National Aeronautics and Space Administration

SCaN Support for ESE

SCaN Space Communications and Navigation

Science & Exploration, enabled. Together.

Elizabeth Hook-Rogers
SMD Portfolio Liaison
20 June 2024

Purpose

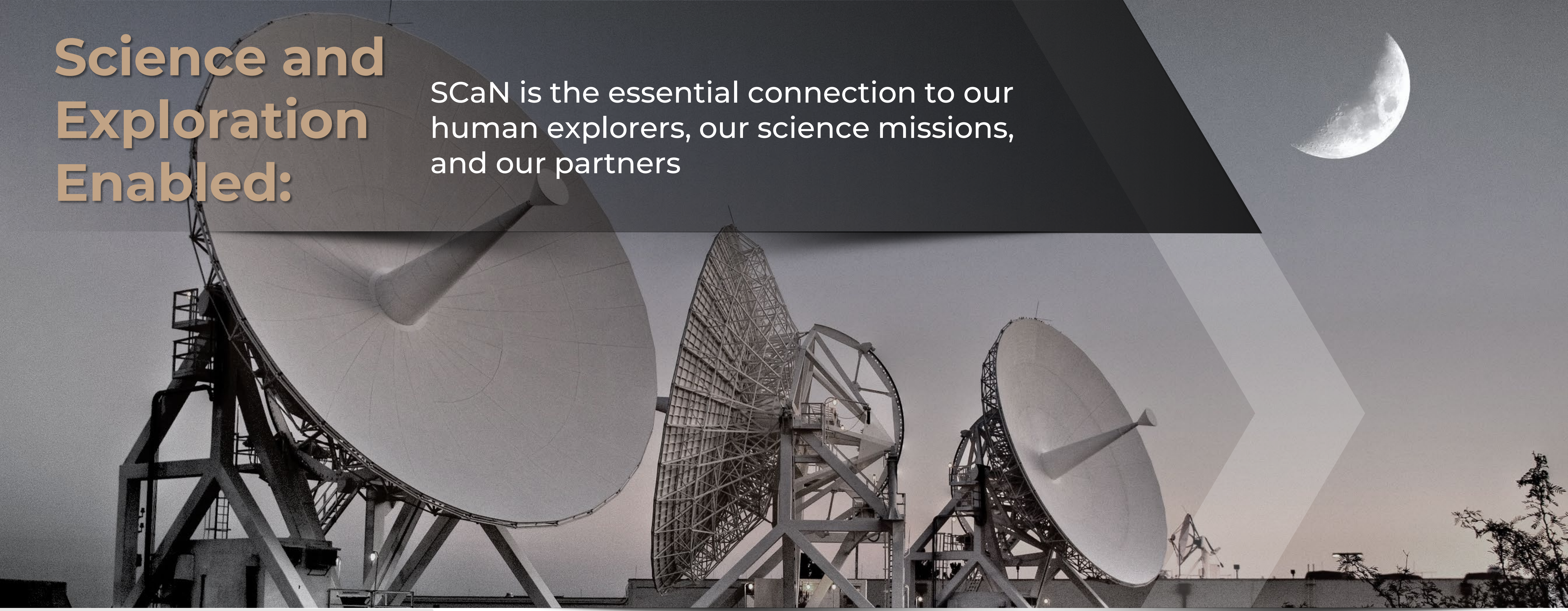
Provide reference material with more information about SCaN

Ensure awareness of infrastructure changes SCaN has coming up

Record any questions or concerns that you may have

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

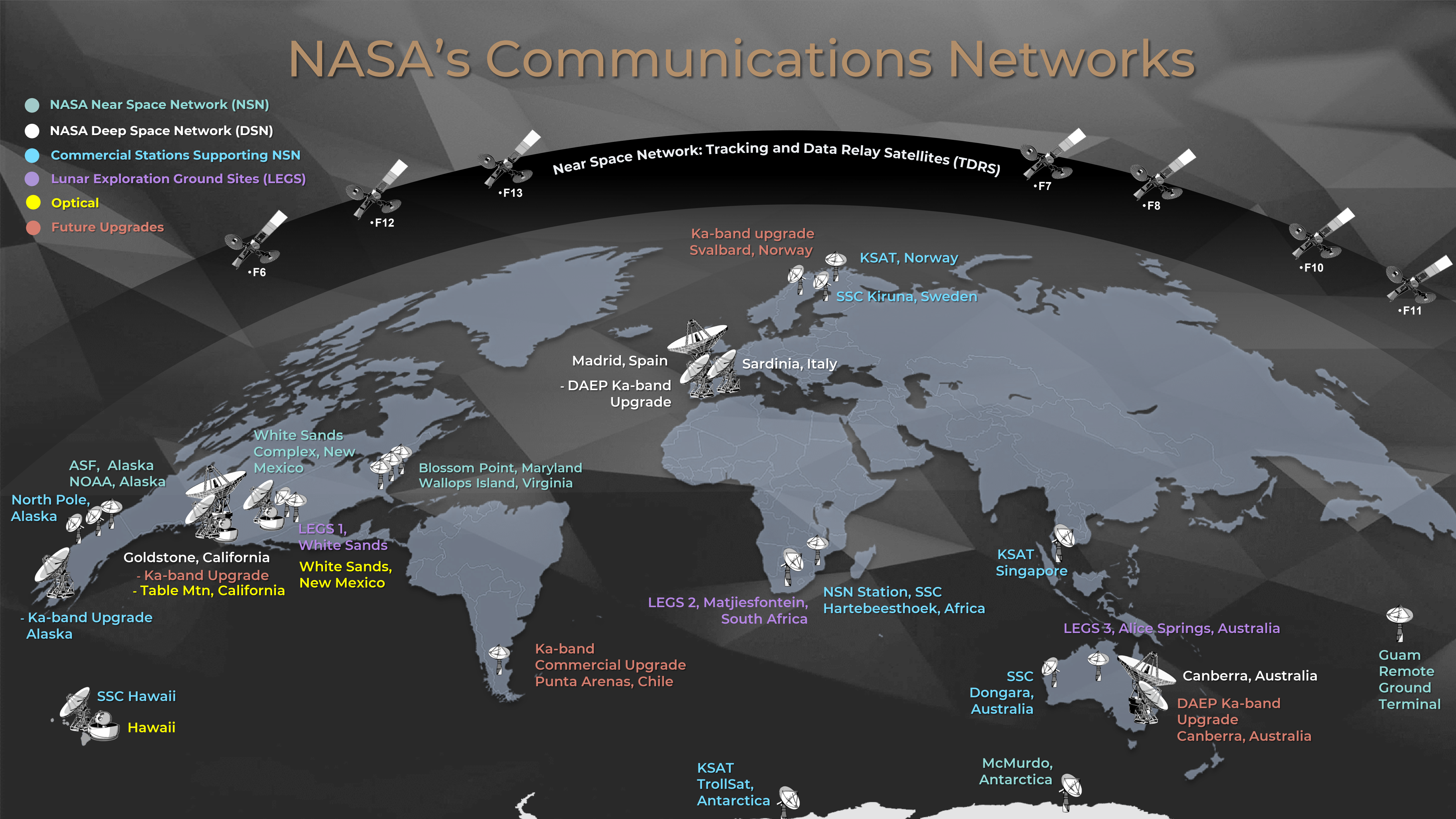
Focal Points for Change: Strategic Evolution

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
NASA Near Space Network (NSN)
NASA Deep Space Network (DSN)
Commercial Stations Supporting NSN
Lunar Exploration Ground Sites (LEGS)
Optical
Future Upgrades
Near Space Network: Tracking and Data Relay Satellites (TDRS)
•F6
•F12
•F13
•F7
•F8
•F10
•F11
Ka-band upgrade Svalbard, Norway
KSAT, Norway
SSC Kiruna, Sweden
Madrid, Spain
- DAEP Ka-band Upgrade
Sardinia, Italy
White Sands Complex, New Mexico
Blossom Point, Maryland
Wallops Island, Virginia
ASF, Alaska
NOAA, Alaska
North Pole, Alaska
Goldstone, California
- Ka-band Upgrade
- Table Mtn, California
LEGS 1, White Sands
White Sands, New Mexico
- Ka-band Upgrade Alaska
KSAT Singapore
NSN Station, SSC Hartebeesthoek, Africa
LEGS 2, Matjiesfontein, South Africa
LEGS 3, Alice Springs, Australia
Guam Remote Ground Terminal
Ka-band Commercial Upgrade Punta Arenas, Chile
SSC Dongara, Australia
Canberra, Australia
DAEP Ka-band Upgrade Canberra, Australia
SSC Hawaii
Hawaii
KSAT TrollSat, Antarctica
McMurdo, Antarctica

SCaN Requirements

Requirement CS-41: This section shall provide a clear statement of NASA SCaN networks (Deep Space Network [DSN], Near Space Network [NSN]) support requirements in tabular format, showing all mission phases (e.g., launch and early orbital operations, cruise, flybys, orbit insertion, orbital operations, data return), the year in which support is needed, station(s) required, pass lengths in hours, number of passes each week, and the number of weeks for which this support is required.

Proposers should be advised that SCaN intends to migrate away from use of Tracking and Data Relay Satellite Services (TDRSS) and is actively working to validate commercial alternatives. No new mission will be allowed using TDRSS. Missions that are considering proposing specialized services previously offered by TDRSS, such as demand access services, should work with SCaN to understand the potential commercial service alternatives.

Near Space Network

- The NSN acts as a liaison for customers that need communications and navigation services in the near space region–out to two million kilometers from Earth
- The network serves missions throughout their entire lifecycle, providing requirements analysis, spectrum management, communications analysis, service agreements, mission design, mission planning, launch, operations, and post-mission support activities

SCaN Services and Scheduling - NASA

The NSN provides four main services to mission customers:

1. Mission Integration: development of service agreements, interfaces, documentation, support of reviews, etc.
2. Mission Planning and Scheduling: performing link and loading analyses, supporting service requests, and generating and implementing operational schedules
3. Position, Navigation, and Timing (PNT): navigation information, tracking data measurements, and messages
4. User Mission Data Transfer: spacecraft forward command and return telemetry data

NSN Services Brochure 1.2 DIG (nasa.gov)

INTERFACES AND CAPABILITIES

INTERFACE/CAPABILITY	DIRECT TO EARTH	SPACE RELAY
1 Mission Integration and Operational Support		
Customer Mission Engineering and Support Services	Requirements Development, Mission Planning, Analysis and Design, Integration and Network Compatibility Testing, Operational Scheduling, Launch & Commissioning Support, Mission Operations Support, Monitor and Control, Tracking & Orbit Determination, Critical Event Support (Maneuvers, EOL Disposal, etc.), Data Storage and Distribution, Readiness Reviews, Post-Launch Reports and Reviews	
2 Service Management, Planning, and Scheduling		
Monitoring	Real-time monitoring and reporting	
Scheduling	Advanced and on-demand scheduling via web-based interfaces	
Service Accounting	Provides proficiency statistics, reporting of total support time	
3 Spacecraft Metric Tracking Capabilities		
Radiometric Tracking Services	Tone or PN Ranging, 1-way or 2-way Doppler, Antenna Angle Data	Spread Spectrum Ranging, 1-way or 2-way Doppler, Antenna Angle Data
Radiometric Measurement Accuracy	Range: S/X-band: ≤ 1 m systematic; 5 m noise, 1σ Doppler (Range-Rate): S-band 1-way: ≤ 3 mm/s, 1σ S-band 2-way: ≤ 1.5 mm/s, 1σ X-band 1-way: ≤ 0.7 mm/s, 1σ Ka-band 1-way: ≤ 0.2 mm/s, 1σ Antenna Angles (From Ground): S: 0.03°, X: 0.05° Ka: 0.01° (auto), 0.05° (program)	Range: S/Ku-band: ≤ 4.5 m systemic; 2.73 m noise, 1σ Doppler (Range-Rate): S-band 1-way ≤ 3.5 mm/s, 1σ S-band 2-way ≤ 1.75 mm/s, 1σ Ku/Ka-band 1-way ≤ 0.51 mm/s, 1σ Ku-band 2-way ≤ 0.25 mm/s, 1σ Antenna Angles (From Relay): ≤ 0.1°
Relative Dynamics	Velocity: ≤ 11.6 km/s free flight, ≤ 15 km/s powered flight; Acceleration: ≤ 14.8 m/s² free flight, ≤ 50 m/s² powered flight; Jerk: ≤ 0.02 m/s³ free flight, ≤ 2 m/s³ powered flight	
Radar Tracking Service Bands	C-band (5.4-5.9 GHz) Single Object X-Band (10.499 GHz) Multi Object	N/A
Radar Tracking Loop Gain (dB)	C-Band: 212-245 (227 typical) X-Band: 246 (nominal)	N/A
Other	**Ground Antenna Slew Rate:** Azimuth and Elevation: ≥ 10°/sec (10°/sec²) * Train: ≥ 5°/sec (5°/sec²) * 18-meter systems ≥ 2°/sec (1°/sec²)	**Time Correlation:** User Spacecraft Clock Calibration System: ≤ ±5 µs Return Channel Time Delay: ±25% of a bit period
4 Terrestrial Link Data Transport Capabilities		
Data Storage	Station storage: 5-30 days; Cloud-based: Mission-driven	7 days
Network Data Rate	Mission-driven (up to 1.2 Gbps)	
SLE Protocols	F-CLTU, EF-CLTU (Forward), RAF, RCF, ROCF (Return)	
SLE Versions Supported	CCSDS 910.4, CCSDS 911.1, CCSDS 911.2, CCSDS 911.5, CCSDS 912.1, CCSDS 912.11, CCSDS 912.3, CCSDS 913.1	
Offline-Data Transfer	CFDP, SFTP	
Security	Trusted networks (access controls, firewalls, authentications, etc.)	
4 Optical Communications Capabilities (Demonstration Only)		
Wavelength	1550 nm	
Max Forward Data Rate	20.4 Mbps	1.244 Gbps
Max Return Data Rate	261 Mbps	1.244 Gbps
Modulation	PPM (Order 16 or 32)	PPM (Order 16) or DPSK
Encoding	SCC (Rate 1/3 or Rate 2/3)	SCC (Rate 1/2)
Framing	Ethernet	AOS, Ethernet
Optimetrics	Optical ranging capabilities and accuracy TBD	
4 Forward (Command) Communications		
Frequency Bands (Near-Earth Use)	S-band: 2025-2110 MHz X-band: 7145-7235 MHz Ka-band: 22.55-23.15 GHz	S-band: 2025-2110 MHz Ku-band: 13.775 GHz Ka-band: 22.55-23.55 GHz

INTERFACES AND CAPABILITIES (CONTINUED)

INTERFACE/CAPABILITY	DIRECT TO EARTH	SPACE RELAY
4 Forward (Command) Communications (continued)		
Maximum Bandwidth	S-band: 5 MHz X-band: 10 MHz Ka-band: 40 MHz (Typical)	S-band: 6 MHz Ku-band: 50 MHz Ka-band: 50 MHz
Forward Max Data Rate (prior to encoding)	S-band: 5 Mbps X-band: 10 Mbps (5 Mbps Typical) Ka-band: 40 Mbps	S-band MA: 300 Kbps S-band SA: 4.2 Mbps Ku-band: 50 Mbps Ka-band SA: 50 Mbps
Antenna System EIRP (dBW)	S-band: 51-81 (56 typical) X-band: 85-86 Ka-band: 89	S-band MA: 42 S-band SA and Ku-band SA: 48.5 Ka-band SA: 63
Modulation	PM, FM, PCM, PCM/PM, PCM/PSK/PM, BPSK, QPSK, OQPSK, UQPSK, Filtered OQPSK	Spread spectrum: BPSK or UQPSK Non-spread: BPSK, QPSK, OQPSK, PCM/PM, or PCM/PSK/PM
Encoding	Uncoded, or LDPC 1/2 or 7/8	Uncoded, Rate 1/2 Conv., Reed-Solomon, Concatenated (1/2 Conv. + RS), LDPC 1/2 or 7/8
Polarization	Circular (LHC, RHC)	Circular (RHC, LHC only for MA services)
4 Return (Telemetry) Communications		
Frequency Bands (Near-Earth Use)	S-band: 2200-2300 MHz X-band: 8025-8500 MHz Ka-band: 25.5 – 27 GHz	S-band: 2200-2290 MHz Ku-band: 15.0034 GHz Ka-band: 25.25 – 27.5 GHz
Maximum Bandwidth	S-band: 5 MHz X-band: 375 MHz X-band (SRS): 10 MHz Ka-band: 1500 MHz	S-band (MAR & SAR): 6 MHz Ku/Ka-band: 225 MHz Ka-band (Wide): 650 MHz
Return Max Data Rate (prior to encoding)	Rates will vary – examples: S-band: 2.2 Mbps (PACE) X-band: 220 Mbps (ICESat-2) X-band (SRS): 13.1 Mbps (IRIS) Ka-band: 3.5 Gbps (NISAR)	S-band MA: 1 Mbps S-band SA: 14.1 Mbps Ku/Ka-band: 600 Mbps Ka-band (Wide): 1200 Mbps
Antenna System G/T (dB/K)	S-band: 19.1-29.6 (21 typical) X-band: 30.5-39 (32 typical) Ka-band: 38-47.5 (41.3 typical)	S-band MA: 3.2 (for LEO) S-band SA: 9.5 (for LEO) Ku-band: 24.4 (for LEO) Ka-band: 26.5 (for LEO)
Demodulation	PM, FM, PCM, PCM/PM, PCM/PSK/PM, BPSK, QPSK, OQPSK, AQPSK, Filtered OQPSK, SQPN, 8PSK	Spread spectrum: BPSK or OQPSK Non-spread: BPSK, QPSK, OQPSK, 8PSK PCM/PM, or PCM/PSK/PM
Decoding	Uncoded, Rate 1/2 Conv. and/or Reed-Solomon, LDPC 1/2 or 7/8, or Turbo Rate 1/2	Uncoded, Rate 1/2 Conv., Reed-Solomon, Concatenated (1/2 Conv. + RS), LDPC 1/2 or 7/8, Rate 7/8 TPC
Polarization	Circular (LHC, RHC)	Circular (RHC, LHC only for MA services)

a Services and performance levels depend on many factors and are not uniform across network assets. Contact us for assessment of mission design, network performance, signal design compatibility, orbital design, antenna considerations, angles/off-pointing, atmospherics, etc. Maximum rates and bandwidths are given in accordance with system limitations, though higher rates may be possible. Confirmation of support depends upon many factors including mission planning & analyses performed by the NSN.

b Additional capabilities could be supported. Contact us for more information.

c In-progress and future upgrades will allow increases in network capability. NASA may consider adding capabilities with technologies not currently on its roadmap. Contact us for information on future capabilities.

d 2nd and 3rd generation TDRS only.

e LEGS only.

f These values are based on a 1-second measurement integration interval.

g Free flight values apply to S, X, Ku, and Ka-band. Powered flight values apply to S and X-band.

h These are preferred capabilities. Additional legacy capabilities exist, as shown on Page 2.

CONTACT US

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FS-2022-9-863-GSFC

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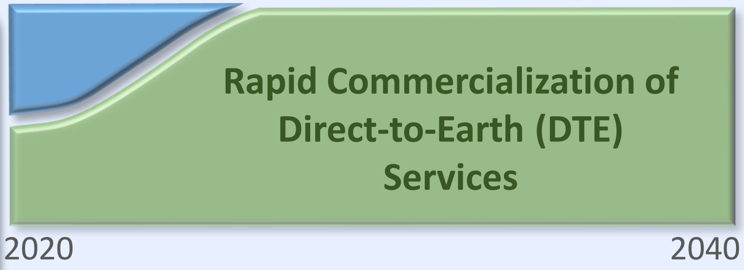
Near Space Network
Plan for Commercial Communications Services

"DIVIDE AND CONQUER" APPROACH IS TAILORED TO MARKET CAPABILITIES AND RISKS

Ground Stations: Commercialization Target



- Commercial transition in progress; commercial and partner services represented ~61% of passes in FY23
- Near-term increase in services provisioned by current commercial & partner ground sites

NASA-owned service capability   Commercially-provided

TDRS: Commercialization Target

- Time required to gradually transition
- TDRS is expected to support legacy users into the early 2040's
- Commercial SATCOM capability will be used for new missions

- SCaN is balancing the need for future investments in legacy systems with migration away from government systems
- The transition to commercial services for SATCOM and DTE is expected to progressively reduce sustainment and maintenance cost
- OMB has communicated that NASA should transition away from TDRS and government-owned ground stations to commercial vendors, aligning with National Space Policy
- NASA will not be launching additional TDRS; in 2015, option for a subsequent 3rd generation spacecraft (TDRS-N) was rejected

TDRS Transition

Legacy Architecture and Services (Switchboard in the Sky)

- High Operating & Maintenance Costs
- Limited Capacity
- Heavily relies on scheduling and coordination
- Closed ecosystem
- Complex and costly mission integration

- This legacy paradigm has held back mission network performance, forcing users to use vintage networks

Technology and Service Evolution

- Diverse commercial SATCOM-as-a-service offerings
- Ability to support more users simultaneously
- On-demand capabilities
- Supported by a large industrial base and market
- Capability offerings that increase user autonomy and reduce network reliance

- High-throughput, demand-responsive networks have the potential to unleash new modes of science, and remove long-standing network constraints

Unlocking Next Generation Technology & Services Through CSP

- 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 Program (CSP)

- NASA announced on April 20, 2022, that the CSP awarded contracts totaling **$278.5 million** to demonstrate how commercial satellites can support NASA missions.
    - Six providers are matching / exceeding the awards with own funds. Estimated total investment of **$1.5 billion** over five years.
        - Vendors are progressing successfully through their agreed to milestones. Demonstrations will continue through mid-2027

CSP’s Funded Space Act Agreement Partners: Projected Services

The FSAAs were awarded with the objective of demonstrating end-to-end services to meet multiple NASA mission use cases ranging from routine operations to TT&C, launch, and LEOP support

FSAAs with each vendor are unique based on their services and proposed milestones

	Architecture	Data Delivery (High-Rate Optical)	Data Delivery (High-Rate RF)	TT&C (Low-Rate RF)	TT&C (Launch)	TT&C (LEOP)
amazon | project kuiper	*LEO Optical*	✓				
SPACEX	*LEO Optical*	✓				
Viasat +Inmarsat	*GEO Ka-band*		✓			
Legacy Inmarsat	*GEO L-band*			✓	✓	✓
SES	*GEO C-band and MEO Ka-band*		✓	✓		
TELESAT	*GEO C-band and LEO Ka-band*		✓	✓		
KEPLER**	*LEO Optical*	✓		✓		✓

** Non-reimbursable Space Act Agreement in negotiation

Guidance and Questions

Work with SCaN to identify needs and they will help you coordinate for appropriate commercial services

Point of Contact: Jeff Hayes, jeffrey.hayes-1@nasa.gov

Backup

SCaN

Space Communications and Navigation

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Near Earth Relay: Historical Context

Origins of Tracking and Data Relay Satellite (TDRS) System were with the Shuttle and International Space Station and the driving need for 24x7 coverage

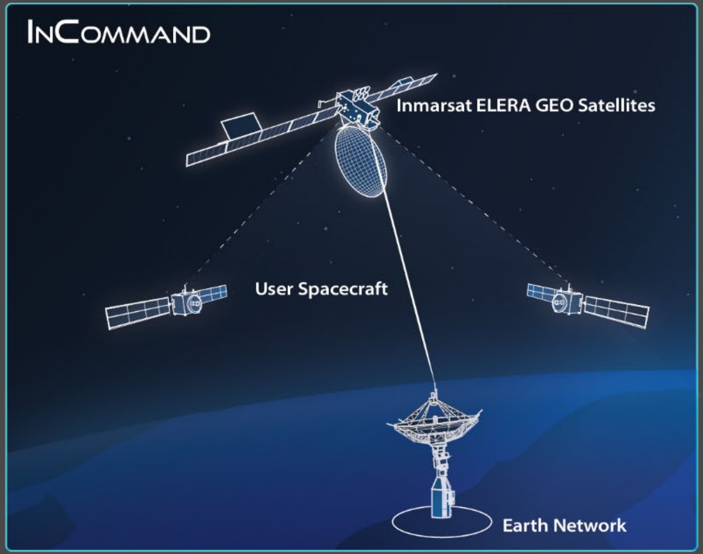
- TDRS system was built up over decades in deployments of three generations of satellites – the first launched in 1983 and the last satellite in 2017
- Capabilities incrementally improved over the generations, but fundamental architecture remained consistent over 40+ years

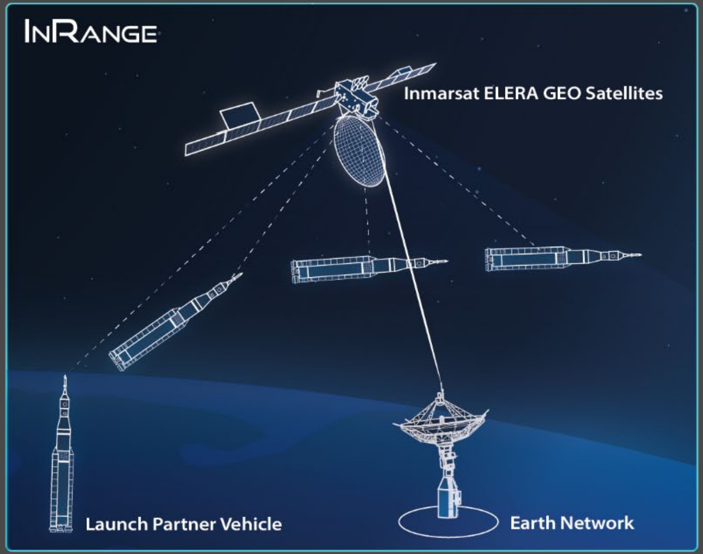
NASA will not be launching additional TDRS

- Options for a subsequent 3rd generation spacecraft (TDRS-N) was rejected by the Office of Management and Budget (OMB) and unsupported in congressional justifications
- OMB consistently communicated for over a decade that NASA should transition away from TDRSS, aligning with National Space Policy

Legacy Inmarsat

NETWORK ARCHITECTURE





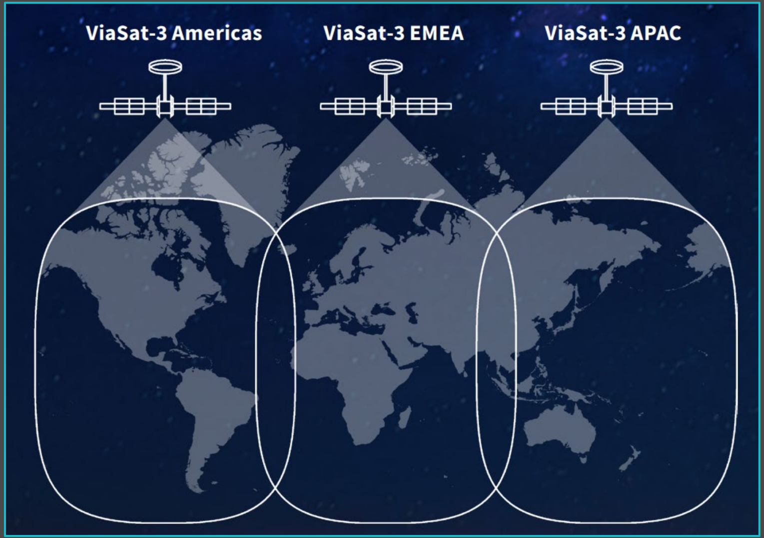
Inmarsat Government will leverage their established ELERA L-band network and satellite constellations to support user satellite communication needs. The revolutionary InRange and InCommand capabilities powered by ELERA is expected to provide critical support for launch and space relay services.

KEY FEATURES

- World-wide L-band network with 99.9% network reliability
- Eliminates dependency on ground infrastructure
- Continuous near real-time telemetry
- Rapidly deployable using existing space and ground infrastructure
- Decreased “black-out” communications phases post launch

Viasat

NETWORK ARCHITECTURE



The ViaSat-3 constellation is Viasat’s next generation of ultra-high-capacity, Ka-band satellites in GEO. Viasat-3 will offer enhanced global coverage, network capacity. The first satellite of the global ViaSat-3 constellation was successfully launched from NASA's Kennedy Space Center in Florida in 2023.

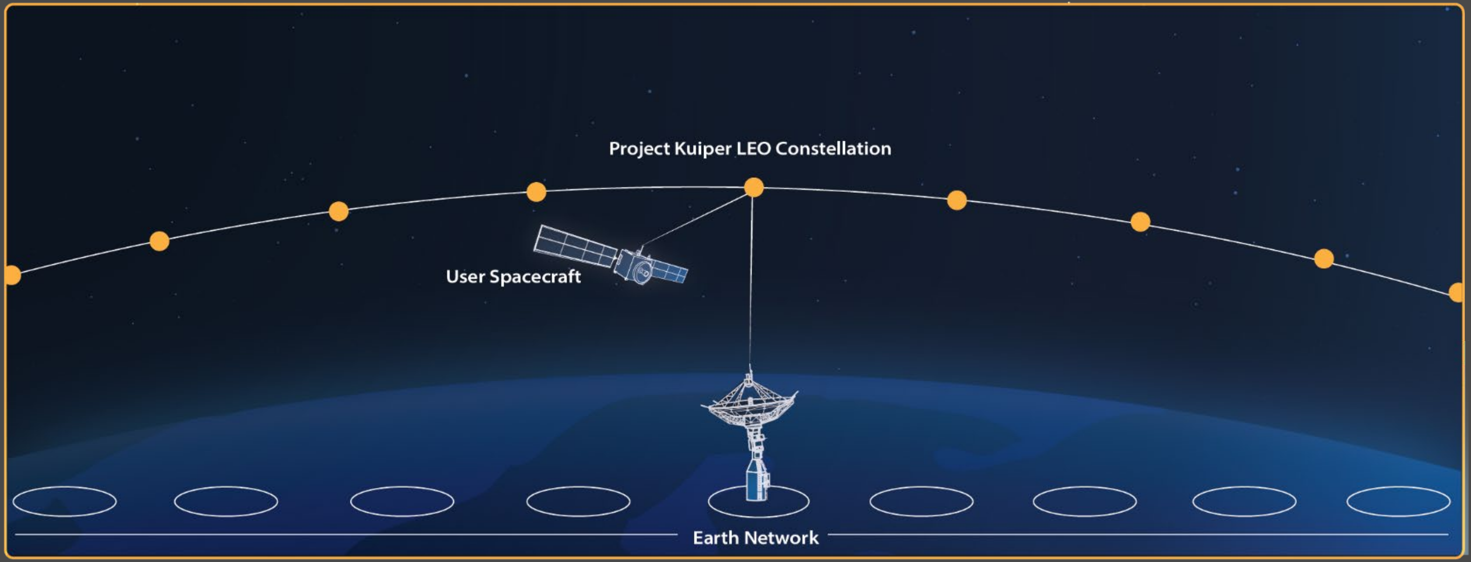
For space-users, the constellation is designed to significantly reduce the time it takes to transmit data from satellites by extending the real-time Earth network into space. This will enable space relays between satellites in different orbits and allow Earth-observation satellites and others to download their data more quickly.

KEY FEATURES

- Ka-band operations
- Each ViaSat-3 satellite is planned to have the ability to deliver download speeds of up to 100+ Mbps and 1 Terabit of throughput data per second
- Near-global coverage
- Dynamic bandwidth allocation to move capacity where and when needed

Project Kuiper

NETWORK ARCHITECTURE



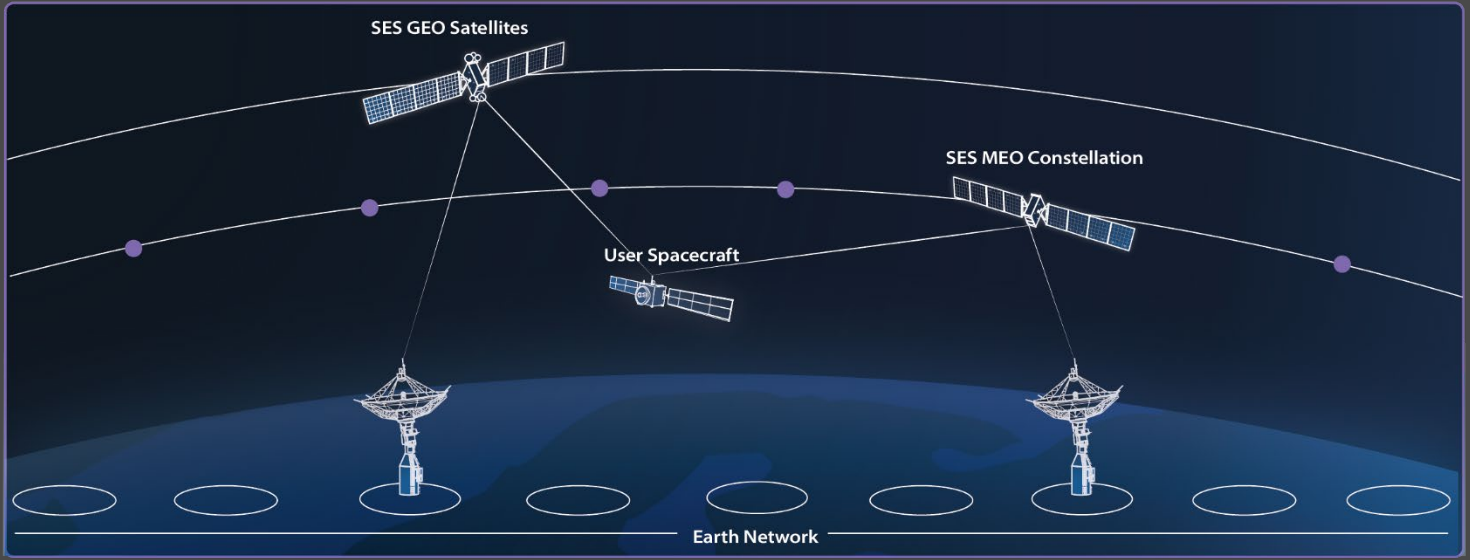
A constellation of more than 3,000 satellites deployed in LEO and equipped with optical terminals and advanced antennas will link to a secure, ground-based communications network to deliver resilient, low-latency communications to users on Earth and in space.

KEY FEATURES

- High-speed, low-latency optical services
- Resilient on-orbit optical mesh networking
- End-to-end encryption for customers
- Secure, global ground network
- Improved performance over traditional C- and Ku-bands

SES

NETWORK ARCHITECTURE



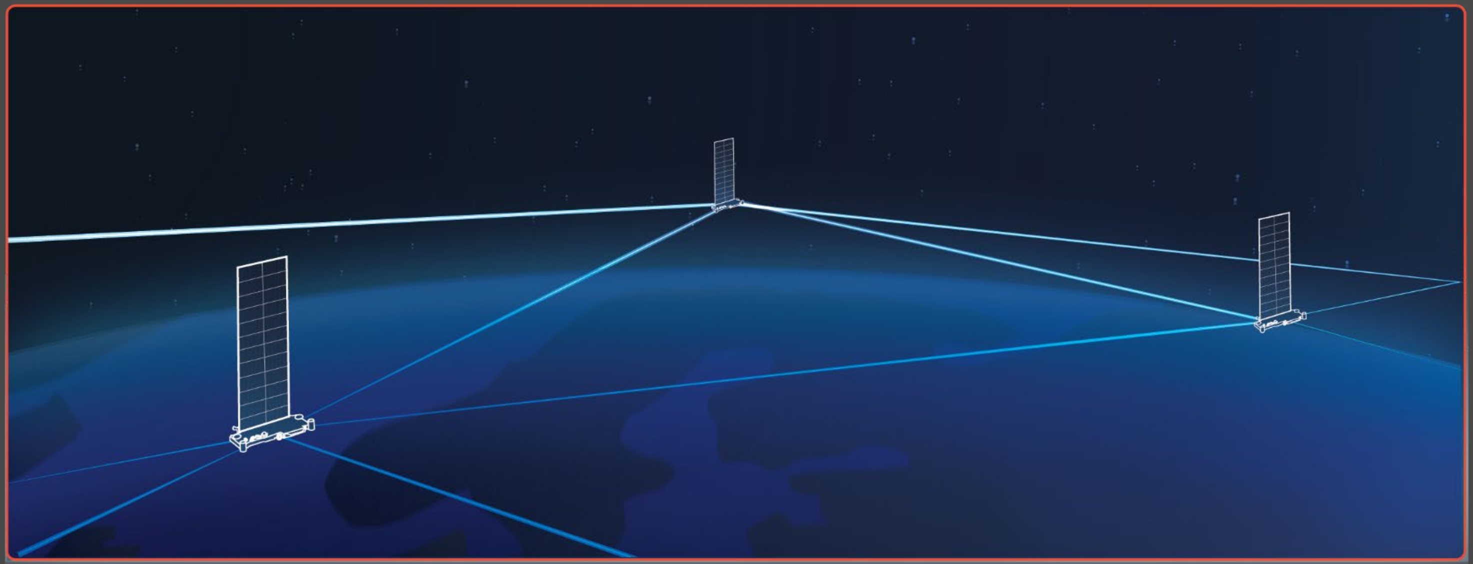
SES' multi-orbit, multi-band offering will support routine missions, contingency operations, launch and ascent, and early operations phase communications across multiple bandwidths for spacecraft in low-Earth orbit.

KEY FEATURES

- Multi-band, multi-orbit satellite services
- Proven non-geostationary orbit (NGSO) innovative technology
- 5000 customer beams per O3b mPOWER satellite
- Designed to meet stringent cybersecurity requirements
- High throughput – up to 100 Mbps per LEO spacecraft

SpaceX

NETWORK ARCHITECTURE



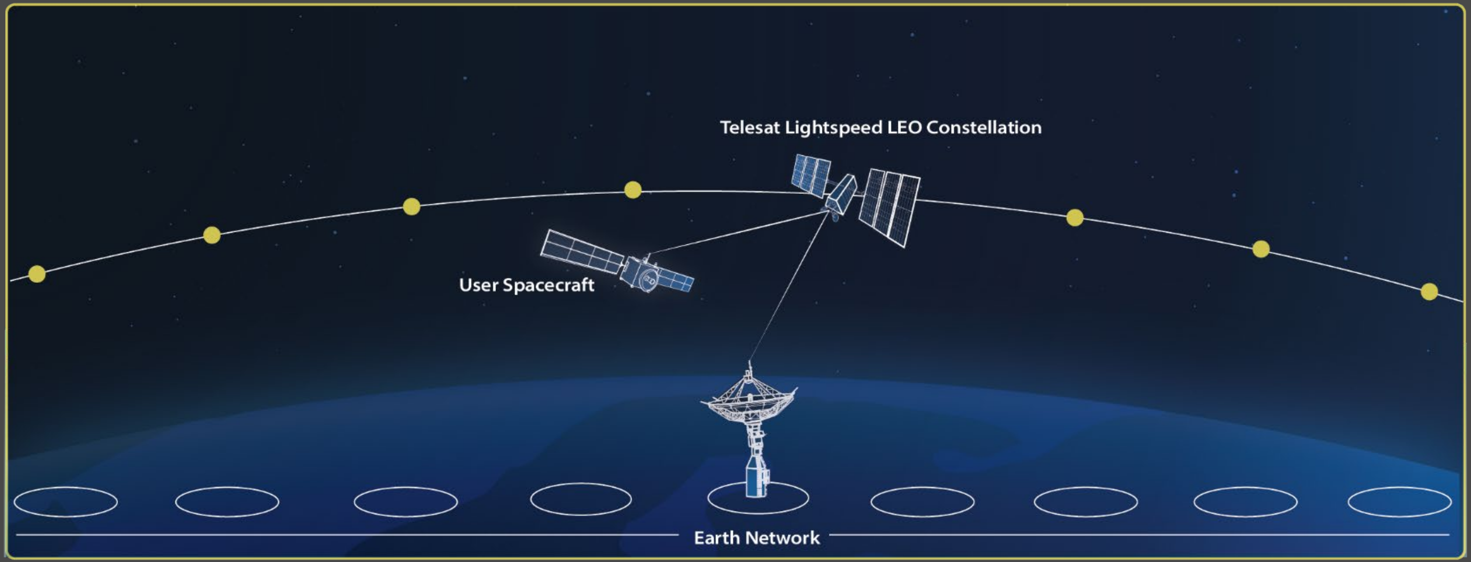
SpaceX will leverage the powerful mesh network of their established Starlink satellite constellation and leading-edge laser communications technology to provide data relay services for a variety of missions.

KEY FEATURES

- Reputable Starlink LEO constellation with proven reliability
- Enabled through leading-edge laser communication technology
- Mesh communications network constructed of optic intersatellite links
- Always-on capability with no prioritization or de-confliction required enabled by autonomous scheduling and data routing
- Bidirectional communication from and to anywhere in less than 100ms

Telesat

NETWORK ARCHITECTURE



Telesat will harness the power of their advanced Telesat Lightspeed network to demonstrate connectivity, tasking and command, telemetry, and mission data flow services to users in LEO.

KEY FEATURES

- Optically linked LEO satellites
- RF space-to space relay capabilities
- Inter-satellite latency on par with fiber networking
- High throughput providing enterprise-class connectivity
- Advanced digital beam-forming technology for dynamic capacity allocation

Next Steps: Path to Commercial SR Services

2022

- CSP formulated to demo commercial Earth Proximity Space Relay
- 6 FSAA Awards June 2022
- Demos through mid 2027
- CSP User Group (CSUG) to share status of the demos with mission community

2023

- NSN Services RFP released Feb 2023
- Awards summer & fall expand set of DTE providers

2024

- Agency decision milestone for TDRS flyout to assess progress, vendor readiness, and projected ability to meet user needs

2025

- Wideband multilingual terminal flight demo

2026

- Define service requirements
- Finalize framework for how validation of SATCOM services

2027

- Initiate fair and open competitive process to select first vendor set
- Release RFP

2028

- Complete “validation readiness reviews” before executing validation activities (per vendor)

2029

- **Final validation tasks completed.**
- **2029 CSP will deliver an operational SR capability to the NSN to manage.**

2030