SCaN-MOCS-0001

SPACE COMMUNICATIONS AND NAVIGATION PROGRAM

Space Communications and Navigation (SCaN) Mission Operations and Communications Services (MOCS)

Revision 2

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National Aeronautics and Space Administration

NASA Headquarters
Washington, D. C.

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Space Communications and Navigation (SCaN) Mission Operations and Communications Services (MOCS)

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Preface

This document is under configuration management of the SCaN Integrated Network Configuration Control Board (SINCCB). This document will be changed by Documentation Change Notice (DCN) or complete revision. Proposed changes to this document must be submitted to the SCaN Configuration Management Office along with supportive material justifying the proposed change.

Comments or questions concerning this document and proposed changes shall be addressed to:

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Change Information Page

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Revision	***Effective Date***	***Description of Change***
Baseline (CR 106)	March 21, 2016	Initial Release

Revision 1 (CR 120)	March 26, 2018	• Editorial revisions for clarity, verbiage, grammar, and acronyms throughout the document • Replaced DSN Mission Services Planning & Management Office (DMSP&MO) with CIMO throughout the document • Updates throughout the document for consistency with other SCaN documentation • Changes references from Communications Service Office (CSO) to NASCOM in Sections 3.4 and 4.2 • Updated SN Rates in Section 5.3 to match published 2017 SN Rate Letter • Reconfigured Section 5.3 to create a more balanced presentation of the material between the three SCaN networks • Moved Costs for using the DSN from Section 5.4 to Appendix F • Updated contact information for the Points of Contact in Section 6 • Added references to the Customer Service Portal in Section 6.1 • Moved Acronym list to Appendix A • Updated references in Appendix B • Updated tables in Appendix D • Added Points of Contact to Appendix E • Updated cost algorithms in Appendix F
Revision 2 (CR 125)	March 15, 2019	• General updates for 2018-19 information throughout the document • Updated SN Rates in Section 5.3 to match published 2018 SN Rate Letter • Updated Points of Contact in Section 6.2 • Updated cost algorithms in Appendix F

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Section 1. Introduction

1.1 Purpose

This document is intended to assist in the preparation of proposals responding to Announcements of Opportunity (AOs) that are issued by National Aeronautics and Space Administration's (NASA) Science Mission Directorate (SMD).

NASA provides many mission operations and communications services relating to the planning and execution of the transport of voice, video, and data for mission support. Costs accrue when using these services and estimates, and these costs need to be included in proposals responding to an AO. To facilitate proposal preparation, proposers are encouraged to read this document and to contact the individuals named in Section 6. Respondents preparing proposals should carefully review this entire document to ensure that the document that they are submitting addresses each applicable item.

In order to appropriately assess SCaN's ability to support candidate missions, it is in the interest of the selected investigation teams to provide information on the communication parameters when submitting a proposal. To that end, while this document provides an initial set of information, additional detail is often referenced. Appendix A contains references and links to websites where further information can be found. Appendix C, Appendix D and Appendix E provide samples of the information that should be submitted with the proposal. For more details on the requested information, proposers are encouraged to contact the points of contact listed in Section 6.

1.2 Scope

Services and support offered by NASA's SCaN networks are available to all NASA sponsored flight projects and science investigators; the SCaN networks provide standard services to NASA missions—from Hubble Space Telescope to smallsat missions. Other Government agencies and commercial flight projects may become eligible for services offered by the SCaN networks through negotiation with NASA Headquarters.

The scope of this document covers the SCaN networks services that are current at the time of publication. This document will be updated over time as new services and rates are made available to the public.

1.3 SCaN Network Services Division

NASA's SCaN Program manages and directs the Mission Commitment Office (MCO) and the three networks that provide Data Transport, Navigation, and Radiometric and Science services for different types of missions. Functional responsibilities for the MCO and the three networks are shown in Figure 1-1.

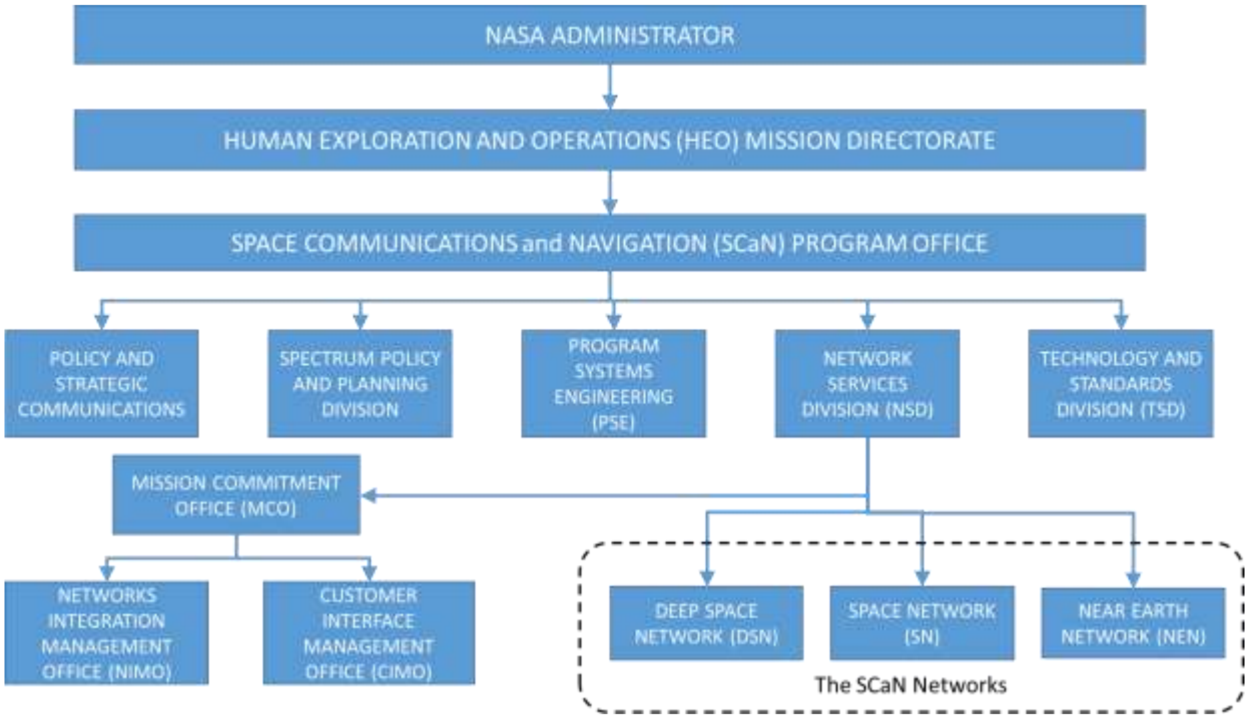

Figure 1-1: Network Functional Responsibility

1.3.1. MCO

SCaN implements a well-established process to capture and assess user requirements in order to determine how to best support those requirements. The process is collaborative and relies on continuous communication and exchange of information between the customer and SCaN throughout all phases of mission development. It is the responsibility of SCaN's MCO, along with the Networks Integration and Management Office (NIMO) and the Deep Space Network's (DSN) Customer Interface Management Office (CIMO) to facilitate this process on behalf of the SCaN networks.

1.3.2. The SCaN Networks

The SCaN networks—comprised of the Near Earth Network (NEN), the Space Network (SN), and the DSN—provide communications and navigation services over the full operational life cycle of a mission from launch to end of life and/or deorbit. While missions may have a desire to use specific resources in accordance with NPD 8074.1 Management and Utilization of NASA's Space Communication and Navigation Infrastructure, the SCaN networks will make the final decision on the provision of its assets.

1.3.2.1. DSN

The DSN, consisting of ground stations utilizing 34- and 70-meter antennas, is focused on providing support to missions operating beyond Geosynchronous Earth Orbit (GEO). Historically, the DSN has supported High Earth Orbit (HEO), Lunar, Lagrangian, and planetary missions. The DSN operations are the responsibility of the Jet Propulsion Laboratory (JPL) in Pasadena, California.

1.3.2.2. NEN

The NEN, consisting primarily of a combination of NASA, partner, and commercial ground stations with antennas up to 18 meters in diameter, is focused on supporting launch and operational activities in the Low Earth Orbit (LEO) range as well as GEO, Lunar, and Earth-Sun Lagrange points. Most NEN antennas slew very quickly, enabling the NEN to track Launch vehicles during ascent and high-speed low altitude missions with brief visibility windows. The NEN operations are the responsibility of Goddard Space Flight Center (GSFC) in Greenbelt, Maryland.

1.3.2.3. SN

The SN, consisting of a constellation of relay satellites in GEO pointing towards the Earth and the ground segment that operates the constellation, enables continuous communications services to missions operating in Medium Earth Orbit (MEO) and below with support provided to Highly Elliptical Orbit (HEO) when the orbit brings the spacecraft within range. The SN has continuous visibility to missions from Launch through LEO operations. NASA's SN is the responsibility of the GSFC.

Section 2. SCaN Network Policies and Standards

It is NASA policy that space missions receiving funding from NASA comply with all applicable international and United States regulations, standards, and agreements. Such regulations and standards include those promulgated by the:

- International Telecommunications Union (ITU)
- National Telecommunications and Information Agency (NTIA)
- Consultative Committee for Space Data Systems (CCSDS)
- Space Frequency Coordination Group (SFCG).

Information about the ITU and NTIA regulations may be obtained from NASA's Spectrum Management Office by consulting the reference documents listed in Appendix A. Additional information on recommended CCSDS standards applicable to the support that the SCaN networks provide as well as recommendations from the SFCG can also be found by consulting the reference documents listed in Appendix A.

2.1 Use of the Electromagnetic Spectrum

Per NASA Policy Directive (NPD) 2570.5E, it is NASA policy that all NASA satellite, airborne and other missions, whether directly developed and operated by NASA or those supported through contracts or other financial agreements that require the use of the electromagnetic spectrum, shall follow the United States and international spectrum regulatory rules and processes. All uses of the radio frequency spectrum require an authorization either from the NTIA, for Federal Government systems, or a license from the Federal Communications Commission (FCC) for Non-Federal Government systems (e.g., commercial, academic).

The design and operation of systems using radio-frequency communications, navigation, and sensors (i.e., any system that involves the use of the radio frequency spectrum for transmission, reception, or both) needs to consider a variety of factors, including spectrum regulations, network services, spaceflight equipment availability, and others depending upon the mission needs. Additional information concerning NASA spectrum policy and processes can be found in NPD 2570.5E and NASA Radio Frequency Spectrum Management Manual (NPR 2570.1C). These requirements and processes apply to electromagnetic spectrum use for radio frequency (<300 GHz) communication, navigation, radio science, active sensing, and passive sensing.

All missions and projects requiring the use of the electromagnetic spectrum should contact the associated Center/Facility Spectrum Manager (SM) as early in the proposal or mission development process as possible to discuss the electromagnetic spectrum operations concept and the necessary system certification and frequency authorization (licensing) requirements. The current NASA Center SMs, NASA National Spectrum Program Manager, and other points of contact are provided on NASA's spectrum website (www.nasa.gov/directorates/heo/scan/spectrum/index.html).

2.2 Bandwidth Efficient Modulation (DSN, NEN, SN)

Missions operating in the 2, 8, 26, and 32 GHz spectral bands should employ bandwidth efficient modulation methods in conformance with SFCG and CCSDS recommendations. Spectral Emission Masks for Category A missions ($r < 2 \times 10^6$ km, where "r" is the range from the spacecraft to Earth) are found in the SFCG's Handbook, available on the SFCG web site. Specific modulation methods meeting the SFCG mask are enumerated in CCSDS Recommendations 401 for non-deep space and Earth resources missions, respectively.

As a matter of DSN policy, it is recommended that Category B missions ($r \geq 2 \times 10^6$ km) employ bandwidth efficient modulation to comply with SFCG Recommendation 23-1, from CCSDS 413.0-G-2, whenever operating in the 8400 - 8450 MHz band. CCSDS Recommendation 401 (2.4.17B) B-1 lists acceptable modulation schemes. Not all schemes are implemented in the DSN, so there may be additional losses that need to be accounted for due to mismatches between the spacecraft transmission and the ground demodulation.

2.3 Coding

Most missions employ error-detecting/error-correcting codes to substantially improve telemetry link performance. Users are reminded that their encoders should conform to the CCSDS Telemetry Channel Coding Blue Book. Supported codes include but are not limited to:

1) Uncoded
2) Convolutional Rate 1/2
3) Convolutional Rate 1/3 (DSN does not support)
4) Reed-Solomon
5) Convolutional/Reed-Solomon
6) Turbo codes with rates: 1/2, 1/3, 1/4, or 1/6
7) Low Density Parity Check (LDPC) Rate ½ (DSN supports rate 2/3 and 4/5 also)
8) LDPC Rate 7/8 (Note: This service has been partially implemented and is not yet available across the SCaN networks).

DSN has implemented LDPC for all frequency bands except Near Earth Ka-band (26 GHz) and will implement Near Earth Ka-band in the future. The SN and NEN also support LDPC.

Proposers are encouraged to contact the representatives listed in Section 6.1, Requesting MCO Support, for the most recent list of supported codes.

2.4 Space Link Extension (DSN, NEN, SN)

Missions using DSN and SN services may utilize a standard Space Link Extension (SLE) Services Interface for transferring data to and from DSN or SN sites to control centers on the ground (e.g., Project Operations Control Center [POCC], Mission Operations Center [MOC], etc.). NEN SLE services are limited to certain antennas, including but not limited to the White Sands 1 (WS1) ground system, the Wallops Ground Station (WG-1) and McMurdo Ground Station (MG-1).

Seven international space agencies, including: Agenzia Spaziale Italiana (ASI), Centre Nationale d'Etudes Spatiales (CNES), Deutsche Zentrum fur Luft- Und Raumfahrt (DLR), European Space Agency (ESA), Indian Space Research Organization (ISRO), Japanese Aerospace Exploration Agency (JAXA), and NASA have agreed to implement the SLE Services Interface to achieve full international interoperability. The interface architecture conforms to standards adopted by the CCSDS.

Section 3. Summary of SCaN Network Standard Services

SCaN has developed a set of *Standard Services* which are inherent to the current functional capabilities of the SCaN networks without modification. There are little-to-no modifications/dependencies on the development of new functions within any of the SCaN networks for standard services. Use of the Standard Services enables more streamlined service evaluation, acquisition, and use. Current Standard Services include end-to-end transport of information between the point of origin (e.g., mission platform[s]) and destination (e.g., mission operations center, university, etc.).

Standard services for Data Transport facilitate the exchange of information between a mission's platform(s) and locations on the Earth. Typically, minimal processing is applied to the data—only that which is necessary to communicate with the end points (e.g., RF encoding to IP-based transport). Transported data may include voice, video, and/or data. Note that Command and Telemetry data are critical subsets of Forward and Return data transport functions. As services for this type of data deal particularly with the exchange of information to and from a mission's platform(s) for the purposes of monitoring and maintaining control of the platform, this information is typically of higher priority than other categories of data to be transported by the SCaN networks.

This section provides a very brief summary of the standard services that the SCaN networks offer their customers. For additional information on these services, please reference the SCaN Services Catalog (see Appendix A for reference information). Each of the service categories listed in the tables below may contain several services. Some of those individual services may require that special arrangements be made with SCaN before they can be provided. Proposal respondents who are interested in services that are not a part of the standard Tracking, Telemetry & Command (TT&C) set should contact the person(s) named in Section 6. for additional information.

3.1 NEN Service Summary

Table 3-1 summarizes the NEN service categories. More detailed information can be found in the SCaN Services Catalog and the NEN User Guide (See Appendix B for references).

Table 3-1: NEN Service Summary

Service Category	Service	Service Type	Brief Description
Data Transport	Forward	Data Stream	Forward: Transmission of voice, video, and/or data, and delivery of telecommands to spacecraft. Return: Telemetry voice, video, and/or data capture, decoding, and additional value-added data routing.
	Return	Data Stream	

Service Category	Service	Service Type	Brief Description
Navigation and Radiometric	Radiometric	Raw Doppler	Measurements and products based on one-way Doppler, two-way Doppler, and range tones; processing to determine orbital elements for mission platform navigation.
	Radiometric	Raw Ranging	
	Radiometric	Tracking Angle Data	

3.2 SN Service Summary

Table 3-2 summarizes the service categories provided by the SN. More detailed information can be found in the SCaN Services Catalog and the SN User Guide (See Appendix B for references).

Table 3-2: SN Service Summary

Service Category	Service	Service Type	Brief Description
Data Transport	Forward	Data Stream	Forward: Transmission of voice, video, and/or data and delivery of telecommands to spacecraft. Return: Telemetry voice, video, and/or data capture, decoding, and additional value-added data routing.
	Forward	Forward Communications Link Transmission Unit (FCLTU)	
	Return	Data Stream	
	Return	All Frames	
	Return	Channel Frames	
Navigation and Radiometric	Radiometric	Raw Doppler	Measurements and products based on one-way Doppler, two-way Doppler, and Pseudo Noise (PN) ranging; processing to determine orbital elements for mission platform navigation.
	Radiometric	Raw Ranging	
	Radiometric	Tracking Angle Data	

3.3 DSN Service Summary

Table 3-3 summarizes the service categories supported by the DSN. More detailed information can be found in the SCaN Services Catalog and the DSN Service Catalog (see Appendix B for references). See Table 3-3 for a list of standard DSN services included in the *Aperture Fee.*

Table 3-3: DSN Service Summary

Service Category	Service	Service Type	Brief Description
Data Transport	Forward	FCLTU	Forward: Transmission of voice, video, and/or data, and delivery of telecommands to spacecraft. Return: Telemetry voice, video, and/or data capture, decoding, and additional value-added data routing.
	Forward	File	
	Return	All Frames	
	Return	Channel Frames	
	Return	File	
	Return	Packet	
Navigation and Radiometric	Radiometric	Validated Doppler	Measurements and products based on one-way Doppler, two-way Doppler, and range signal; processing to determine orbital elements for mission platform navigation. Radio interferometric techniques used to determine the plane-of-sky position and velocity of a user mission platform (Delta-DOR).
	Radiometric	Validated Ranging	
	Radiometric	Delta-DOR	
Science	Science	Radio Science	Radio Science: Open-loop receiver measurements. VLBI: Similar to Radio Science but measures natural phenomena. Wide and narrowband VLBI. Radar: Transmits Radio Frequency (RF) carrier toward user-defined target; captures reflected signal.
	Science	Very Long Baseline Interferometry (VLBI)/Radio Astronomy	
	Science	Radar Science	

3.4 MCO Service Summary

Table 3-4 summarizes the services supported by MCO. More detailed information can be found in the SCaN Services Catalog (see Appendix B for reference information).

Table 3-4: MCO Service Summary

Activity	Description
Non-Recurring Engineering	Up-front engineering costs associated with research, development, design, and testing. Once developed and manufactured, those up-front costs are no longer incurred; hence the “non-recurring” aspect of the costs.
RFICD Development	The RF Interface Control Document (RFICD) (called the Operations Interface Control Document [OICD] for DSN) is a required document developed early in the design phase. It describes, defines, and identifies the specific radio frequency communications interface details and the performance parameters of the communications link between the customer's spacecraft and the SN, NEN, and DSN. As part of its development, analysis activities determine that the RF link can be closed using the Networks assets.
Coverage Analysis	Analysis to determine the extent to which Network assets cover the area for the requested communications and/or navigation services. The analysis is performed to verify that SCaN is able to meet customer requirements with respect to the SCaN assets identified for mission service. Coverage analysis begins during the early customer requirements phases and continues until firm-coverage requirements and flight segment design are finalized.
Compatibility Testing	Verify and validate the compatibility between the satellite/spacecraft transponder and the networks, using test equipment at GSFC facilities and JPL facilities that emulate the utilization of a network asset. Compatibility tests occur prelaunch in order to minimize post-launch anomalies and expensive troubleshooting. Completion of the required testing results in certification of the transponder/transmitter being tested and validates RF computations.
End-to-End Validation	Utilizing Network assets end-to-end tests (e.g., Project Interface Tests [PIT]) verify that all applicable Network interfaces and electronic communications, including mission operations [control] center(s), communications circuits/paths, and the network service provider are in place and functioning to fully support mission operations. This type of test for the DSN requires the spacecraft as one end point and the MOC as the other.
Network Integration Management Staffing	Personnel assuring the continued understanding of the mission’s requirements, concerns, system performances, etc., by providing and integrating Network services. Network Integration Managers (NIM) at GSFC and Mission Interface Managers (MIM) at JPL act as the service provider gateway and interface with customers from early planning through design, development, testing, flight operations, and closeout.

Activity	Description
Network Integration Management Documentation	Generation of mission operations-related documentation to meet mission requirements.
Loading Analysis	Assessment (internal) of Network service capabilities and capacity with respect to mission requirements. Missions requiring unique communications equipment and modifications at SCaN facilities for unique data-handling requirements.
Verification Testing	Various tests performed to verify the Networks ability to meet mission requirements. Network verification testing is accomplished without the mission's participation. It is an internal network check of operational configuration and capability where coordination of the applicable engineers and assets are exercised. It may include test data injection at the front end and cursory local systems checks.
Agreements	Documents the commitment for a specific mission to receive standard and custom data support services from SCaN Networks, including any request for supplemental services from non-NASA stations. Service Level Agreements (SLAs) commit SCaN's Networks to specific services for the duration identified in the agreement. While DSN Service Agreements (DSAs) and Project Service Level Agreements (PSLAs) are the primary agreements describing committed services, service level agreements may also include a combined Service Level Agreement (SLA) for missions requesting services from multiple Networks, Task Agreements (TA), Internal Task Agreements (ITA), and Implementing Arrangement Documents (IAD).
Anomaly Resolution	Anomaly resolution will be undertaken, as necessary, to identify the root cause of an anomalous event. *Note: The first block of time, as identified in the DSA/PSLA/SLA, is funded by SCaN. Additional charges are assigned in accordance with the cause of the anomaly*.
Access to Service Management Capabilities (Schedule, Performance Data)	Missions will have access to scheduling and performance data to conduct mission operations. The access to service management capabilities consist of schedule, performance, and monitoring of the mission.
Readiness Reviews	Mission Commitment Organizations (MCOs) support major reviews for a mission event (e.g., launch, planetary Entry, Departure, and Landing [EDL], planetary maneuver) that include the assessment of the readiness of the SCaN Networks and integrated service providers (e.g., Flight Dynamics Facility [FDF], Ranges, and Department of Defense DoD]). They may include reviews of the Networks' requirements and readiness for a specific mission and/or milestone event.

Activity	Description
Post-Mission Reporting	Provides a report to the customer with a timeline of the Networks' activities that occurred during the service period as well as any anomaly follow-up information. The team conducts a lessons-learned review to assess the planning and operations activities executed during mission support, summarize those findings, and identify opportunities for improvement in the process.
Space Communications Mission Model (SCMM) [1]	A database of all in-flight missions, as well as those in development and formulation, and those in conceptual stages up to 7 years in the future.
Flight Dynamics / Navigation Support	The Goddard Space Flight Center FDF provides services related to antenna pointing and navigation requirements including expertise that provides support through the entire mission life cycle. Flight dynamics and navigation support includes several areas such as expendable launch vehicle tracking and trajectory, mission design, mission analysis, orbit maneuvers, orbit determination, tracking station, and network and data performance evaluation. *Note: The Jet Propulsion Laboratory Advanced Multi-Mission Operations System (AMMOS) provides similar services, beyond geostationary orbit, that are reimbursed to the Science Mission Directorate*.
OCIO/NASCOM Tail Circuits [1]	Unique circuits between the mission control center(s) (MOCs) and the standard NASA-provided/existing communications networks point-of-presence. Activities that are part of this category include planning and coordinating with NASA Communications Network (NASCOM) or commercial entity to provide data transport services for mission.
Unique Project Equipment/Needs	Non-recurring and recurring costs associated with Flight mission projects requiring unique communications equipment and modifications at SCaN facilities for unique data-handling requirements, including hosting customer equipment, custom modification of Network equipment, and mandated site selections.
Mission Operations Proficiency Testing	Data flow testing with all MOCs and SCaN assets on a routine basis to maintain operations proficiency. Includes coordinating and conducting testing among all Flight Operations teams and shifts with a goal of maintaining familiarity and team proficiency, maintaining the interface connectivity, exercising failover, and confirming MOC software performance levels.

[1] These are internal SCaN functions. They are not provided to the customer but are included here for completeness.

3.5 Critical Event Communications

When requesting mission critical event support, proposers may want to consider an expanded set of communications and navigation services and assets compared to routine operations. The MCO is prepared to discuss common approaches to ensure support during critical events. Critical Events are defined as “spacecraft events that could result in the loss of mission if anomalies occur.” These events include:

- Launch and early orbit operations
- Spacecraft separation
- Powered flight
- Critical Maneuvers (e.g., Deep Space Maneuvers [DSMs], docking/undocking)
- Orbit insertion
- Entry/Descent/Landing
- Flybys
- Re-entry

Any of the networks (NEN, SN, or DSN) can provide critical event support—including launch, early orbit, and separation—if the launch trajectory permits. However, in cases where there are coverage gaps, SCaN may need to use one or more fixed or portable ground stations from an external organization to provide adequate coverage.

Section 4. Support from Non-SCaN Network Service Providers

If needed, the SCaN networks will assist user missions with procuring services from other non-SCaN network entities and partners, including but not limited to other SCaN divisions, other NASA organizations, other Government agencies, and international and commercial partners. This section discusses the most common external organizations for whom the SCaN networks assist missions with procuring services.

If the mission desires to use communication and navigation assets outside of the SCaN network, the mission should consult NPD 8074.1 and work with SCaN on the capabilities needed to ensure the most cost-effective method for the agency.

4.1 Spectrum Management

Although the Spectrum Management Office falls under the responsibility of the SCaN Program Office, it is not part of the SCaN networks or MCO (see Figure 1-1). It is NASA policy that any satellite mission supported by the Agency, whether directly developed and operated by NASA or those supported through contracts or other financial agreements that require the use of the electromagnetic spectrum for transmission, reception, or both, shall follow the United States spectrum regulatory rules and processes as well as all applicable international spectrum regulations.

The Center/Facility Spectrum Manager or NASA National Spectrum Program Manager will provide assistance during all phases of a mission or project from conceptual, preproposal efforts through formulation and implementation. The Spectrum Manager will support the project at each review in the project life cycle and assist with design and spectrum considerations such as frequency selection, conformance to regulatory constraints, and compliance with any other electromagnetic spectrum constraints. A key element of this support is assisting with or preparing inputs for spectrum certification as early in the acquisition and procurement cycles as possible.

If support from the Spectrum office is required, proposal respondents may either contact their local center Spectrum Manager or the National Spectrum Program Manager directly or request assistance in coordinating Spectrum support from the SCaN networks by consulting one of the Points of Contact listed in Section 6.

4.2 NASA Communication Network (NASCOM)

The NASCOM provides Wide Area Network (WAN) and Local Area Network (LAN) voice, video, and data services in support of the Agency.

The Corporate Communications Services are managed out of Marshall Space Flight Center (MSFC) and include NASA-wide voice and video teleconferencing, corporate network routed data services as well as Layer 2 Virtual Private Network service. The fundamental function of these services is to provide enterprise-level communications services across the Agency.

The Mission Communications Services are managed out of GSFC and include mission routed data services (including IOnet), dedicated mission data services, and mission voice services. The fundamental purpose of these services is to support spacecraft operations. These include terrestrial transport of spacecraft command, telemetry, and tracking data as well as delivery of science data products. The Mission Network must also address risks to the health and safety of human life as well as serious damage or loss of spacecraft. The mission voice services provide order wire and other voice service in support of spacecraft operations.

4.3 Flight Dynamics Facility (FDF)

The GSFC FDF provides expertise in navigation analysis and system design, operations planning, trajectory design, orbit determination, network operations support, and critical real-time mission operations. This expertise spans the technical areas of orbit determination and trajectory design for low-Earth, geosynchronous, highly elliptical, lunar, libration-point, heliocentric orbits, other celestial-body centered orbits ELV and human spaceflight operations, and support of over 25 on-orbit spacecraft.

FDF evaluates tracking data from the SN, NEN, DSN, and NASA and DoD C-band radar sites and certifies tracking capability for new stations needed for mission support. FDF also participates in end-to-end verification and validation to ensure that FDF products, such as pointing data for the SN and NEN, are received in the proper format. Mission integration is a part of FDF's support of the SCaN networks and its flight project customers. FDF can interface with any of the SCaN networks (NEN, SN, or DSN) to support a mission's flight dynamics needs. Products generated by FDF include ephemerides, acquisition data that is used to establish two-way communication with space vehicles; maneuver planning and execution for spacecraft; on-console support for testing and real-time operations; evaluation of ELV performance during ascent utilizing guidance data; and other navigation sources, local oscillator frequency analysis for Tracking Data Relay Satellite (TDRS) transponders, orbit event predictions, and calibration of sensors used for tracking spacecraft.

The capabilities of the Goddard FDF include the following:

1) Orbit determination in multiple regimes
2) Launch vehicle support, including but not limited to Atlas V, Delta II, Delta IV, and Sea Launch
3) Launch and early-orbit support utilizing a diversity of networks
4) Tracking performance evaluation of a multitude of ground-based and space-borne assets
5) Certification of new tracking equipment
6) Mission integration that combines engineering knowledge of the SCaN networks and the analytical and operational aspects of our flight project customers
7) Backup navigation support to the Human Spaceflight Program
8) International Space Station orbit determination and support to all Visiting Vehicles.

4.4 Advanced Multi-Mission Operations System (AMMOS)

AMMOS is the responsibility of the Multiple Ground System and Services (MGSS) Program located at the JPL. AMMOS consists of a core set of products that can be readily customized to accommodate the specific needs of individual missions. AMMOS provides the elements of a Mission Operations System (MOS) that are common to multiple missions, eliminating the need for duplication of development and maintenance of the MOS. Using AMMOS may lower mission cost and risk by providing a mature base for a MOS.

AMMOS is comprised of multi-mission hardware, software, processes, procedures, and facilities used to implement and operate the MOS. Components of the AMMOS include:

- Planning and Sequencing
- Telemetry Processing
- Data Archive
- Navigation, Mission Design, and Solar System Dynamics
- Operations Configuration Management
- Mission Support Facilities
- Ground Data System (GDS) Integration, Test, Deployment and Support
- Operations Engineering
- Data Relay Coordination for Landed Assets who do not have the direct-to-earth bandwidth needed to execute the mission.

AMMOS supports the entire life cycle of a flight project or experimental investigation.

4.5 JPL Mission Design and Navigation

The JPL Mission Design and Navigation (MDNAV) section provides support in mission design, deep space navigation analysis and operations planning, orbit determination, maneuver design and analysis, critical real-time mission operations, and network operations support. MDNAV typically supports on the order of 25 space missions through all mission phases from pre-project through termination.

The MDNAV charter is to build the maps and tools for interplanetary navigation, design efficient routes for spacecraft to reach any remote solar system location (including within the Earth-Moon system), and safely pilot spacecraft to their ultimate destination. The overarching themes of this work are science-driven modeling, filtering and optimization, managing trajectory knowledge, control, observability, and uncertainties.

The capabilities of JPL MDNAV include the following:

1) Development and refinement of precision ephemerides for solar system bodies
2) Trajectory design and optimization satisfying multiple mission constraints
3) Launch and early-orbit phase operations for missions utilizing the DSN
4) Orbit determination in multiple regimes
5) Maneuver design and analysis
6) Multi-mission flight dynamics software development
7) Astrodynamics technology research and development
8) Certification of new tracking equipment.

Section 5. Network Support Cost Estimation

As a matter of policy, NASA includes estimated costs for mission operations and communications services as well as an assessment of key parameters for mission operations in the evaluation and selection processes of all near-earth and deep-space missions. The purpose of this policy is to:

- Enable evaluation of the reasonableness and cost effectiveness of the proposed communications and navigation approach
- Implement formal NASA-wide, full-cost accounting
- Better manage NASA's heavily subscribed communications resources
- Promote trade-offs between space and ground, including parameters such as data volume, data latency, data rate, contact time, aperture size, and cost of associated systems
- Encourage hardware and operations system designs minimizing life-cycle costs while accomplishing the highest-priority science objectives.

Generally, mission proposals must include nonrecurring (e.g., Mission Planning & Integration [MP&I]) and recurring estimates as well as those for services during routine operations and critical event support.

Cost numbers and equations supplied in this section are for planning purposes only. The calculated estimate of services provided is required by the SMD to document the full value of the mission and its services. NASA missions that use standard services will not be charged by SCaN for recurring cost for aperture or per-minute fees.

This section explains how to estimate costs for the DSN, NEN, and SN. To ensure accuracy and to validate cost estimates, proposal respondents should contact the appropriate representatives listed in Section 6.

5.1 Nonrecurring Engineering Costs

Nonrecurring engineering (NRE) costs (e.g., TT&C services, ground communications, MIM support) are those associated with unique equipment that a mission customer provides at NASA facilities, including installation and sustainment engineering. NRE costs also include any unique equipment that a mission requires as well as its installation and the sustaining engineering of that equipment as well as modifications that the networks must make to their systems in order to recognize a new mission. Proposal respondents are advised to contact the point of contacts listed in Section 6. to obtain a cost estimate for their missions.

5.2 Mission Planning and Integration (MP&I)

MP&I is the set of activities performed and coordinated by the SCaN MCO, NIMO, and CIMO facilitate the successful provision of NASA's space communications services to evaluate and address mission needs. MP&I includes those tasks that must be executed prior to the operational use of the SCaN networks as well as actual cost estimates for the use of SCaN networks in accordance with needed functionality. Typically, MP&I activities occur prior to the launch of a space vehicle, although they may occur any time within the life of a mission if changes are needed. Additionally, for longer-duration missions (e.g., interplanetary), a set of MP&I activities is typically incorporated during the initial planning activities. These MP&I activities may include the development of the RFICD, Compatibility Testing, Anomaly Resolution, and Post Mission Reporting. MP&I activities ensure common understanding of the mission services requirements, understanding of the capabilities of the SCaN networks, and mutual compatibility between the mission (i.e., platform[s], mission operations center[s]) and the SCaN networks). Funding of these efforts is dictated by NASA policies. Because both NASA missions and SCaN are funded through NASA, NASA missions fund SCaN only for the MP&I activities related to the dependencies on their processes/functionality (e.g., planning and development for non-standard services); they are not charged for the SCaN networks internal management functions related to standard services (e.g., network capacity planning). Conversely, non-NASA missions are responsible for funding all network integration and data-services activities in support of their missions, including reimbursement of SCaN costs in support of their MP&I activities. It is not possible to provide a simple cost structure such as the one used for the specific stations and/or services. Proposal respondents are advised to contact the point of contacts listed in Section 6. to obtain a cost estimate for their missions.

5.3 Cost Estimates for Using the SCaN Networks

Each of the SCaN Networks has a charging paradigm optimized in accordance with the structure of the network. For the purpose of initial costing, service costs can be estimated by multiplying the length of the needed pass (see Table 5-1) by the cost of that pass (see Table 5-2).

In some cases, the length of the pass is just the time that the mission requires service. In others, the length of a pass is determined by taking the length of time that the mission requires service and then adding a period of time at the beginning, called “set up time,” to move the antenna into position and establish the link, and a period of time at the end of the pass, called “tear down time,” to dissolve the link and remove the antenna and link from operations. See Table 5-1 for details on how to calculate the pass length.

Table 5-1: Pass Length Calculation

Network	Pass Type	Pass Length
NEN	Nominal	Minutes of required service plus 10 minutes of set up time and 10 minutes of tear down time.
SN	Nominal	Minutes of required service.
SN	Extended Elliptical	Minutes of required service plus a minimum of 4 minutes of set up time and 4 minutes of tear down time.
DSN	Nominal	Integer multiples of 1-hour plus 45 minutes of set up time and 15 minutes of tear-down time.

The NEN charges on a per-pass basis while the cost for using the SN is dependent on the services provided. The DSN uses a complex set of algorithms to determine aperture fees, which is described in detail in Appendix F.

Table 5-2 lists the advertised rates for using the NEN and SN as well as references for how to determine the rates for using the DSN. These rates are for missions with ops concepts for relatively brief and infrequent communications. Missions whose requirements are different should contact the points of contact listed in Section 6. to determine the cost for using the networks.

Table 5-2: Rates for Estimation for Using the SCaN Networks

Network	Services	Cost
NEN	S-band, X- band, and/or Ka-band forward/command, return/telemetry, and tracking services.	$491.00 per pass, where one pass is ≤ 30 minutes of uplink/downlink time.
SN	Single Access (SA) Service (forward/command, return/telemetry, tracking, or any combination of these).	$91.00 per minute.
SN	Multiple Access Forward Service.	$15.00 per minute.
SN	Multiple Access Return Service.	$8.00 per minute.
DSN	See Appendix F for information on DSN services and how to calculate the fees for those services.	

The rates listed in Table 5-2 are reviewed and may be changed each Fiscal Year. Proposers are encouraged to get the most recent rates directly by contacting NIMO and/or CIMO or from the network websites:

- NEN: http://www.nasa.gov/directorates/heo/scan/services/networks/txt_nen.html
- SN: http://www.nasa.gov/directorates/heo/scan/services/networks/txt_sn.html.
- DSN: https://www.jpl.nasa.gov/deepspace/files/820-100-F1.pdf; page 54, Section 6.3.1

5.4 Critical Event Support Costing

Costs for critical event support, which can be obtained from one of NASA's standard networks (DSN, NEN, SN), is computed in the same way as for routine telemetry support. If it is not possible to utilize one of the NASA networks because no station element is in view or they are otherwise unavailable, then estimates will have to be provided by the appropriate network representatives identified above.

Because mission requirements vary over such a broad range, it is not possible to provide a simple means to calculate the cost of telemetry support in the early mission phase. Please see Section 6. for the point of contact who can assist in establishing alternative solutions and/or in costing the required support.

5.5 Non-SCaN Support Costing

Cost for support from non-SCaN networks resources and entities is dependent on the mission needs and the supporting entity to be used. However, if requested, SCaN will integrate the requested support into the overall network plan. SCaN negotiates the costs for using non-SCaN assets on a case-by-case basis and therefore cannot include that information in this document. SCaN negotiates bulk-buy agreements for the use of commercial and/or international service providers and makes every effort to negotiate the most cost-effective rates possible. However, as these contracts are negotiated on a periodic basis, the actual costs for using such providers cannot be included in this document. If support is required from outside the three SCaN networks, proposal respondents shall contact MCO (per NPD 8074.1) for assistance in assessing the need, capabilities, and cost of those services. Please see Section 6. for the appropriate point of contact.

Section 6. Requesting Support from the SCaN Networks

Early planning and coordination between SCaN and its customers is critical to ensuring quality service with minimal complications. Proposers are encouraged to contact SCaN as early in their development process as possible to begin premission planning and analysis activities and to ensure that the network(s) have both the capability and capacity to satisfy the mission requirements.

During the concept study phase (Phase-A or Step-2), as the mission's concept is more clearly defined, a Letter of Commitment is generated or updated from Step 1. The resulting documentation of services and costs will be captured in the agreement to be signed by appropriate Project and Network representatives by Preliminary Design Review (PDR) for NEN / SN and Critical Design Review (CDR) for the DSN. The agreement will identify all mission operations requirements, including those provided by non-SCaN sources, becoming a source of end-to-end operations information and documenting any cost analyses leading to the selection of non-SCaN services. A Letter of Commitment is only done for Step 1 if nonstandard services are required. Please reference the RFP documentation for a description of Phase A, Step 1, and Step 2 requirements.

6.1 Requesting MCO Support

Missions desiring use of SCaN services should make contact with the SCaN networks as early in the development process as possible. For missions whose assets will be in deep space, contact the CIMO. Missions whose assets are in LEO should contact the NIMO. Missions whose assets are near Earth but beyond LEO may contact either office; the office's first duty will be to help the mission decide which network or combination of networks should be used. Missions may also contact the SCaN Mission Commitment Manager for questions related to which network is appropriate.

The NASA Headquarters point of contact for SCaN assets is:

John Hudiburg
Mission Integration & Commitment Manager
Space Communications and Navigation (SCaN)
NASA Headquarters
Washington, D.C. 20546
Office: HQ:7Z76
Phone: (202) 358-1202
Email: john.j.hudiburg@nasa.gov

For additional information on MCO, its points of contact and the services that it and SCaN provides, proposal respondents may visit the SCaN Customer Service Portal (https://mcocsp.nasa.gov/web/guest/welcome). Please note that this is a public website. Access to the restricted section of this portal, which contains the mission-specific information, will only be granted to the selected proposers after award.

6.2 Process for Requesting NEN or SN Services

At the time when initial science operations concepts are being defined, proposers should contact the person named below for information about NEN and/or SN mission operations services and costs. A representative from the NIMO will assist proposers by providing service and cost information. Further, NIMO aids in documenting initial mission operations requirements in a Networks proposal package.

The point of contact for NEN and SN services is NIMO:

Cathy Barclay, Acting Chief
Networks Integration Management Office, Code 450.1
Exploration and Space Communications Projects Division
Goddard Space Flight Center, Greenbelt, MD 20771
Phone: (301) 286-8626;
FAX: (301) 286-0275
Email: catherine.b.barclay@nasa.gov

6.3 Process for Requesting DSN Services

Proposers should contact the person(s) named below for information about DSN mission operations services and costs at the time when initial science operations concepts are being defined. A representative will assist proposers by providing information concerning services and costs.

The point of contact for DSN services is CIMO:

Glen Elliott
Manager Office 912: Mission Support Definitions and Commitments
Jet Propulsion Laboratory
M/S 301-355
4800 Oak Grove Drive
Pasadena, California 91109-8099
Phone: (818) 393-6373
e-mail: Glen.Elliott@jpl.nasa.gov

Appendix A. Acronym List

AF	Aperture Fee
AF'	Aperture Fee discounted for Multiple Spacecraft per Aperture applications
A_W	Aperture Weighting (For costing DSN stations)
AMMOS	Advanced Multi-Mission Operations System
AO	Announcement of Opportunity
ASI	Agenzia Spaziale Italiana (Italy)
b/s	Bits per second
BER	Bit Error Rate
BWG	Beam Wave Guide (Refers to specific DSN 34M antennas)
Category A	Missions whose distance from Earth is $< 2 \times 10^6$ km.
Category B	Missions whose distance from Earth is $\geq 2 \times 10^6$ km.
CCSDS	Consultative Committee for Space Data Systems
CDR	Critical Design Review
CIMO	Customer Interface Management Office
CNES	Centre National d'Etudes Spatiales (France)
CSO	Communications Service Office
CSR	Concept Study Report
dB	Decibels
DCN	Documentation Change Notice
DDOR	Delta Differenced One-way Range
DLR	Deutsche Zentrum fur Luft- Und Raumfahrt (Germany)
DMSP&MO	DSN Mission Services Planning & Management Office
DoD	Department of Defense
DSA	Deep Space Network Service Agreement
DSM	Deep Space Maneuver
DSN	Deep Space Network
EDL	Entry, Departure, and Landing
ELV	Expendable Launch Vehicle
ESA	European Space Agency
F_C	Frequency of Contacts (For costing DSN stations)
FCC	Federal Communications Commission

FCLTU	Forward Communications Link Transmission Unit
FDF	Flight Dynamics Facility
FY	Fiscal Year
GDS	Ground Data System
GEO	Geosynchronous Earth Orbit
GHz	Gigahertz (1 x 10^9 cycles per second)
GSFC	Goddard Space Flight Center
HEO	Highly Elliptical Orbit
Hz	Hertz (cycles per second)
IAD	Implementing Arrangement Document
ISRO	Indian Space Research Organization
ITA	Internal Task Agreement
ITU	International Telecommunications Union
JAXA	Japanese Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
K	Kilo (1 x 10^3) or Kelvin
K_A-Band	Frequency band: Deep Space (Category B) 31.8 - 32.3 GHz downlink Near-Earth (Category A) 25.5 - 27.0 GHZ downlink
Km	Kilometers
LAN	Local Area Network
LDPC	Low Density Parity Check
LEO	Low Earth Orbit
LEOP	Launch and Early Orbit Phase
MCO	Mission Commitment Office
MDNAV	Mission Design and Navigation
MEO	Middle Earth Orbit
MGSS	Multiple Ground System and Services
MHz	Megahertz
MIM	Mission Interface Manager
MOC	Mission Operations Center
MOCS	Mission Operations and Communications Services
MOS	Mission Operations System
MP&I	Mission Planning and Integration

MSFC	Marshall Space Flight Center
MSPA	Multiple Spacecraft per Aperture
Msps	Megasymbols Per Second
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications Network
NEN	Near Earth Network
NIM	Network Integration Manager
NIMO	Networks Integration Management Office at GSFC
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
NRE	Nonrecurring Engineering
NTIA	National Telecommunications and Information Agency
OCIO	Office of the Chief Information Officer
OICD	Operations Interface Control Document
PDR	Preliminary Design Review
PIT	Project Interface Test
PN	Pseudo Noise
POCC	Project Operations Control Center
PSLA	Project Service Level Agreement
R_B	Base Rate (For costing DSN stations)
Rad	Radians
RF	Radio Frequency
RFICD	RF Interface Control Document
S/C	Spacecraft
SA	Single Access
SCaN	Space Communications and Navigation
SCMM	Space Communications Mission Model
SFCG	Space Frequency Coordination Group
SLA	Service Level Agreement
SLE	Space Link Extension
SM	Spectrum Manager

SMD	Science Mission Directorate (formerly NASA Headquarters Office of Space Science Code S)
SN	Space Network (TDRS)
TA	Task Agreement
TDRS	Tracking Data Relay Satellite
TT&C	Tracking, Telemetry, and Command
WAN	Wide Area Network
WS1	White Sands 1
VLBI	Very Long Baseline Interferometry
X-Band	Frequency band (Space Research Segment): Deep Space (Category B) 7145-7190 MHz uplink, 8400-8450 MHz downlink Near-Earth (Category A) 7190-7235 MHz uplink, 8450-8500 MHz downlink

Appendix B. Reference Documents and Websites

Prospective users of NASA facilities can obtain additional information from the following documents. Please note that some of these documents may only be available behind the NASA firewall. If proposal respondents are in need of a document and cannot access it, they are advised to contact the appropriate point of contact in Section 6.

1) *Radio Regulations*, International Telecommunications Union, Geneva, Switzerland, Latest Edition.
2) *Manual of Regulations and Procedures for Federal Radio Frequency Management*, National Telecommunication & Information Administration, U.S. Department of Commerce, Washington D.C., Latest Edition. ***Information is available at:*** http://www.ntia.doc.gov/osmhome/redbook/redbook.html
3) Consultative Committee for Space Data Systems (CCSDS). Blue Books published by the CCSDS Secretariat, NASA Headquarters, Washington D.C. 20546. ***Copies of CCSDS Recommendations and Reports are available at:*** http://public.ccsds.org/publications/default.aspx
4) *Space Frequency Coordination Group On-Line Handbook*, ***Recommendations and other technical documents are available at:*** https://www.sfcgonline.org/resources
5) *Management and Utilization of NASA's Space Communication and Navigation Infrastructure,* NPD 8074.1. ***Copies of the document are available at:*** http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPD&c=8074&s=1
6) SCaN Customer Service Portal. ***Web site located at:*** https://mcocsp.nasa.gov/
7) NIMO Commitments homepage. ***Web site located at:*** https://esc.gsfc.nasa.gov/nimo
8) Near Earth Network Homepage. ***Web site located at:*** https://esc.gsfc.nasa.gov/nen http://esc.gsfc.nasa.gov/assets/files/453-UG-002905%282%29.pdf
9) Space Network Homepage. ***Web site located at:*** https://esc.gsfc.nasa.gov/sn
10) Deep Space Network Homepage. ***Web site located at:*** https://www.jpl.nasa.gov/deepspace/
11) DSN Commitments homepage. ***Web site located at:*** https://www.jpl.nasa.gov/deepspace/about/commitments-office/
12) *Space Communications and Navigation Network Service Catalog*, SCaN-SERVICE CATALOG. ***Copies of the document are available at:*** https://mcocsp.nasa.gov/web/guest/resources
13) *DSN Service Catalog*, DSN No. 820-100, Rev. F, JPL D-19002, Jet Propulsion Laboratory, ***latest copies available at:*** https://www.jpl.nasa.gov/deepspace/files/820-100-F1.pdf

14) DSN Aperture Fee Calculator located at: https://www.jpl.nasa.gov/deepspace/about/commitments-office/proposal-preparation/ under the heading “DSN Aperture Fee Online Tool.”
15) NASA Communication Network (NASCOM) / Communications Service Office (CSO) homepage. ***Web site located at:*** https://cso.nasa.gov/learn
16) Flight Dynamics Facility (FDF) homepage. ***Web site located at:*** http://fdf.gsfc.nasa.gov/services
17) AMMOS Homepage. ***Web site located at:*** https://ammos.jpl.nasa.gov/
18) Spectrum Management Office homepage. ***Web site located at:*** http://www.nasa.gov/directorates/heo/scan/spectrum/index.html
19) NPD 2570.5E, NASA Electromagnetic Spectrum Management, 11 July 2011. ***Copies of the document are available at:*** http://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=2
20) NPR 2570.1C, NASA Radio Frequency Spectrum Management Manual, 22 Sep 2014. ***Copies of the document are available at:*** http://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=2

Appendix C. Sample MCO Questionnaire

PART A – MISSION INFORMATION

Project full name: Acronym or short title:

Person Submitting Questionnaire: Date:

Title: e-mail address: Telephone:

Project purpose (25 words or less):

Sponsoring organization type: NASA Center Sponsoring org. name:

Current project phase: ☐ Formulation (Phase A-B) ☐ Implementation (Phase C-D) ☐ Operations (Phase E) ☐ Extended operations (Phase E extension)

Expected prime mission duration: Potential extended operations:

Are you planning on utilizing NASA navigation services? ☐ Yes, JPL-NAV ☐ Yes, FDF ☐ No ☐ Not sure

Where is the mission operations control center?

Where will the science data be delivered (facility and location)?

Are you planning on utilizing NASA Communications (NASCOM) Remote Internet Protocol Operational Network (IONet) services? ☐ Yes ☐ No ☐ Not sure

Are you planning to use any non NASCOM communication interfaces (stand alone or in conjuction with NASCOM) for tracking, telemetry and command services?
☐ Yes ☐ No If YES, describe interfaces (i.e. dedicated circuit, public internet with VPN)

Will you require mission voice services? ☐ Yes ☐ No ☐ Not sure

Do you require SN or NEN services during launch and early orbit when the S/C may still be connected to the launch vehicle? ☐ Yes ☐ No ☐ Not sure

Do you require SN, NEN or DSN services during powered flight? ☐ Yes ☐ No ☐ Not sure

Do you require SN, NEN or DSN services immediately following separation when the spacecraft is not at its nominal attitude or not under its final attitude control (i.e tumbling/rotating)? ☐ Yes ☐ No ☐ Not sure

Are there other assets providing services? ☐ Yes ☐ No ☐ Not sure

If yes, which assets?

Points of Contact	**Name**	**Phone**	**Email**
Project Manager			
Project networks services			
Financial point-of-contact			
Radio frequency engineer			

Types of SCaN Network services requested, if known (check all that apply):

Service	SN	NEN	DSN
Telemetry	☐	☐	☐
Tracking*	☐	☐	☐
Science Data	☐	☐	☐

Activities for which services are requested, if known (check all that apply):

Activity	SN	NEN	DSN
Testing	☐	☐	☐
Launch only	☐	☐	☐
Launch and Phase E Support	☐	☐	☐

Command	☐	☐	☐	Please define mission phases			
Radio Science	☐	☐	☐				
*Do you need 1-way or 2-way Doppler during launch & early orbit and/or during on-orbit ops? ☐ Yes ☐ No ☐ Not sure * If 2-way Doppler is n eeded, is Ranging data needed? ☐ Yes ☐ No ☐ Not sure *Are there specific critical events that require mandatory coverage? ☐ Yes ☐ No ☐ Not sure Critical events: List critical support requirements				Backup Contingency	☐	☐	☐
				Pre-Launch Non-Recurring Engineering	☐	☐	☐
				Post Launch special events	☐	☐	☐
				Please list mission phases			
				Nominal operations	☐	☐	☐
				Special Support Reqts	☐	☐	☐
				End-of-life (EOL)/Mission(DSN)	☐	☐	☐

PART A – MISSION INFORMATION CONTINUED

Launch-Related Information

Launch site location:	Launch vehicle:
Launch date:	Name of Primary Payload:
Launch window:	Launch trajectory:
Launch period: to	Recycle time for launch scrubs:

Orbit Information

Apogee and perigee, or semi-major axis and eccentricity for earth orbiting missions:

Inclination for earth orbiting missions:

Argument of right ascension:

Nodal crossing type (ascending or descending) for earth orbiting missions:

Local time of nodal crossing for earth orbiting missions:

Will there be any transfer orbits?

Repeat cycle, if appropriate:

For non earth orbiting missions, describe destination (example L1, L2, Lunar Orbit, Mars orbit, Mercury flyby):

PART B – ADDITIONAL INFORMATION

What organization is obtaining spectrum and frequency authorizations?

If applicable, provide NTIA/FCC Spectrum Certification number and Radio Frequency Authorization (RFA) number. _____

What organization will do acquisition data (ephemeris) generation?

Are there applicable CCSDS standards? ☐ Yes ☐ No Which version?

COP-1? ☐ Yes ☐ No Will VCIDs will be utilized?

COP-2? ☐ Yes ☐ No

Has NASA determined if this mission is a reimbursable? ☐ Yes ☐ No
If yes, provide NASA Point of Contact:

Any additional information or special requests you would like to add?

PART C1 – NEN/SN SERVICES INFORMATION

Frequency

Frequency band to be used: ☐ Ku ☐ Ka ☐ S ☐ X ☐ Other

Will simultaneous receipt (return link) of two bands be required? ☐ Yes ☐ No

What modulation will be used with each band on return link(deg or rad/sin or square)?

What modulation will be used with each band on forward link(deg or rad/sin or square)?

For SN service : ☐ SA ☐ MA ☐ SMA ☐ DAS

Data Delivery (see part D1 for DSN)

Command (R/T forward link) data rates in sps:

Telemetry (R/T return link) data rates in sps:

Science data volume per contact (Mbytes)

Latency (science data delivery) requirements:

PART C1 – NEN/SN SERVICES INFORMATION CONTINUED

Spacecraft Services Information

	Space Network (SN)			Near Earth Network (NEN)		
	Min	**Avg**	**Max**	**Min**	**Avg**	**Max**
Desired number of contacts per day:						
Average length of each contact:						
Are there required min./max. separation times between contacts for telemetry and command?						

Other constraints:

Other special considerations:

PART C2 – NEN/SN RADIO FREQUENCY (RF) INFORMATION FOR LINK ANALYSES

Uplink/Forward Link Information (for each link)

Service Description:

Frequency:

Polarization:

Data Modulation Information:

Description: (Note: If there are multiple channels, please provide the details for each channel; for example, if the signal includes both a channel on the baseband carrier and includes a channel on the subcarrier which modulates the carrier, please describe each channel individually. If the signal is a single data source and separated into channels, please describe (or provide a block diagram) how this signal is separated, including single data rate and separate channel rates and any requirements to recombine the channels into a single data stream.)

Modulation Type: | Modulation Index (if not PSK):

Sub-carrier Modulation Frequency (if applicable):

Data rate prior to any coding (should include CCSDS overhead):

Data format: | Symbol rate prior to any convolutional coding:

Symbol rate after all coding: | Symbol format:

PN spreading rate per SNUG constraints (if applicable):

Required BER: | Receiver implementation loss:

Required acquisition performance:

Other links, modes, playbacks?

NEN Ranging Modulation Information (if applicable):

Description: | Highest tone/code frequency:

Highest tone/code modulation index: | Lower tone/code modulation index (if applicable):

Receive Vehicle RF Information:

Description: | Receive antenna gain Information (include gain characteristics, polarization, and beam-width and axial ratio associated with gain):

Passive loss from antenna to receiver: | Noise figure of receiver and/or system noise temperature at receiver:

(continued on next page)

Part C2 – NEN/SN RF Information, Continued

Downlink/Return Link Information (for each link):

Service description:

Frequency (include description on coherent and non-coherent operations as applicable):

Data Modulation Information:

Description: (Note: If there are multiple channels, please provide the details for each channel; for example, if the signal includes both a channel on the baseband carrier and includes a channel on the subcarrier which modulates the carrier, please describe each channel individually. If the signal is a single data source and separated into channels, please describe (or provide a block diagram) how this signal is separated, including single data rate and separate channel rates and any requirements to recombine the channels into a single data stream.)

Modulation type:

Modulation index (if not PSK):

Subcarrier modulation frequency (if applicable):

Data rate prior to any coding (should include CCSDS overhead):

Data format:

Symbol rate prior to any convolutional coding:

Type of coding :

Symbol rate after all coding:

Symbol format:

PN spreading rate (if applicable):

Required BER:

NEN Ranging modulation information (if applicable):

Description:

Turnaround Modulation Index for a single uplink tone:

Accuracy Requirements:

Transmit vehicle RF information:

Description:

Transmitter power:

Passive loss from transmitter to antenna input:

Transmit antenna gain Information (include gain characteristics and beamwidth and axial ratio associated with gain & polarization):

Tracking Information (excludes ranging, which was discussed earlier):

Description:

Doppler Requirements: ☐ 1-way ☐ 2-way ☐ Differenced One-Way

Doppler Accuracy Required:

Point-of-Contact for RF Link Analyses Questions (name, phone, email):

PART C3 – NEN GATEWAY INFORMATION

Data Volume per Pass	
AOS Frame Size	CRC? ☐ Yes ☐ No
VC Separation? ☐ Yes ☐ No	If Yes, VC List:
Latency Requirement:	Data File naming convention:
Delivery Protocol (SFTP, CFDP, SCP):	
SFTP End Point Retrieval? ☐ Yes ☐ No	If No, Self Service retrieval? ☐ Yes ☐ No

PART C4 – SN GATEWAY INFORMATION

SN Gateway Encapsulation Format:

Space Link Extension ☐ **LEO-T** ☐ **IPDU** ☐

Encapsulation Format General Information:

Frame Sync Enabled? ☐ Yes ☐ No

Frame Sync Pattern xxxxxxxx **Frame Length** ####

Location ☐ First ☐ Last **Size in Bits (default is 32)** ##

Slip Size ## **Search Frames** #

Lock Frames # **Check Frames** #

Automatic Polarity Control Enabled? ☐ Yes ☐ No

NOTE: A detailed questionnaire for selected encapsulation format will be sent to project.

PART D1 – DSN SERVICES INFORMATION OVERVIEW

Frequency

Frequency band to be used: (Near Earth or Deep Space) ☐ Ka ☐ S ☐ X

Will simultaneous receipt of two bands on return link be required? ☐ Yes ☐ No

Data Delivery

Command (R/T forward link) data rates in bps:

Telemetry (R/T return link) data rates in bps:

Science data volume per contact (Mbytes) in bps:

Latency (science data delivery) requirements:

Delay Tolerant Networking (DTN) requirements:

CFDP service requirements and type:

Spacecraft Services Information

Required number of passes per mission phase, e.g. - LEOP, Cruise, orbit insertion, etc, use the DSN RF Aperture Fee tool located at https://dse.jpl.nasa.gov/ext/			
Any 70 meter requirements, if yes give description:	Yes	No	
Any high power uplink requirements above 20kw, if yes give frequency band:	Yes	No	
Are there any special tracking pass requirements: e.g. – DDOR passes per week in what mission phase, MSPA, Relay, Array, Beacon . If yes put it in the DSN RF Aperture Fee tool.	Yes	No	
Is DSN Direct from Earth (DFE) service required (telemetry, command) for a rover or lander? If yes, what is the minimum horizon elevation (when pointed to earth) for the lander or rover?:	Yes	No	
Will the mission operate at a low Sun Earth Probe (SEP) angle (other then inferior or superior conjunction? If yes what is the minimum SEP angle?:	Yes	No	

Other constraints:

Other special considerations :

Part D2 – DSN Radio Frequency (RF) Information

Uplink/Forward Link Information (for each link)

Service Description: Comand

Frequency:

Polarization:

Minimum EIRP required:

SLE FCLTU: PLOP 1 PLOP-2

Modulation Type: Modulation Index: Sine Square

Sub-carrier Modulation Frequency (if applicable): 8Khz 16Khz

Bit rate in bps:

Modulation format: NRZ-L,M,S Bi-Phase L

Manchester M,S

CLTU Frame Length:

Ranging Modulation Information (if applicable):

Type : Highest Clock:

Sequential

PN – regenerative

PN – non-regenerative Lower Clock:

Spacecraft Receive G/T Information:

Description:

Receive antenna gain Information (include gain characteristics, polarization, and beam-width and axial ratio associated with gain):

Passive loss from antenna to receiver:

Noise figure of receiver and/or system noise temperature at receiver:

Downlink/Return Link Information:

Service description:

Frequency (include description on coherent and non-coherent operations as applicable):

Data Modulation Information:

Description: The DSN supports multiple polarizations and modulations schemas. Describe each frequency downlink channel if more than more for an off-nominal configuration, e.g. – LCP and RCP combined for S or X-band, LCP only for Ka-band.

Modulation type: Modulation index:

Subcarrier modulation frequency (if applicable):

Telemetry bit rates including headers (all) in bps:

Data format:

Type of coding, e.g. – Turbo, LDPC, Reed-Solomon, Convolutional:

Spacecraft RF information:

Description:

Transmitter power:

Minimum G/T required at the ground antenna:

Tracking Information (excludes ranging, which was discussed earlier):

Description:

Doppler Requirements: ☐ 1-way ☐ 2-way

Point-of-Contact for RF Link Analyses Questions (name, phone, email):

PART D3 – DSN COMMUNICATIONS WAN/LAN INFORMATION

Data Volume per Pass MBs/GBs

Latency Requirement for Science and Engineering data, Specify each VC separtely:

VC0 =

VC1 =

Etc.

Timely = within 10 second

Complete = Streaming service that commences during the tracking

Offline = normally postpass with latency commensurate with data volume and data circuit capacity

Appendix D. Sample DSN Communications System Parameter Tables

The requirements in this appendix do not apply to Step 1 proposals. They apply only to the Concept Study Reports (CSR) that will be prepared by investigations selected at the outcome of Step 1 to conduct Phase A concept studies.

At a minimum, proposals should contain the set of telecommunications parameters shown in Table D-1. While proposers may or may not wish to use a tabular format, the required parameter values should be supplied in a clear, concise, and readily apparent form.

Table D-1: Telecommunications Parameters and Definitions

Parameter	Units	Description
Maximum Spacecraft (S/C) Distance	Kilometers (Km)	Maximum S/C-earth station distance during primary mission.
1st Encounter Distance	Km	Maximum S/C-earth station distance during first encounter.
2nd Encounter Distance	Km	Maximum S/C-earth station distance during second encounter.
Nth Encounter Distance	Km	Maximum S/C-earth station distance during Nth encounter.
Uplink Transmitter Power	Watts	Earth Station Transmitter Output.
Uplink Frequency Band	GHz	Proposed earth-to-space frequency band expressed in Gigahertz (GHz) (2, 7, 34 GHz).
Uplink Command Mod. Index	Radians (Rad)	Earth Station Uplink Command Modulation Index (Peak Radians).
Uplink Ranging Mod. Index	Rad	Earth Station Uplink Ranging Modulation Index (Peak Radians).
Uplink Transmit Antenna Gain	Decibels (dBi)	Gain (or name) of earth stations transmitting antenna (*e.g.,* 34M Beam Wave Guide (BWG).
S/C HGA Receive Gain/Loss	dBi/dB	Gain of spacecraft's high-gain receive antenna/Circuit loss to LNA.
S/C MGA Receive Gain/Loss	dBi/dB	Gain of spacecraft medium-gain receive antenna/Circuit loss to LNA.
S/C LGA Receive Gain/Loss	dBi/dB	Gain of spacecraft low-gain receive antenna/Circuit loss to LNA.

Parameter	Units	Description
Telecommand Data Rates	bits per second (b/s)	Maximum and Minimum desired telecommand data rate (Max/Min).
Telecommand Bit-Error-Rate	-	Required telecommand Bit-Error-Rate (BER).
S/C Receiver Noise Temperature	Kilo (K)	Total spacecraft receiver system noise temperature.
S/C Receiver Bandwidth	Hertz (Hz)	S/C Receiver's phase-locked-loop threshold bandwidth (2 Blo).
Turnaround Ranging	Yes/No	Statement whether turnaround ranging is required.
Required Ranging Accuracy	Meters	Specify project's required range measurement accuracy.
S/C Transmitting Power	Watts	S/C Power amplifier output.
Downlink Modulation Format	Name	Format name (*e.g.,* PCM/PM/Bi-phase, PCM/PSK/PM, BPSK, QPSK, etc.).
Downlink Frequency Band	GHz	Proposed space-to-earth frequency band expressed in GHz (2, 8, 26, 32 GHz).
S/C HGA Transmit Gain/Loss	dBi/dB	Gain of spacecraft's high-gain transmit antenna/Circuit loss from PA.
S/C MGA Transmit Gain/Loss	dBi/dB	Gain of spacecraft's medium-gain transmit antenna/Circuit loss from PA.
S/C LGA Transmit Gain/Loss	dBi/dB	Gain of spacecraft's low-gain transmit antenna/Circuit loss from PA.
Downlink Receive Antenna Gain	dBi	Gain (or name) of earth station receiving antenna (*e.g.,* 34M BWG).
Telemetry Data Rates	Bits per second (b/s)	Maximum and minimum desired uncoded telemetry data rates (Max/Min).
Downlink Telemetry Mod Index	Rad	S/C Downlink Telemetry Modulation Index (Peak Radians).
Telemetry Coding & Code Rate	Name & Rate	Telemetry code (*e.g.,* convolutional, Reed-Solomon, concatenated, Turbo, etc.).
Telemetry Frame Length	Bits	Total telemetry frame length.
Frame Deletion Rate	Rate	Acceptable Transfer Frame deletion rate from bit errors.
Telemetry Bit-Error-Rate		Telemetry Bit Error Rate (BER) required for desired frame deletion rate.

Parameter	Units	Description
Subcarrier frequency and format	Hz/Sine or Square	Subcarrier frequency used/Sine or Square wave format.
Ground Station Implementation Losses	dB	Total losses, including phase jitter, demodulation loss, and waveform distortion.
Downlink Ranging Mod Index	Rad	S/C Downlink Ranging Modulation Index (Peak Radians)
Hot Body Noise	(K)	The predicted increase from the reference temperature (Tr), resulting from the receiving antenna being directed toward a body having a temperature greater than that of the cold sky reference.

Table D-2 is a sample telecommunications link parameter form containing the necessary parameters. Proposers are requested to include this completed form in their proposals.

Table D-2: Sample Table for Inclusion in Proposal

Parameter	Value	Parameter	Value
Maximum S/C Distance (km)		Turnaround Ranging (Yes/No)	
1st Encounter Distance (km)		Required Ranging Accuracy (m)	
2nd Encounter Distance (km)		S/C Transmitting Power (Watts)	
Nth Encounter Distance (km)		Downlink Modulation Format (Name[s])	
Uplink Transmitter Power (Watts)		Downlink Frequency (GHz)	
Uplink Command Mod Index (Peak Radians)		S/C Downlink Telemetry Mod Index (Peak Radians)	
Uplink Ranging Mod Index (Peak Radians)		S/C Downlink Ranging Mod Index (Peak Radians)	
Uplink Frequency (GHz)		S/C HGA Transmit Gain (dBi)/Loss (dB)	
Uplink Transmit Antenna Gain (dB)		S/C MGA Transmit Gain (dBi)/Loss (dB)	
S/C HGA Receive Gain (dBi)/Loss (dB)		S/C LGA Transmit Gain (dBi)/Loss (dB)	

Parameter	Value	Parameter	Value
S/C MGA Receive Gain (dBi)/Loss (dB)		Downlink Receive Antenna Gain (dBi)	
S/C LGA Receive Gain (dBi)/Loss (dB)		Downlink Subcarrier frequency and format	
Telecommand Data Rates (b/s)		Telemetry Data Rates (b/s)	
Telecommand Bit-Error-Rate		Telemetry Coding (Name)	
S/C Receiver Noise Temperature (K)		Telemetry Frame Length	
S/C Receiver Bandwidth (Hz)		Frame Deletion Rate	
Hot Body Noise (K)		Telemetry Bit-Error-Rate	
		Ground Station Implementation Losses (dB)	

Information requested in Table D-2 above should be provided for each link whether Direct-to Earth, Relay, or other (spacecraft separation, Launch and Early Orbit Phase [LEOP], cruise, Entry, Departure, and Landing [EDL], orbit ops).

Link design control tables should be provided for the following conditions as a minimum:

- Spacecraft separation
- Emergency mode at maximum distance from Earth
- Maximum science data rate at maximum distance from Earth.

If a proposal does not contain sufficient information for an evaluator to independently verify that each communication's link operates properly, a negative finding is likely to be made.

Station Requirements by Mission Phase

Proposers should clearly state their Networks support requirements, preferably in a tabular format. For all mission phases (*e.g.,* launch and early orbit operations, cruises, maneuvers, flybys, orbit insertion, orbit operations, data return, etc.) proposals should show the mission's phase, the year in which the services are desired, stations required, pass length, number of passes per day/week, and the duration that these services are required. A sample table containing a few entries for a fictitious planetary mission appears below in Table D-3. Proposers are requested to include a completed form showing all major mission phases and the services required in their proposals.

Table D-3: Sample Station Requirements by Mission Phase Table

DSN Support Summary												
Mission(s)				2022	2023	2024	2025	2026	2027	2028	2029	
Cost Method	Fiscal		Total Setup Time	157.4	163.9	196.3	320.1	520.6	364.6	554	69.7	
Fiscal Year	2018		Total Teardown Time	39.4	41	49.1	80	132.1	91.1	138.5	17.4	
User Type	Gov		Total Configuration Time	196.8	196.8	196.8	196.8	196.8	196.8	196.8	196.8	
Additional Fees	$0		Total Tracking Time	1081.4	692.4	970.3	2370	4180.6	2892.6	4296	533.7	
Total DSN Time (hours)	19968.1		Total DSN Time	1278.2	897.2	1213.6	2770.2	4849.3	3348.3	4988.9	620.8	
Total DSN Passes	1253		Total Cost	$2,556,006.00	$1,322,630.00	$1,878,662.00	$5,063,609.00	$9,724,249.00	$6,721,997.00	$10,050,689.00	$1,207,547.00	
Total Cost	$39,533,379											
Brakedown by Support Activity												
Mission	**Support Activity Name**	**Antenna**	**Service Year**	**Usage**	**Number of Weeks**	**Total Number of Passes**	**Average Number of Passes Per Week**	**Total Setup Time (hours)**	**Total Teardown Time (hours)**	**Total Track Time (hours)**	**Total DSN Time (hours)**	**Total Cost for Period**
	X TTC 34m BWG1 BWG2 BWG3 BWG4 2022	34m	2022		29	143	6	143.4	35.9	1032.4	1211.7	$2,478,446
	X TTC 34m BWG1 BWG2 BWG3 BWG4 2025	34m	2025		5	29	6	29.4	6.4	203.4	239.2	$470,465
	K+X TTC 34m BWG1 2022	34m	2022		7	14	2	14	3.5	49	66.5	$77,560
	K+X TTC 34m BWG1 2023	34m	2023		52	163	3	163.9	41	692.4	897.2	$1,322,629
	K+X TTC 34m BWG1 2024	34m	2024		52	196	4	196.3	49.1	970.3	1213.6	$1,878,662
	K+X TTC 34m BWG1 2025	34m	2025		50	295	6	294.7	73.7	2166.6	2535	$4,593,144
	K+X TTC 34m BWG1 2026	34m	2026		53	518	10	518.6	129.6	4148.6	4796.8	$9,612,919
	K+X TTC 34m BWG1 2027	34m	2027		36	359	10	358.6	89.6	2868.6	3316.8	$6,635,199
	K+X TTC 34m BWG1 2028	34m	2028		52	520	10	520	130	4160	4810	$9,600,167
	K+X TTC 34m BWG1 2029	34m	2029		7	64	9	63.7	15.9	509.7	589.3	$1,140,749
	X TTC 70m 2026	70m	2026		10	10	1	10	2.5	40	52.5	$111,330
	X TTC 70m 2027	70m	2027		6	6	1	6	1.5	24	31.5	$86,798
	X TTC 70m 2028	70m	2028		34	34	1	34	8.5	136	178.5	$378,522
	X TTC 70m 2029	70m	2029		6	6	1	6	1.5	24	31.5	$86,798

MSPA User(s) Information (DSN)

Missions planning to employ Multiple Spacecraft per Aperture (MSPA) can reduce their costs by using shorter track lengths and operating in a non-coherent, one-way mode, provided that they do not require an uplink (see Section F.3). However, proposers planning to avail themselves of such savings should include a Letter(s) of Agreement from each of the other projects with whom they will be sharing the MSPA capability, stating how the uplink services (*e.g.,* commanding, coherent radio metric data capture, etc.) will be shared.

Absent such Letter(s) of Agreement, reviewers will employ their judgment as to whether the proposed MSPA utilization is within “reasonable” levels.

Appendix E. Form for Estimating DSN Mission Support Costs

Proposers calculating DSN aperture fees should use the on-line tool located at the URL https://dse.jpl.nasa.gov/ext/.

Training on the use of the tool can be provided by the following CIMO DSN Mission Interface managers:

Glen Elliott

Manager Office 912: Mission Support Definitions and Commitments

Jet Propulsion Laboratory

M/S 301-355

4800 Oak Grove Drive

Pasadena, California 91109-8099

Phone: (818) 393-6373

e-mail: Glen.Elliott@jpl.nasa.gov

Appendix F. Estimated Costs for Using the DSN

To simplify DSN cost estimation, an algorithm has been developed permitting users to calculate the DSN Aperture Fee and included services. Cost of service varies with aperture size (e.g., 34 meter vs. 70 meter) and utilization type. DSN service operations and maintenance types (see Table F-1) are included in the Aperture Fee.

Table F-1: Service Types Included in DSN Aperture Fee

Service Category	Service	Service Type / Detail
Data Transport	Forward/Command	Command Radiation Command Delivery
Data Transport	Return/Telemetry	Frame Packet Telemetry File
Navigation and Radiometrics	Tracking	Validated Radiometric Data Delta-DOR Data
Science	Radio Science	Experiment Access Data Acquisition
Science	Radio Astronomy / VLBI	Signal Capturing VLBI Data Acquisition
Science	Radar Science	Experiment Access Data Acquisition

F.1. DSN Aperture Fees

The algorithm for computing DSN Aperture Fees is shown and explained below.

Equation F-1: DSN Aperture Fee Calculation

AF = RB x AW

Where:

AF = Aperture Fee per hour of use.

RB = hourly rate, adjusted annually.

AW = aperture weighting:

= 1.00 for all other 34-meter stations (i.e., 34 BWG and 34 HEF).

= 2.00 for a two 34-meter station array ***or 2-station Delta Differenced One-Way Range (DDOR).***

= 3.00 for a three 34-meter station array.

= 4.00 for a four 34-meter station array.

= 2.00 for 70-meter stations.

At the time of publication of this document, the DSN *contact dependent hourly rate (RB)* is $950.

A *station contact, Frequency of Contacts (FC),* may be any length and is defined as either the duration of the spacecraft's scheduled pass or 12 hours, whichever is less.

For a standard pass, a 45-minute setup and a 15-minute tear-down time must be added to each scheduled pass to obtain the station contact time (other configuration times apply to Beacon Monitoring, MSPA, Array, and Delta-DDOR passes—see relevant cost sections below). Note that scheduled pass-lengths should be integer multiples of 1-hour with a maximum of 12 hours per pass.

Total DSN cost is obtained by partitioning mission support into calendar weeks, grouping weeks having the same requirement in the same year, multiplying by weighted AF, and summing these fees over the mission's duration. AFs include several services in the following categories: command, telemetry, tracking, radio science, radio astronomy, radar science, and services.

F.2. DSN Costing Calculations

Calculate DSN costs (Aperture Fee, AF in $/Hr.) by using the RF Aperture Fee tool located at URL: https://dse.jpl.nasa.gov/ext/ . Training for use of the tool is located at https://deepspace.jpl.nasa.gov/about/commitments-office/proposal-preparation/ .

To utilize the tool, either contact the person named in Section 6.3, Appendix E, or the DSN website listed above.

F.3. DSN Fee Reduction for Utilizing Multiple Spacecraft per Antenna (MSPA)

Some flight programs, such as those surveying Mars, have clustered several spacecraft about a planet/body. It is possible to simultaneously capture telemetry signals from two or perhaps more spacecraft provided that they lie within the beamwidth of the Earth station's antenna.

If this situation applies and the constraints set forth here and in the DSN Service Catalog are acceptable, then it may be possible to reduce the Antenna cost by half for spacecraft operating without an uplink in a non-coherent mode. To calculate the cost, first compute the AF, using https://deepspace.jpl.nasa.gov/about/commitments-office/proposal-preparation/ . Thereafter, apply the correction factor according to the formula:

Equation F-2: Aperture Fee Cost for Multiple Spacecraft per Aperture (MSPA)

AF' = (0.50) AF

Where: AF' = weighted Aperture Fee per hour of use for spacecraft operating without an uplink in the MSPA mode. (Spacecraft having an uplink when operating in an MSPA mode should use the aperture fee (AF) computed according https://deepspace.jpl.nasa.gov/about/commitments-office/proposal-preparation/

The reduced price, Aperture Fee Discounted for Multiple Spacecraft per Aperture applications (AF'), reflects the lack of capability resulting from no uplink communications. It is based upon the loss of commanding and ranging services to the spacecraft operating in a one-way, non-coherent mode. If MSPA users agree, all could time share the uplink and then reallocate cost savings according to their individually negotiated sharing arrangements. When switching the uplink from one spacecraft to the next, full costs, AF, begin to apply to the new two-way coherent user at the onset of the switching operation.

MSPA exists if, and only if, the same DSN antenna is simultaneously supporting two or more spacecraft without regard to whether an uplink is required by either.

F.4. Clustered Spacecraft Aggregated DSN Costing

Occasionally a mission comprises several spacecraft flying in a geometric formation but with spacing too large to utilize MSPA. Rather than request simultaneous support from several DSN stations, the project may agree to sequentially contact each spacecraft. From a project viewpoint, it is desirable to treat sequential DSN communications with several spacecraft as a single DSN contact for costing purposes. For information on the condition and constraints that allow for Clustered Spacecraft Aggregation, please see the SCaN Services Catalog.

Clustered Spacecraft Aggregated DSN Costs are calculated by:

- Adding a single setup and tear-down time for the aggregated period
- Including costs for time needed to move from one spacecraft to the next
- Treating the series of links during a pass as a single contact for the costing algorithm
- Computing the cost following Equation F-1 in Section F.1 or go to https://deepspace.jpl.nasa.gov/about/commitments-office/proposal-preparation/.

All missions consisting of a cluster of spacecraft not meeting the criteria in Section F.3 should calculate their costs separately using the RF Aperture Fee tool located at URL: https://dse.jpl.nasa.gov/ext/ treating each sequential communication with a member of the cluster as a separate and individual contact.

F.5. Data Relay DSN Costing

Data between a landed object and a DSN station, which is relayed through an orbiting spacecraft, may be unaccompanied or interspersed with data from other sources. At any specific time, a DSN station may be communicating with one or more surface objects.

Proposals for missions employing relays should include their *pro rata* share of the DSN station cost. Pass cost can be found by calculating the time required to return the total amount of relayed data, assuming that only this data being transmitted from the orbiting relay element, or by assuming 1-hour whichever is greater. Station configuration times need not be considered. Proposals should state their rationale and assumptions for their computed share of the DSN cost carefully, completely, and in sufficient detail so that evaluators can independently verify the computations.

F.6. DDOR DSN Costing

Under the correct geometric circumstances, DDOR can result in a net reduction in needed tracks. This is because adding DDOR passes can reduce the number of contacts needed to collect long data arcs of coherent Doppler and ranging measurements necessary to compute a spacecraft's trajectory. DDOR can also be used as an independent data source to validate orbit solutions. However, two widely separated Earth stations are required simultaneously to view the spacecraft and the natural radio sources.

DSN 34M and 70M stations can be used to collect DDOR data. To calculate a cost for a DDOR pass, users should determine the following:

1) DSN stations desired for the DDOR pass.
2) Amount of DDOR data required to obtain the spacecraft's position.
3) Pass length needed to obtain the data.
4) Setup time of 90 minutes (a 45-minute standard pass setup period for the station plus an additional 45 minutes for DDOR). The tear-down time remains at 15 minutes for each DDOR pass (Note: There is a 90-minute setup plus 15 minutes tear-down time for each station in the DDOR array.).
5) Cost of the pass by summing the cost for the two desired DSN stations plus setup and tear-down times over the length of the pass.

F.7. Beacon Tone Monitoring DSN Costing

Beacon Tone Monitoring is a low-cost method for verifying spacecraft health. A spacecraft transmits up to four predetermined tone frequencies (subcarriers) indicating its current condition. Spacecraft must be designed to monitor their subsystems and direct an appropriate tone to be transmitted. Beacon Tone Monitoring is particularly useful during long cruise periods when little or no science data is being collected.

Beacon Tone tracks (exclusive of configuration time) are generally short (40 to 60 minutes) and must occur at prescheduled times when the spacecraft is in view of a DSN complex. DSN 34M or 70M stations capture tones and project personnel are informed of the frequency received. Project personnel, not DSN personnel, must determine the meaning of the received tone.

Because no science or housekeeping data is received, it is possible to reduce the configuration times and hence cost for Beacon Tone Monitoring. Proposers calculating a cost for Beacon Tone Monitoring should compute AF for the requested DSN antenna using a setup time of 15 minutes and a tear-down time of 5 minutes (rather than 45 minutes and 15 minutes, respectively). The minimum pass length, including configuration times, is 1 hour (40-minute pass plus 20 minutes of setup and tear-down time).

Document Number

Space Communications and Navigation (SCaN)

Mission Operations and Communications Services (MOCS)