NASA's Mission Operations and Communications Services

This Document applies only to proposals in response to NASA's for Stand Alone Missions of Opportunity Notice (SALMON) Announcement of Opportunity

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1.0 INTRODUCTION

This document is intended to assist in the preparation of proposals in response to NASA's for Stand Alone Missions of Opportunity Notice (SALMON) Announcement of Opportunity (AO). NASA has extensive institutional resources that provide mission operations and communications services to NASA missions. Mission operations services provide standard capabilities to satellite operations control centers and can include command generation, telemetry decoding and analysis, attitude and orbit analysis and determination, level-0 data processing, autonomy and monitoring, etc. Communications services transmit flight data and navigation signals between spacecraft and ground terminals and between the terminals and mission-related operations and data centers.

The use of these services may incur costs to the user and estimates for these costs need to be included in proposals submitted under this AO as separate line items. To facilitate proposal preparation, proposers are expected to read this document and contact the individuals named below.

1.1 Costing Policy

As a matter of policy, NASA will include estimated costs for communications services, as well as an assessment of key parameters for mission operations, in the evaluation and selection processes for all Earth-orbiting and deep space missions. Costs for tracking station support shall be provided as a separate line item. We have implemented this policy to:

- assist in the management of NASA's heavily subscribed communications resources,
- encourage tradeoffs between on-board processing and storage vs. communications requirements, and
- encourage proposers to design hardware, software and operations systems which minimize total life-cycle costs while accomplishing the highest-priority science objectives.

1.2 Specification of Service Providers

NPR 7120.5D requires all flight projects to develop requirements and plans during mission formulation for mission operations and communications services that are to be employed by the project over its life cycle.

The proposal must include a rationale for the level of communications services proposed, the basis for costs of communications services, key communications parameters, and a rationale and cost basis for mission operations services. Required services should be identified irrespective of the provider. Proposers may choose to use many, some, or none of the NASA-provided services referenced below. As a matter of policy, proposers should be prepared during the definition phase to support tradeoff studies on the use of NASA-provided services versus any proposed alternatives. Contact and consultation with NASA is encouraged early in the proposal development process to help the project converge on the best approach.

If SMD finds that the proposed approach does not result in the lowest life-cycle cost, the Directorate may direct the project or PI to modify their approach. If utilizing NASA-provided support services increases the project / PI costs but reduces the cost to NASA, any funding impacts to the project / PI will be resolved.

2.0 NASA'S MISSION OPERATIONS SERVICES

Mission operations services provide standard capabilities to satellite operations control centers and can include command generation, telemetry decoding and analysis, attitude and orbit analysis and determination, level-0 data processing, etc. NASA can provide mission operations services through the Goddard Space Flight Center (GSFC) or through the Jet Propulsion Laboratory (JPL). Generally, flight projects obtain these services via task-order mechanisms available at the Centers. Mission operation services at GSFC and JPL are discussed below.

2.1 Mission Operations Services at GSFC

The Space Science Mission Operations (SSMO) project at GSFC provides project management for the operations and maintenance of our currently operating space science missions at GSFC. SSMO becomes involved in mission development phases of new missions to assure safe and effective mission operability. SSMO takes responsibility for GSFC space science missions after orbital verification is complete and routine operations are underway. SSMO currently manages operations for 21 space science missions, 10 on-site at GSFC and 11 at remote locations at laboratories and universities around the country.

The complexity, cost, and risk of operations may be dramatically affected by decisions made early in the development cycle. Consequently, the SSMO project plays a significant role during the various phases of the mission life cycle from the formulation and approval phases through the implementation and evaluation phases and eventual decommissioning. A major objective of the SSMO project, in conjunction with the science community, is to transfer lessons learned from operations into the operations requirements and the development of operations concepts of future missions.

The SSMO can provide assistance for the following disciplines:

- General consulting on mission operations concepts and applicability of existing science mission concepts and architectures,
- Assistance in obtaining cost estimates for GSFC mission operations contract alternatives, and
- Assistance in orbit design alternatives to meet the stated science objectives(s).

For more information regarding the SSMO, please contact:

Patrick L. Crouse
NASA/GSFC
Code 444
Greenbelt, MD 20771

Email: Patrick.L.Crouse@nasa.gov
Telephone: 301 286-9613
FAX 301 286-1602

Also of value to missions in development is the GSFC Mission Services Evolution Center (GMSEC). GMSEC provides mission operations systems and components that perform the following functions:

- Telemetry processing,
- Real time and stored command generation,
- Mission activity planning and scheduling,
- Engineering data trend analysis,
- Level-zero processing,
- Spacecraft simulation,
- Orbit determination and prediction,
- Attitude determination and attitude sensor calibration,
- Ground system automation and autonomy, and
- Flight software development and testing.

In addition, GMSEC maintains an enterprise architecture that allows these functions to be easily integrated and invests in new technology to enable new capabilities, lower costs, and reduce operations risk.

The GMSEC services include the design and implementation of some or all of the mission operations systems and the training of the operations team in its use. The GMSEC architecture's modular and extendible design accommodates components from commercial and other sources and a service-oriented approach. The GMSEC mission operations functions can be used to support spacecraft and observatory integration and test. The SSMO encourages missions in development to consider GMSEC as a means of simplifying ground systems development.

For more information on GMSEC services, contact:

John O. Bristow
NASA/GSFC
Code 581
Greenbelt, MD 20771

Email: john.o.bristow@nasa.gov
Telephone: 301 286-3647
FAX : 302 286-5719

Additionally of value to missions in development and planning is the GSFC Flight Dynamics Facility (FDF). The FDF provides mission operations support that perform the following functions:

- Mission design, analysis and orbit maneuver services including mission planning and mission concept development,
- Orbit determination and prediction,
- Acquisition data processing and aids,
- Attitude determination prediction and control, and
- Tracking station, network and data evaluation.

In addition, the FDF maintains a product center that provides Internet access to mission-required and mission-unique data products. Typical products include: predictive ephemeris files, shadow predictions, solar, lunar and planetary (SLP) files, time conversion coefficients, NASA Directory of Station Locations, SKYMAP Star Catalogs, long term ephemerides, etc.

For more information on FDF services, contact:

Susan L. Hoge
NASA/GSFC
Code 595
Greenbelt, MD 20771

Email: Susan.L.Hoge@nasa.gov
Telephone: 301 286-3661
FAX: 301 286-0369

2.2 Mission Operations Services at JPL

At JPL, the Interplanetary Network Directorate (IND) manages the Multimission Ground Systems and Services (MGSS) organization. The MGSS program office develops, maintains and employs a set of tools and services known as the Advanced Multi-Mission Operations System (AMMOS) which are placed and configured in mission control centers and are tailored for working with the DSN. AMMOS elements are developed and maintained at JPL and may be configured for user sites. AMMOS offers a selection of services for spacecraft command and control, data reduction and analysis, and navigation. DSN services are integrated, and certain DSN services may be a prerequisite to obtaining AMMOS value-added services. In addition to its standard services, AMMOS can provide users with specific software tools. Such tools include telecommand encapsulation and protocol verification, mission analysis software, spacecraft monitoring programs, and data analysis software.

Because each mission is unique, it is difficult to provide *a priori* tool prices. Generally, AMMOS personnel need to confer with project personnel to determine specific tool requirements. Thereafter, it should be possible to quote a price for the product. If a tool's specification is completed by the end of Phase B, then work can commence at the start of Phase C/D so that the tool will be available at launch.

For assistance with AMMOS tools and services, see Reference 5 and contact the following MGSS Program Commitments Engineer (Organization 315C):

Brian A. Morrison
Multimission Ground Systems & Services
(MGSS) Program Commitments Engineer
Jet Propulsion Laboratory
M/S 264-214
4800 Oak Grove Drive
Pasadena, California 91109

e-mail: Brian.A.Morrison@nasa.gov
Phone: 818 454-2836
FAX: 818 393-6991

3.0 NASA'S COMMUNICATIONS SERVICES

Under the auspices of the Space Communications and Navigation (SCaN) program, NASA operates four networks for supplying space communications services. These networks are the Deep Space Network (DSN), the Ground Network (GN), the Space Network (SN), and the NASA Integrated Services Network (NISN). The GN and SN support the near-Earth and high-Earth, highly elliptical, and lunar orbiting missions. The DSN supports planetary and heliospheric missions, those operating at the Lagrangian points (L1 and L2) and the highly-elliptical Earth-orbiting missions requiring a reasonable G/T. NISN operates NASA's wide-area network (WAN) and provides for communications circuits from NASA centers to several universities and research centers. Each network has a technical interface for developing new requirements.

3.1 Ground Network Services

Ground Network (GN) operations are the responsibility of the GSFC. The GN has Earth stations located and available in the United States at: Poker Flats, Alaska; Wallops Island, Virginia; White Sands, New Mexico; Hawaii; as well as in Antarctica, Chile, Australia, South Africa and Norway. The GN can also make arrangements for the use of foreign government Earth stations as required. Generally, these stations support non-deep space missions in the 2, 8, and 26 GHz bands; however, several are capable of receiving signals from deep space missions as well. Earth-station antennas range in size from 2.4 to 18 meters in diameter. Table 1-1 shows several of the service categories.

Table 1-1: GN and SN Service Categories

GN Service Category	Brief Description
Commanding	RF modulation, transmission, and delivery of telecommands to spacecraft.
Telemetry	Telemetry data capture, decoding, and additional value-added data routing.
Tracking	Radio metric data capture (range, Doppler, and angles).
Mission Planning	Communications design
Network Integration Management	System engineering, advance mission planning, RF compatibility testing, mission system testing, spectrum and frequency management, and spacecraft contingency TT&C.

For more information, consult the Ground Network User's Guide (see Reference 6).

3.2 Space Network Services

NASA's Space Network (SN), also managed by GSFC, consists of five geosynchronous satellites. Satellite control and data capture facilities are located in: Guam , GSFC, and White Sands, New Mexico. This satellite fleet consists of first and second generation Tracking and Data Relay Satellites (TDRSs). All satellites offer S-band Multiple Access (MA) capability and S & Ku-band Single Access (SA) channels. The second generation TDRSs offer enhanced MA capability and higher data rates on the S-band (6 Mbps) and K_A-band (600 Mbps) SA channels. The services listed in Table 1-1 are also available to SN users.

For more information, consult the Space Network web site (see References).

3.3 Process for Requesting GN or SN Services

Proposers should contact the person named below for information about GN or SN 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. Further, they will assist in documenting initial mission operations requirements in a preliminary Project Service Level Agreement (PSLA). During the study phase, as the proposer's mission concept becomes more clearly defined, the detailed requirements in the PSLA will be clarified. The resulting documentation of services and costs (if any) will become the Network Requirements Document to be signed by appropriate Project and Network representatives.

The primary GN and SN point of contact for this AO is the GSFC Network Integration Manager (see also References 6 and 7):

Scott A. Greatorex
Networks Integration Management Office
Goddard Space Flight Center
Code 450.1
Greenbelt, Maryland 20771

e-mail: Scott.A.Greatorex@nasa.gov
Phone: 301 286-6354
FAX: 301 286-0275

3.4 The Deep Space Network

The Interplanetary Network Directorate (IND) manages the Deep Space Network (DSN) located at the Jet Propulsion Laboratory (JPL). IND is the executive agent for the operations and engineering of the DSN and provides the technical expertise needed for flight projects to use the DSN. This expertise includes communications formats, antenna capabilities and performance limits, scheduling, loading and other operations considerations, and, in particular, maintaining the cost algorithm for employing the DSN.

The DSN consists of control, communications, and test facilities at JPL, and Earth-station complexes located near Goldstone, California; Canberra, Australia; and Madrid, Spain. The DSN provides communications services between spacecraft and Earth-station complexes together with the ground communications among the complexes and the DSN control center located at JPL in Pasadena, California.

3.4.1 DSN Services

The DSN support philosophy has evolved to a support paradigm based upon standard services. Standard services are described in the *Deep Space Network Services Catalog* (Reference 5). These services support both Earth-orbiting and deep space science missions. Table 1-2 summarizes the DSN standard data services and engineering support categories. Each of the Service Categories in Table 1-2 may contain several service options.

Table 1-2: DSN Standard Data Services and Engineering Support Categories

Service Category	Available Service/Support
Command	Command radiation service and command delivery service.
Telemetry	Frame service, packet service, telemetry file service, and beacon tone service.
Tracking	Validated radio metric data service, and Delta-DOR service.
Calibration and Modeling	Platform calibration service and media calibration service.
Radio Science	Experiment access service and data acquisition service.
Radio Astronomy / VLBI	Signal capturing service, VLBI data acquisition service, and VLBI data correlation service.
Radar Science	Experiment access service and data acquisition service.
Engineering Support	System engineering, advance mission planning, emergency mission operations center, RF compatibility testing, mission system testing, spectrum and frequency management, and spacecraft search.

3.4.2 Process for Requesting DSN Services

Proposers should contact the person named below for information about DSN services and costs at the time when initial science operations concepts are being defined. Further, initial tracking requirements will be captured in the DSN cost sheet(s) followed by a supportability/feasibility study; the estimated costs will be documented in a Letter of Commitment. During the study phase, as the proposer's mission concept becomes more clearly defined, the commitments letter will be further clarified with more specific requirements. The resulting clarification of services and costs will be documented in the DSN Services Agreement (DSA) to be signed by appropriate Project and Network representatives. The DSA will identify all mission operations requirements, including those provided by non-DSN sources, in order to provide a source of end-to-end operations information and to document any cost analyses leading to the selection of non-DSN services.

The primary DSN point-of-contact for this AO is the Future Missions Planning Manager (Organization 911):

Andrew Kwok
Future Missions Planning Manager
Jet Propulsion Laboratory
M/S 126-238
4800 Oak Grove Drive
Pasadena, California 91109

e-mail: andrew.kwok-1@nasa.gov
Phone: 818 354-5555
FAX: 818 393-2606

3.5 NASA Integrated Services Network (NISN)

The mission of the NISN is to provide cost-effective wide area network telecommunications services for transmission of data, video and voice for all NASA Enterprises, Programs and

Centers, utilizing commercial capability wherever possible. NISN services can be used to provide data links between NASA centers and project operations sites that may be located away from a NASA center. These circuits may be for routine operations or may be temporary for support of integration and test activities or launch activities

For more information, contact the customer commitment representatives listed in Section 3.3 or 3.4.2 above. Also contact NISN directly; see: http://www.nisn.nasa.gov/.

3.6 Communications Standards

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

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

Information about the ITU and NTIA regulations can be obtained from the NASA Management Office at the Glenn Research Center or by consulting References 1 and 2. Recommended standards applicable to DSN, Ground Network, or Space Network (TDRSS) support can be obtained from Reference 3, the CCSDS home page. Recommendations of the SFCG are available in Reference 4.

Capabilities described below result in the more efficient use of NASA's facilities. Proposers should carefully consider each item below. Networks to which each item is applicable are noted following the subsection's title.

3.6.1 Space Link Extension (DSN, GN, SN)

Project Operation Control Centers (POCCs) using DSN, GN and SN services should utilize a standard *Space Link Extension* (SLE) *Services Interface* for transferring data to and from DSN, GN or SN sites. This interface is designed to provide international control center–network interoperability and reduce mission risk by facilitating the rapid substitution of a different Earth station, not necessarily only NASA's, in the event of a failure. Since 2005 the SLE Services interface requires POCCs to directly access DSN stations for the following services: Command Link Transmission Unit (CLTU), Return All Frames (RAF), Return Channel Frames (RCF), and CCSDS File Delivery Protocol (CFDP). Proposers interested in SN or GN services should contact the person named in Section 3.3.

Seven international space agencies, including: ASI, CNES, DLR, ESA, ISRO, JAXA, and NASA have agreed to implement the SLE Services Interface to achieve full international interoperability. Interface architecture conforms to standards adopted by the CCSDS (Reference 3).

3.6.2 X-Band and K_A-Band Communications (DSN, GN, SN)

Category A missions (range < 2 x 10^6 km) have an allocation for the *Space Research* service in the 7190-7235 MHz (Earth-to-space) and 8450-8500 MHz (space-to-Earth) bands. Because of the congestion in the 2 GHz band resulting from ever increasing use, proposers are encouraged to use the 7/8 GHz bands whenever possible. Missions operating in either the 2 or 7/8 GHz bands should comply with the spectrum emissions mask in the SFCG Handbook (Reference 4). Approved methods for bandwidth efficient modulation can be found in Reference 3.

Category A missions (range < 2 x 10^6 km) with high data/symbol rates planning to operate in the 8 GHz *Earth Exploration Satellite* (EES) service (8025-8400 MHz), should investigate SN and GN capabilities in the 26 GHz band. Missions utilizing the EES service tend to have very high data/symbol rates and those planning to operate in the 8 GHz band should comply with the spectrum emissions mask in the SFCG Handbook (Reference 4). Approved methods for bandwidth efficient modulation can be found in Reference 3.

Category B missions (range ≥ 2 x 10^6 km) operating in a *Space Research* allocation should be designed to communicate in either the 7/8 GHz or 7/32 GHz bands. Ever increasing congestion and the addition of allocations for incompatible services (e.g., Third Generation Mobil Telephone Systems) have made future operations in the 2 GHz deep space band impractical and therefore, risky and unwise. Accordingly, the Science Mission Directorate (SMD) is recommending against the use of the 2 GHz band for future Category B missions. Deep space missions having high data rates should operate in K_A-Band (31.8 – 32.3 GHz space-to-earth) or, if using the 8400-8450 MHz band, they must utilize bandwidth-efficient modulation (Reference 4). Approved methods for bandwidth efficient modulation can be found in Reference 3.

Additionally, a new allocation for the *Space Research* service is now available in the 25.5 – 27.0 GHz band (a.k.a. 26 GHz band). High data rate space science missions, requiring bandwidths in excess of 10 MHz, should be designed to operate in the 26 GHz band.

3.6.3 Bandwidth Efficient Modulation (DSN, GN, SN)

When operating in the 2 and 8 GHz bands, Category A and B missions should employ bandwidth efficient modulation methods in conformance with SFCG Recommendations. A Spectral Emissions Mask can be found in the Space Frequency Coordination Group's (SFCG's) Handbook, available on the SFCG web site (Reference 4). Separate SFCG Recommendations exist for Category A and B missions. Specific modulation methods meeting the SFCG mask are enumerated in CCSDS Recommendations 401 (2.4.17A), 401 (2.4.17B); and 401 (2.4.18) for non-deep space, deep space, and Earth resources missions respectively. For CCSDS modulation Recommendations consult Reference 3.

3.6.4 CCSDS File Delivery Protocol (DSN)

To improve station utilization efficiency as well as reduce mission risk and costs, all DSN users should employ the CCSDS File Delivery Protocol (CFDP), to transfer data to and from a spacecraft. CFDP operates over a CCSDS conventional packet telecommand, packet telemetry, or an Advanced Orbiting System (AOS) Space Data Link Protocol. CFDP enables the automatic transfer of a complete set of specified files and associated information from one storage location to another replacing an expensive labor-intensive manual method. It operates by copying a file from a source point to a destination site using an Automatic Repeat Queuing (ARQ) protocol. In an *acknowledged mode*, the receiver notifies the transmitter of any undelivered file segments or ancillary data so that the missing elements can be retransmitted guaranteeing delivery. An *unacknowledged mode* is also permitted. CFDP information can be found in the *CCSDS File Delivery Protocol* available on the CCSDS web site (Reference 3).

4.0 NETWORK SUPPORT COSTS

Generally, mission proposals must include both launch and support costs. This section explains how to obtain costs for the GN, SN, NISN, DSN, and AMMOS.

4.1 Costs for the Ground Network and Space Network

GN and SN services are highly mission dependent. Therefore, it is not possible to provide a simple cost structure such as the one used for DSN stations. Proposers are advised to contact the GSFC Networks Integration Management Office listed in Section 3.3 above to obtain a cost estimate for support during mission development and operations for their mission.

For the proposes of initial rough estimates, the following rate may be used for GN S-band, X-band, and/or Ka-band service

- $495 per GN pass (One pass is $\leq$ 30 minutes)

The standard rates for using the SN:

- Single Access Service-Forward command, return telemetry, or tracking, or any combination of these, the rate is $131.00 per minute.
- Multiple Access Forward Service - $29.00 per minute.
- Multiple Access Return Service - $14.00 per minute.

4.2 Costs for Using the Deep Space Network

DSN 34-meter and 70-meter diameter antennas operating in the 2, 7, 8, and 32 GHz bands provide radio frequency communications. User costs vary with aperture size and utilization level. Generally, DSN standard services are included in the *Aperture Fee* (see Equation 4.2.1-1 below).

4.2.1 DSN Aperture Fees

Cost numbers supplied in this Section are for planning purposes only. To ensure accurate application of this information and to validate cost estimates please contact the DSN representative listed in Section 3.4.2. DSN personnel should always be consulted to validate these costs.

The algorithm for computing DSN *Aperture Fees* embodies incentives to maximize DSN utilization efficiency. It employs *weighted hours* to determine the cost of DSN support. The following equation can be used to calculate the *hourly Aperture Fee* (AF) for DSN support.

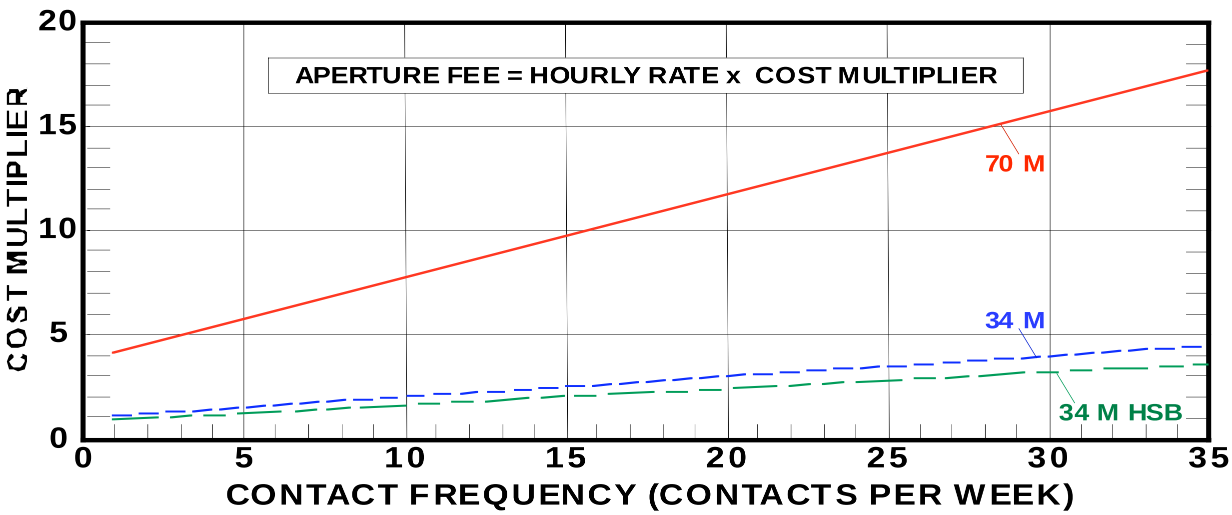
$$AF = R_B \, [A_W \, (0.9 + F_C \, / \, 10)] \qquad (4.2.1\text{-}1)$$

where:

- AF = weighted *Aperture Fee* per hour of use.
- R_B = contact dependent hourly rate, adjusted annually ($1057/hr. for FY09).
- A_W = aperture weighting:
  - = 0.80 for 34-meter High-Speed Beam Waveguide (HSB) stations.
  - = 1.00 for all other 34-meter stations (i.e., 34 BWG and 34 HEF).
  - = 4.00 for 70-meter stations.
- F_C = number of station contacts, (contacts per calendar week).

The *weighting factor* graph below shows relative antenna costs. It graphically illustrates the cost relationships between antennas and demonstrates the benefits of restricting the number of spacecraft-Earth station contacts each week.

A *station contact* may be any length but is defined as the lesser of the spacecraft's view period, the scheduled pass duration plus calibration times, or 8 hours. For a *standard pass*, a 45-minute set-up and a 15-minute tear-down time must be added to each scheduled pass to obtain the *station contact* time (other calibration times apply to Beacon Monitoring and Delta-DOR passes). Note that scheduled pass-lengths should be integer multiples of 1-hour.



Total DSN cost is obtained by partitioning mission support into calendar weeks and summing the *Aperture Fees*. This total cost can be obtained by grouping weeks having the same requirement in the same year, multiplying by weighted *Aperture Fee*, and summing over the mission's duration. *Aperture Fees* include several services in the following categories: command, telemetry, tracking and navigation, radio science, radio astronomy, radar science, and routine compatibility testing.

4.2.2 DSN Compatibility Testing Costing

DSN encourages pre-launch compatibility testing as a means to eliminate post launch anomalies and expensive troubleshooting. DSN maintains a facility known as the Development Test Facility (DTF-21) in Monrovia, California. Except for the high power transmitter, antenna, and low noise-receiving amplifier, which are not included, DTF-21 is configured much like an operational DSN Earth station.

Approximately eighteen months prior to launch, projects should bring their Radio Frequency Subsystems (RFS) to DTF-21 for testing. Testing requires approximately two weeks and includes such items as RF compatibility, data flow tests, and transponder calibration.

Because the DSN believes that this testing materially improves the likelihood of mission success, no charge is made for the use of these facilities for a single set of compatibility tests. Rather, it is included in the hourly-dependent rate, R_B, used in Equation 4.2.1-1.

4.3 PROPOSAL INFORMATION

Evaluation requires an independent assessment of systems proposed in response to the AO to verify the claims made. Absent the necessary information, evaluators are compelled to *assume* values for missing parameters based upon their knowledge and experience. Conservative assumptions by an evaluator can work to the detriment of proposers. Accordingly, proposers are encouraged to provide sufficient information so that evaluators can make the necessary calculations. The points of contact for the NASA network listed above will supply proposers with the lists of mission parameters and other items needed for proposal evaluation.

Any further questions concerning NASA mission operations and communications services should be directed to the technical point-of-contact listed in Section 6.1.1 of this AO.

5.0 REFERENCE DOCUMENTS

Prospective users of NASA facilities can obtain additional information from the following documents:

1. *Radio Regulations*, International Telecommunications Union, Geneva, Switzerland, Latest Edition.

2. *Manual of Regulations and Procedures for Federal Radio Frequency Management*, National Telecommunications & 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 are available at: http://public.ccsds.org/publications/bluebooks.aspx

4. Handbook of the Space Frequency Coordination Group, ESA Frequency Manager and SFCG Secretariat, European Space Agency Headquarters, 8-10 Rue Mario Nikis, 75738 Paris, France. Copies of the document are available at: http://www.sfcgonline.org/

5. *DSN Future Missions Planning Office* homepage. Web site located at: http://deepspace.jpl.nasa.gov/advmiss

6. *Ground Network User's Guide*, (GSFC 453-GNUG) describes the technical capabilities of the ground stations that comprise the Ground Network (GN). See also the following web site: http://scp.gsfc.nasa.gov/gn/index.htm

7. For more information on the Space Network consult the following web site: http://scp.gsfc.nasa.gov/sn/index.htm