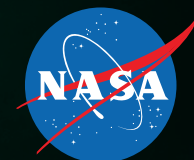


NEAR SPACE NETWORK

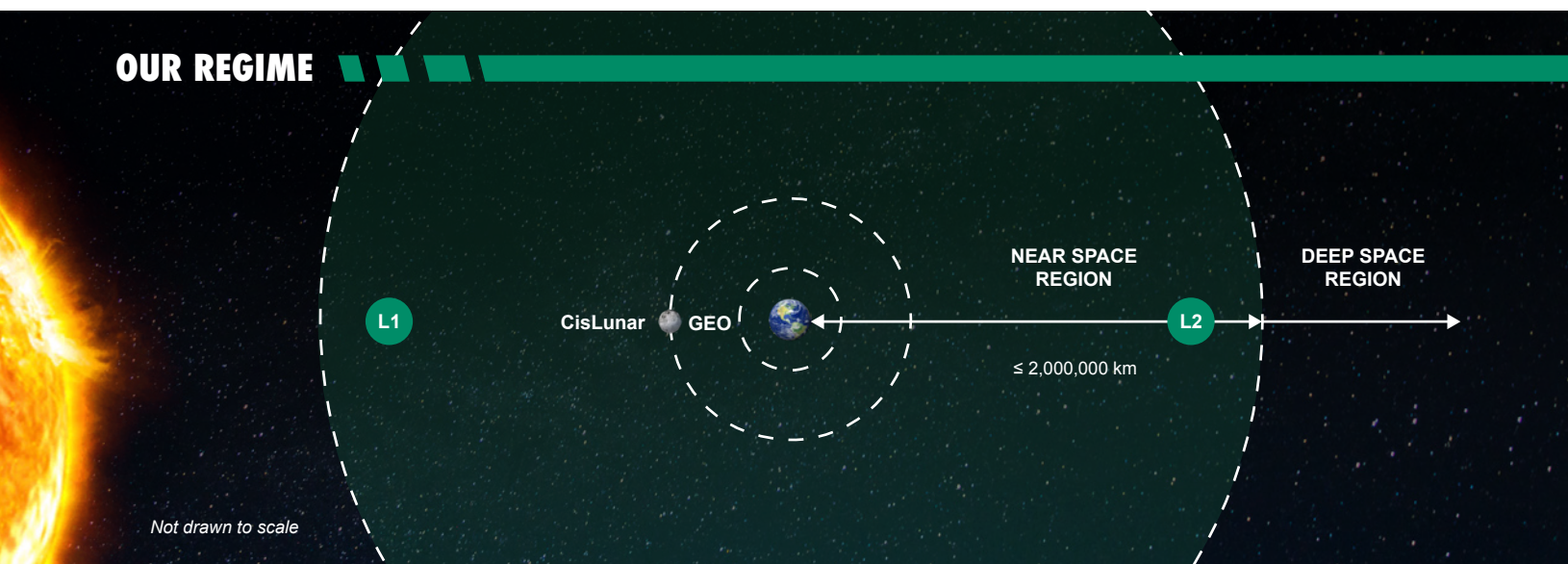
National Aeronautics and
Space Administration



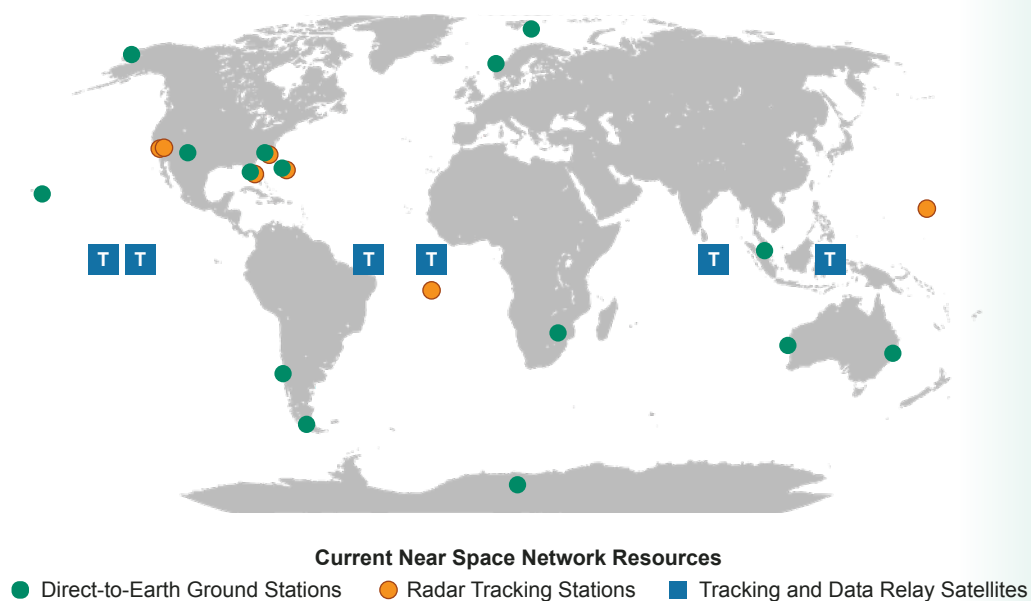
NASA's Near Space Network (NSN) empowers user missions with critical communications and navigation services, enabling the transmission of science and exploration data to and from space. Through space relays and ground-based antennas, the NSN provides data delivery and satellite tracking services, transmitting an average of almost 15 terabytes of critical data daily. As a single point of interface for missions in the near-space region, the NSN orchestrates services through a robust blend of government and commercial service providers.

The network leverages a broad spectrum of government and commercial capabilities and services, negotiating with providers on behalf of all missions to lower the costs of mission services. Users can confidently rely on the proficiency and expertise of NASA's Goddard Space Flight Center, which has a 60-year legacy of excellence in managing NASA communications services.

OUR REGIME



NETWORK MAP

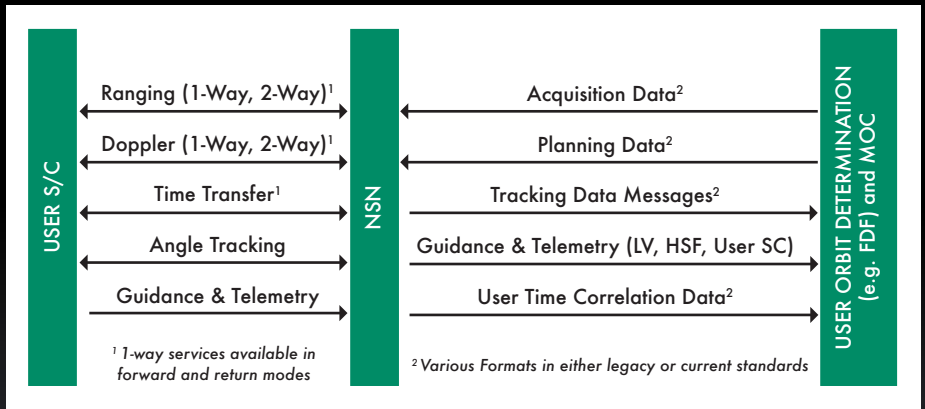


SERVICES PROVIDED

The NSN provides four main services to mission customers:

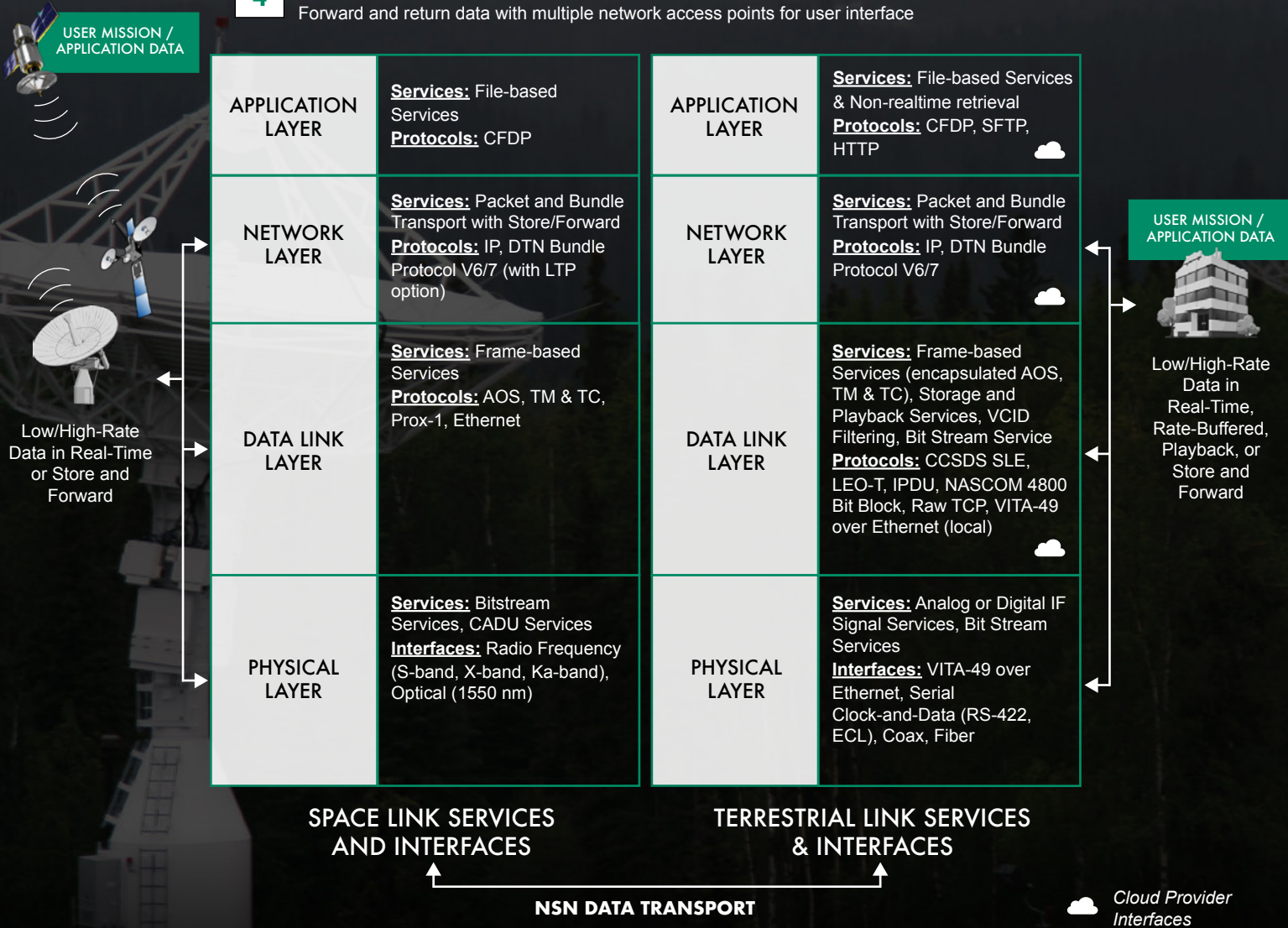
- 1** Mission Integration: development of service agreements, interfaces, documentation, support of reviews, etc.
- 2** Mission Planning and Scheduling: performing link and loading analyses, supporting service requests, and generating and implementing operational schedules
- 3** Position, Navigation,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

3 NSN PNT OPERATIONAL SERVICES






4 NSN END-TO-END USER MISSION DATA TRANSFER SERVICES

Forward and return data with multiple network access points for user interface



INTERFACES AND CAPABILITIES

INTERFACE/CAPABILITY ^a	DIRECT TO EARTH	SPACE RELAY
1 Mission Integration and Operational Support 		
Customer Mission Engineering and Support Services ^c	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 ^c	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 ^a	<u>Range</u> ^d : S/X-band: ≤ 1 m systematic; 5 m noise, 1σ <u>Doppler (Range-Rate)</u> ^d : 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 <u>Antenna Angles (From Ground)</u> : S: 0.03° , X: 0.05° Ka: 0.01° (auto), 0.05° (program)	<u>Range</u> ^d : S/Ku-band: ≤ 4.5 m systematic; 2.73 m noise, 1σ <u>Doppler (Range-Rate)</u> ^d : 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 <u>Antenna Angles (From Relay)</u> : $\leq 0.1^\circ$
Relative Dynamics ^e	Velocity: ≤ 11.6 km/s free flight, ≤ 15 km/s powered flight; Acceleration: ≤ 14.8 m/s ² free flight, ≤ 50 m/s ² powered flight; Jerk: ≤ 0.02 m/s ³ free flight, ≤ 2 m/s ³ 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)	
Other	Ground Antenna Slew Rate: Azimuth and Elevation: $\geq 10^\circ/\text{sec}$ ($10^\circ/\text{sec}^2$) * Train: $\geq 5^\circ/\text{sec}$ ($5^\circ/\text{sec}^2$) * 18-meter systems $\geq 2^\circ/\text{sec}$ ($1^\circ/\text{sec}^2$)	Time Correlation: User Spacecraft Clock Calibration System: $\leq \pm 5$ μs Return Channel Time Delay: $\pm 25\%$ of a bit period
4 Terrestrial Link Data Transport Capabilities ^b 		
Data Storage ^a	Station storage: 5-30 days; Cloud-based: Mission-driven	7 days
Network Data Rate ^a	Mission-driven (up to 1.2 Gbps)	
SLE Protocols	F-CLTU, EF-CLTU (Forward), RAF, RCF, ROCF (Return)	
SLE Versions Supported ^b	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 ^{a b}	20.4 Mbps	1.244 Gbps
Max Return Data Rate ^{a b}	261 Mbps	1.244 Gbps
Modulation ^{b c}	PPM (Order 16 or 32)	PPM (Order 16) or DPSK
Encoding ^{b c}	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 ^e	S-band: 2025-2110 MHz Ku-band: 13.775 GHz Ka-band: 22.55-23.55 GHz ^d

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) b	S-band: 6 MHz Ku-band: 50 MHz Ka-band: 50 MHz d
Forward Max Data Rate (prior to encoding) ^{a b}	S-band: 5 Mbps X-band: 10 Mbps (5 Mbps Typical) e 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) ^a	S-band: 51-81 (56 typical) X-band: 85-86 Ka-band: 89 e	S-band MA: 42 d S-band SA and Ku-band SA: 48.5 d Ka-band SA: 63 d
Modulation ^{b e}	PM, FM, PCM, PCM/PM, PCM/PSK/PM, BPSK, QPSK, OQPSK, UQPSK, Filtered OQPSK	<u>Spread spectrum</u> : BPSK or UQPSK <u>Non-spread</u> : BPSK, QPSK, OQPSK, PCM/PM, or PCM/PSK/PM
Encoding ^{b e}	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 d
Maximum Bandwidth	S-band: 5 MHz X-band: 375 MHz X-band (SRS): 10 MHz Ka-band: 1500 MHz a	S-band (MAR & SAR): 6 MHz Ku/Ka-band: 225 MHz Ka-band (Wide): 650 MHz d
Return Max Data Rate (prior to encoding) ^{a b}	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 d Ka-band (Wide): 1200 Mbps d
Antenna System G/T (dB/K) ^a	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) d
Demodulation ^{b e}	PM, FM, PCM, PCM/PM, PCM/PSK/PM, BPSK, QPSK, OQPSK, AQPSK, Filtered OQPSK, SQPN, 8PSK	<u>Spread spectrum</u> : BPSK or OQPSK <u>Non-spread</u> : BPSK, QPSK, OQPSK, 8PSK PCM/PM, or PCM/PSK/PM
Decoding ^{b e}	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, atmospheric, 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.

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