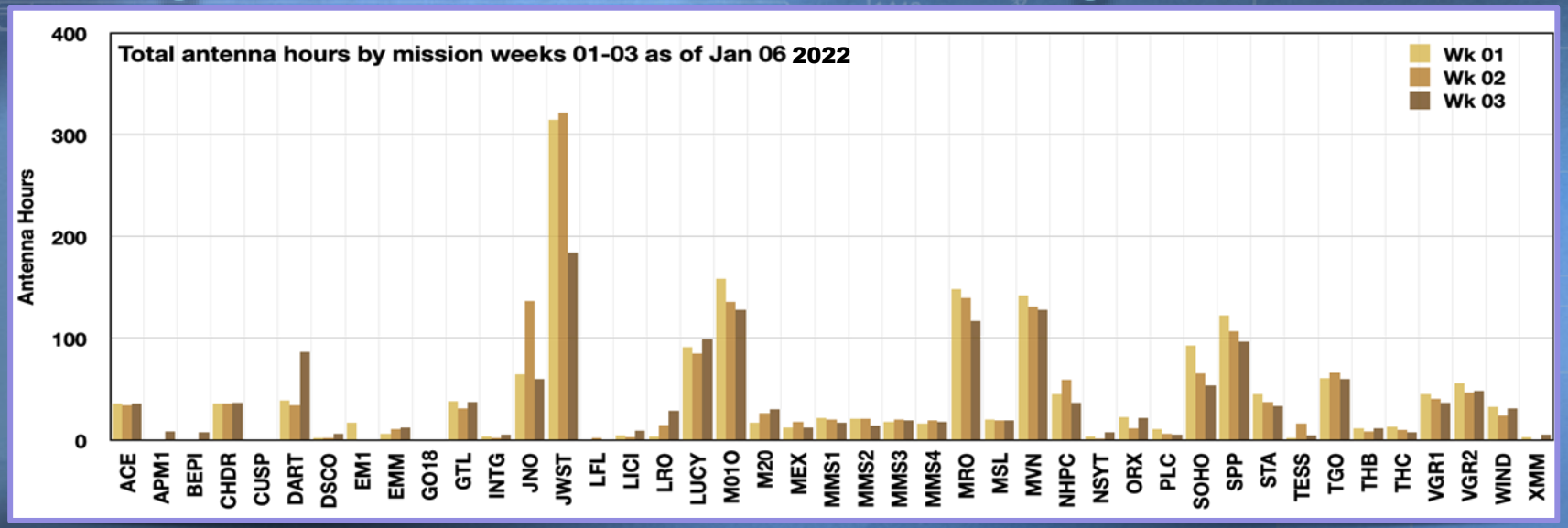
Transformers and Switchgear

Operations Center Co

General Cyber Security

OS Upgrades

Supporting DSN Users: Scheduling and Prioritization

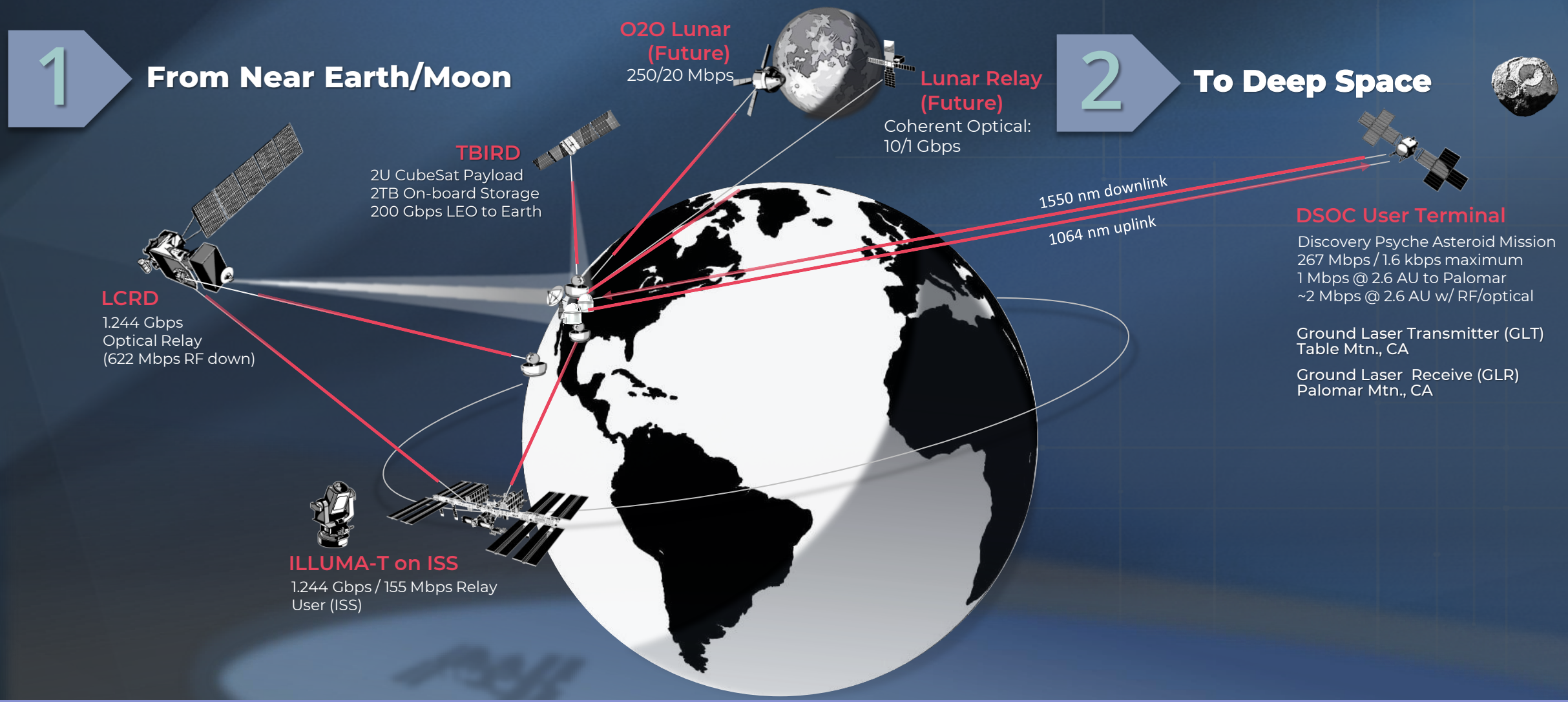


Applying lessons learned from JWST and Artemis 1 scheduling and prioritization techniques will also be key to SCaN's future approaches in support of planetary missions.

- 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, as well clear articulation of mission needs/preferences, to enable more dynamic schedules support in the era of human spaceflight

Supporting DSN Users: Exploring Optical

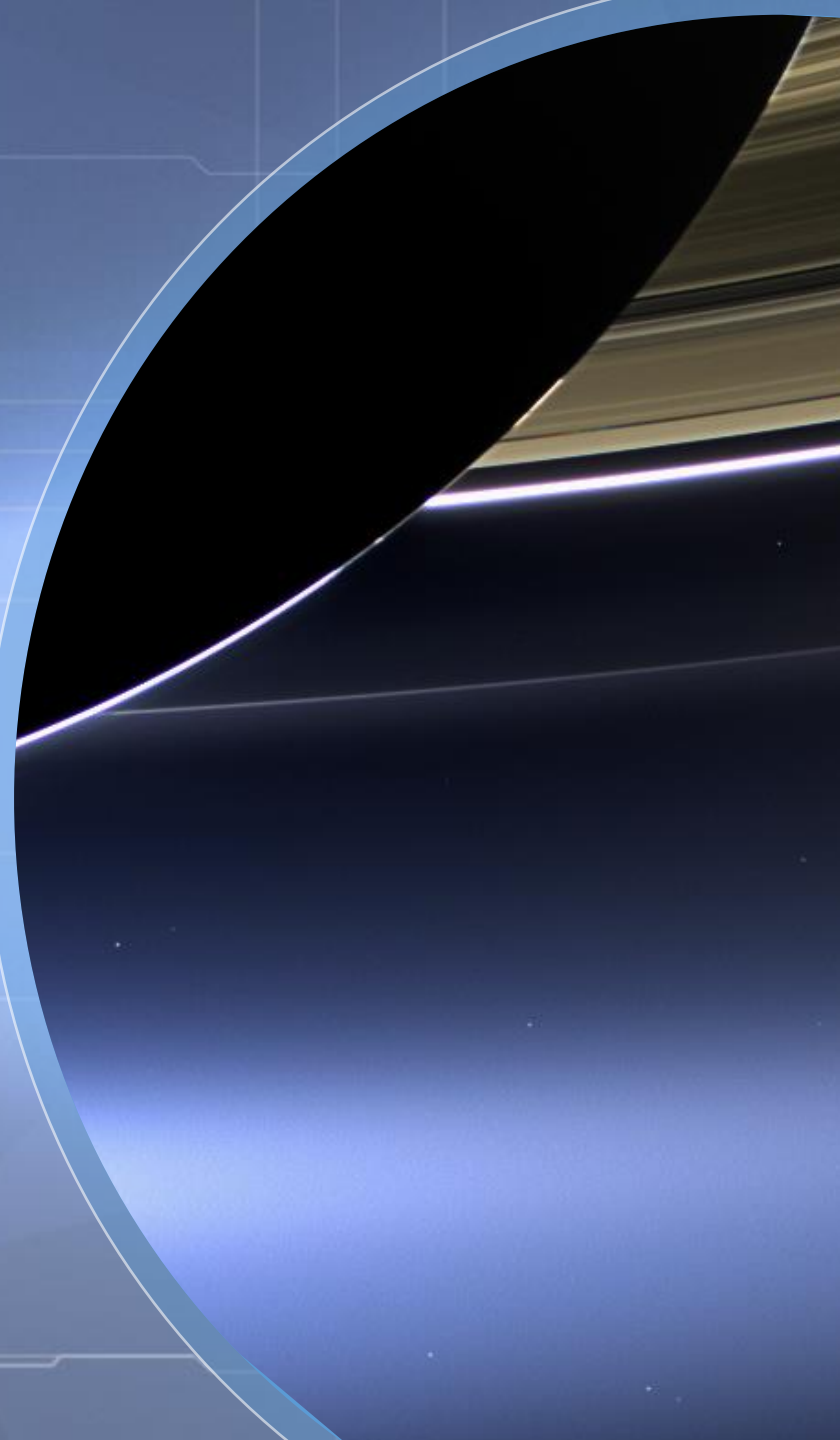


NASA has successfully completed extensive optical demonstrations.
Operationalization needs to be driven by mission community.

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

Space Communications and Navigation

Science & Exploration, enabled.

National Aeronautics and Space Administration

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Acronyms

ASF	Alaska Satellite Facility
BWG	Beam Waveguide
C&N	Communications & Navigation
CDR	Critical Design Review
CLPS	Commercial Lunar Payload Services
DAEP	DSN Aperture Enhancement Project
DLEU	DSN Lunar Exploration Upgrades
DSN	Deep Space Network
DSS	Deep Space Station
DTE	Direct-to-Earth
ESDMD	Exploration Systems Development Mission Directorate
GAVRT	Goldstone Apple Valley Radio Telescope
HEF	High Efficiency
JPL	Jet Propulsion Laboratory
JWST	James Webb Space Telescope
KSAT	Kongsberg Satellite Services

LEGS	Lunar Exploration Ground Sites
LEO	Low-Earth Orbit
NOAA	National Oceanic and Atmospheric Administration
NSN	Near Space Network
ORR	Operational Readiness Review
PDR	Preliminary Design Review
PNT	Position Navigation and Timing
R2G	Road to Green
RFP	Request for Proposal
SCaN	Space Communications and Navigation
SMD	Science Mission Directorate
SOMD	Space Operations Mission Directorate
SPC	Signal Processing Center
SSC	Swedish Space Corporation
TDRS	Tracking Data and Relay Satellite