Space Network (SN)
Tracking and Data Relay Satellite System (TDRSS)
User Services Subsystem Replacement
of Low Data Rate Equipment (USSR/LDRE)

Request for Information (RFI)

03 March 2008

Honeywell Technology Solutions Inc.
Goddard Corporate Park
Lanham, Maryland 20706-2291

Space Network (SN)
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Contract NNG04DA00-C

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SECTION 1. INTRODUCTION

1.1 Purpose

This Request for Information (RFI) is being issued by Honeywell Technology Solutions, Incorporated (HTSI) in support of the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) under the Near-Earth Network System (NENS) in support of NASA's TDRSS S-Band Upgrade Project (TSUP).

Our purpose is to provide information to prepare Industry for potential participation in the significant replacement and enhancement of key ground communications equipment used in NASA's Space Network (SN) at the White Sands Complex (WSC). In turn, HTSI invites Industry to engage in a dialog with us that will ensure that the replacement equipment meets the current state of the art and provides best value to NASA for the years to come.

To meet this purpose, this RFI seeks to achieve the following:

- Begin an early dialog with potential vendors regarding participation in the User Services Subsystem Replacement (USSR) with emphasis on the Low Data Rate Equipment (LDRE).
- Obtain information that will enable us to estimate the Total Cost of Ownership involved in acquiring a Software Defined Radio that must support a Product Life greater than 10 years.
- Obtain information on the technology readiness levels the USSR will require to support SN Legacy Requirements, Constellation Requirements, and S-Band Signal Enhancements.
- Obtain information from potential vendors on their abilities to develop and manufacture ground terminal satellite modems that will meet the USSR requirements within the USSR project schedule.
- Determine to what extent baseband switching and routing functions, as well as service management functions, should be migrated into the traditional modem functions. This may include Consultative Committee for Space Data Systems (CCSDS) Space Link Extension (SLE).
- Determine a logical replacement for the current MIL-STD-1553B data bus based on recommendations from Industry.
- Obtain information on the schedule and deployment strategy for the production unit.

This activity is in preparation for one or more Requests for Proposals that may be issued in the Fall of 2008 to support the modernization of the WSC.

1.2 Scope

The scope of this RFI is limited to the modulators and demodulators (modems) used in the low data rate equipment (LDRE) in NASA's User Services Subsystem Replacement (USSR) Project. The LDRE modems are also known as the Narrowband Modems. Due to time constraints, there will not be a demonstration phase for the LDRE.

The replacement modems must satisfy the legacy requirements of the current SN mission (excluding Shuttle and select other functions identified later in this RFI) as well as the new requirements of the Constellation Program (CxP). A third category of requirements for consideration includes S-Band Signal Enhancements.

The replacement of the companion high data rate modems and related equipment in the WSC is addressed separately by the recent Tracking and Data Relay Satellite System (TDRSS) K-Band Single Access Return Upgrade Augmentation (TKUP-A) Project, the details of which can be found in the K-Band section of the USSR Web Site.

1.3 Subject Equipment and Current Inventory

The specific units of equipment that are the subject of this RFI are the:

- Modulator/Doppler Predictor (MDP)
- Integrated Receiver (IR)
- Test Modem (TM)

Table 1-1 provides an inventory of the legacy units that are now used at the WSC. The inventory is presented in the context of the baseline that was delivered with the Second TDRSS Ground Terminal (STGT) in the early and mid-1990s. The modernization baseline may exceed this count by a modest amount.

Table 1-1. Inventory of Current Low Data Rate Equipment

Modulator/Doppler Predictor (MDP)	Integrated Receiver (IR)	Test Modem (TM)
57	73	29

The equipment in Table 1-1 was used in six Space-to-Ground Link Terminals (SGLTs), two of which were not fully populated. The modernized WSC USSR equipment will likely support eight fully populated SGLTs. Replacement concepts may logically combine the IR and MDP function into a common configuration item, which in turn might contain more than one instance of the combined MDP/IR function. For example, a single hardware chassis might contain two or more independent Narrowband Modems.

For planning purposes, the NASA USSR Project suggests the unit inventory in Table 1-2. Note that the number of TMs is reduced because the new architecture plans to eliminate some redundant TMs that were used in the STGT architecture.

Table 1-2. Likely Inventory of USSR Low Data Rate Equipment

Unit with Combined MDP/IR Functions	Test Modem
174	25

1.4 USSR Project Background

In order to support the new requirements of the Constellation Program (CxP), the TDRS K ground segment modification, and the expanded service requirements of potential SN customers, NASA established the User Service Subsystem Replacement (USSR) Project as part of the SN modernization efforts to upgrade the S-Band and K-Band equipments in the TDRSS ground terminals.

The TDRSS LDRE upgrade portion of the USSR project addresses Space Network (SN) Integrated Receiver (IR) enhancement with Low Density Parity Check (LDPC) forward error correction code, to the TDRSS S-Band Multiple Access Return (MAR), S-Band Single Access Return (SSAR), and Low Data Rate Ku-Band and Ka-Band (KSA) services for improved SN support to next generation missions. The enhancement will enable higher data rates than are currently supported and lower customer received power (P_{rec}) requirements. The IR is expected to be replaced with new equipment capable of supporting all Constellation services modes as well as other S-Band services modes in the SN Users' Guide with improved performance. The MDP also will be enhanced with LDPC code for improved MAF and SSAF services.

In anticipation of increased service requirements of the NASA Exploration Program and other potential Space Network customers exceeding the 300 Mbps maximum data rate currently available via the TDRSS 225-MHz return channels, the K-Band High Data Rate upgrade portion of the USSR project will implement new ground systems to provide high data rate services. The TKUP demonstration conducted during January and February, 2008 will provide results to finalize the signal design and requirements specification for the K-Band data services.

The TDRSS ground terminals were designed and implemented in the early 1990s and some of the systems, including the KSAR high rate equipment and the Narrowband Modems are reaching or close to reaching obsolescence. Because it is currently expected that the TDRSS ground terminals will be called upon to provide operational support for at least another ten years, NASA has been and will be faced with challenges in dealing with this obsolescence.

This background section will focus mainly on the USSR/LDRE upgrade since a K-band RFI has been released to industry to address the high rate equipments in 2005 through the TDRSS K-Band Single Access Return Upgrade Project (TKUP).

1.4.1 TDRSS S-Band Upgrade (TSUP) Goals

In response to these expected needs, the SN seeks to replace the current USSR/LDRE under the TDRSS S-Band Upgrade of the USSR Project. Specifically, TSUP will attempt to achieve the following goals:

- Address the S-Band and K-Band low data rate equipment (NB Modems) obsolescence.
- Address the CxP support requirements and TDRS K ground segment modification.
- Provide enhanced S-Band services by adding the capabilities to process bandwidth efficient coding schemes and to increase the maximum data rate from 6 Mbps to 15.75 Mbps.

1.4.2 TSUP Overview

TSUP is progressing through the following informal stages:

- Signal Design Study
- Requirements Definition
- Procurement and Implementation

1.4.2.1 Signal Design Study

A characterization study was conducted to investigate the bit error rate (BER) performance and the maximum data rate that the SN can reasonably support for S-band services with Low

Density Parity Check (LDPC) code. This study identified LDPC coding schemes that provide optimized performance through the TDRS S-Band channel. This study is summarized in the "Coding and Modulation Study" and is available on the USSR website.

1.4.2.2 Requirements Definition

NASA currently is developing requirements specification for the S-Band upgrade that take into account the current STGT requirements specification, the nonstandard GN signal design as specified in SN User's Guide, Rev 9, the CxP requirements and the signal design enhancement with LDPC coding. Low data rate K-Band services whose data rates are common with SSA will be included in TSUP. The related information is available on the USSR website.

NASA has developed the TKUP Requirements Specification with support from a team of contractors, including HTSI under the NENS contract. The TKUP System Requirements Review (SRR) was held on April 27, 2005. SRR documentation and the SRR presentation material are available on the USSR website, and include the draft version of the System Requirements Document (SRD) which is based on the results of this review and the development since the review.

1.4.2.3 Procurement and Implementation

Following the requirements specification development and SRR stage, NASA plans to task the NENS follow-on contractor to procure production equipment to replace the S-Band and K-Band equipment at all SN TDRSS ground stations. This equipment must perform all the functions of the equipment it will replace, as well as implement the new, S-Band services introduced by TSUP and the K-Band new services introduced by TKUP. This procurement will include equipment for the eight SN TDRS Space-to-Ground Link Terminals (SGLT). For K-Band, each SGLT supports two independent KSAR services, one each for the two TDRS Single Access (SA) antennas. The equipment for each SA antenna service chain contains two fully redundant KSAR receive chains as well as a Test Modulator and associated test signal generation equipment. Thus, this procurement will include over 30 return equipment chains and 14 test equipment chains, plus spare equipment and parts.

The NENS follow-on contractor will release an RFP on behalf of NASA for the procurement of the S-Band and K-Band equipment. The USSR Project will most likely select two vendors for both the S-Band and K-Band production equipment development, delivery, and check-out. However, the USSR project may award four vendors through engineering model delivery, and the down select to two. Production unit procurement is likely to release in early FY09 and will be fairly open and competitive with possible multiple awards.

1.4.3 USSR Project Schedule Milestones

The USSR/LDRE is closely linked to the USSR Project, which, in turn, is part of the larger SN Modernization effort. Table 1-3 lists target milestones for the USSR/LDRE portion of the USSR Project. Table 1-4 shows the overall USSR and Modernization milestones.

Table 1-3. Milestones for USSR/LDRE

Milestone	Target Date
Issue of USSR/LDRE RFI	03 March 2008
First Round of USSR/LDRE RFI Questions	30 Calendar Days
Close of USSR/LDRE First Round	02 April 2008
HTSI Answers Questions	15 Calendar Days
Answers to USSR/LDRE RFI Questions Posted	17 April 2008
Receipt of Second Round USSR/LDRE RFI Formal Responses from Industry 60 Calendar Days after Issue of RFI	02 May 2008

Table 1-4. Target Milestones for User Services Subsystem Replacement Project

Milestone	Target Date
Development of USSR Requirements Specifications	Ongoing
USSR Systems Requirements Review (SRR)	August 2008
USSR Request for Proposals (RFP)	November 2008
Vendor Selection (Mostly Likely Two Vendors)	February 2009
Project Preliminary Design Review (PDR)	June 2009
Modem Engineering Models	February 2010
Project Critical Design Review (CDR)	April 2010
Partial Implementation Complete	Late 2011
All Implementation Complete	December 2012

Interested potential vendors are to provide their production schedule information via the response to this RFI.

1.5 References

The central collection point for USSR references is the USSR web page:

http://scp.gsfc.nasa.gov/ussr/

For convenience, references are listed here.

1.5.1 Legacy White Sands Complex Specifications and Users' Guide

530-RSD-WSC	Requirements Specification for the White Sands Complex, DCN 005, 08 January 2008, NASA, GSFC Code 452.
450-SNUG	Space Networks Users' Guide (SNUG), Revision 9, August 2007, NASA GSFC Code 450.

1.5.2 Legacy Modem Specifications, Interface Control Documents, and O&M Manuals

7472106	Performance Specification, Integrated Receiver. Revision C, 15 August 1991. Interstate Electronics Corporation.
7472306	Performance Specification, Modulator/Doppler Predictor. Revision C, 15 August 1991. Interstate Electronics Corporation
7472506	Performance Specification, Second TDRSS Ground Terminal (STGT) Test Modem. Revision C, 04 April 1994. Interstate Electronics Corporation
STGT-HE-06-1 Appendix F	Interface Control Document for Integrated Receiver – Subsystem Controller/USS ADPE Status and Control 1553B Interface.
STGT-HE-06-1 Appendix G	Interface Control Document for Modulator Doppler Predictor – Subsystem Controller/USS Status and Control 1553B Interface.
STGT-HE-06-1 Appendix H	Interface Control Documents for the Performance Measurement Test Equipment (PTE) and the USS Subsystem Controller (SSC)/USS ADPE.
530-STGT-1E310	Operation and Maintenance Manual, Modulator/Doppler Predictor, Part Number 7472300 (Interstate Electronics). 01 April 1992. NASA, Contract NAS5-3000.

530-STGT-1E311	Operation and Maintenance Manual, Integrated Receiver, Part Number 7472100 (Interstate Electronics). 01 April 1992. NASA, Contract NAS5-3000.
530-STGT-1E312	Operation and Maintenance Manual, Test Modem, Part Number 7472500 (Interstate Electronics). 01 April 1992. NASA, Contract NAS5-3000.
530-STGT-1E314	Operation and Maintenance Manual, GN Modulator Card, Part Number 1547558. September 2000. NASA, Contract NAS9-98100

1.5.3 Constellation Program Requirements

CxP 70022-01	Constellation Program Command, Control, Communication, and Information (C3I) Interoperability Standards Book Volume 1: Interoperability Specification. Revision A, 30 November 2007. NASA
CCSDS 131.1-O-2	Low Density Parity Check Codes for Use in Near-Earth and Deep Space Applications. Consultative Committee for Space Data Systems. Orange Book, Issue 2, September 2007.

1.5.4 S-Band Signal Enhancements

NASA Report	TSUP Technical Study Report, Coding and Modulation Study, to be released by NASA/GSFC contemporary with this RFI.

SECTION 2. REFERENCE ARCHITECTURE

2.1 TDRSS Architecture

The TDRSS is well documented and will only be described briefly here as it applies to USSR/LDRE. For additional information about the TDRSS refer to the references in Section 1.5 on the USSR web site.

Figure 2-1 gives an overview of TDRSS User Services (also called Customer Services) as seen from one ground terminal. At present there are three ground terminals, which together form the WSC. Two ground terminals are located near Las Cruces, New Mexico at White Sands; the White Sands Ground Terminal (WSGT) and the Second TDRSS Ground Terminal (STGT. A third ground terminal in Guam, the Guam Remote Ground Terminal (GRGT), is remotely controlled from White Sands. Each of the two ground terminals at White Sands has three space-to-ground link terminals (SGLTs). Guam has one SN compatible SGLT and one SGLT with a subset of SN capabilities called the Space Network Expansion (SNE). A spare 16.5-meter antenna is under construction at Guam so that three SGLTs might be supported there in the future. A fourth ground terminal is in planning for the Eastern United States which will have one SNE SGLT.

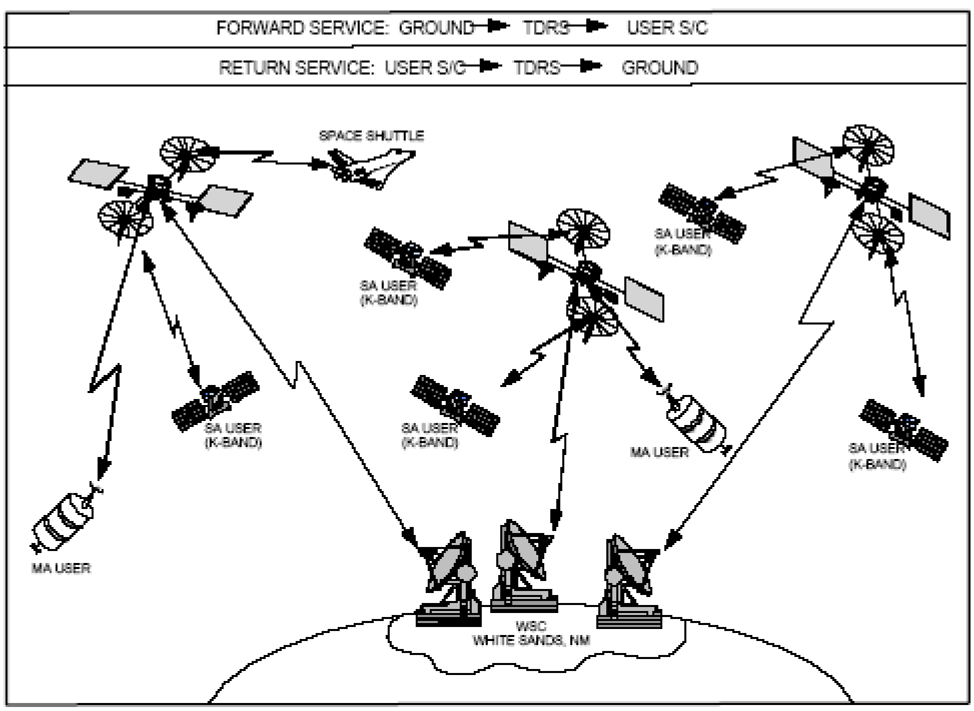

Figure 2-1. TDRSS User Services Overview (One Ground Terminal Shown)

Figure 2-2 provides a top-level view of the frequency plan in the space-to-ground link (SGL) channel and in the space-to-space link (SSL) channel. Figure 2-3 shows the arrangement of the communication systems on a TDRS of the H, I, J class (F8-F10), which, except for the Ka services and onboard MA beamforming, is typical of all the F1-F10 satellites. The term Customer Services is interchangeable with the term User Services.

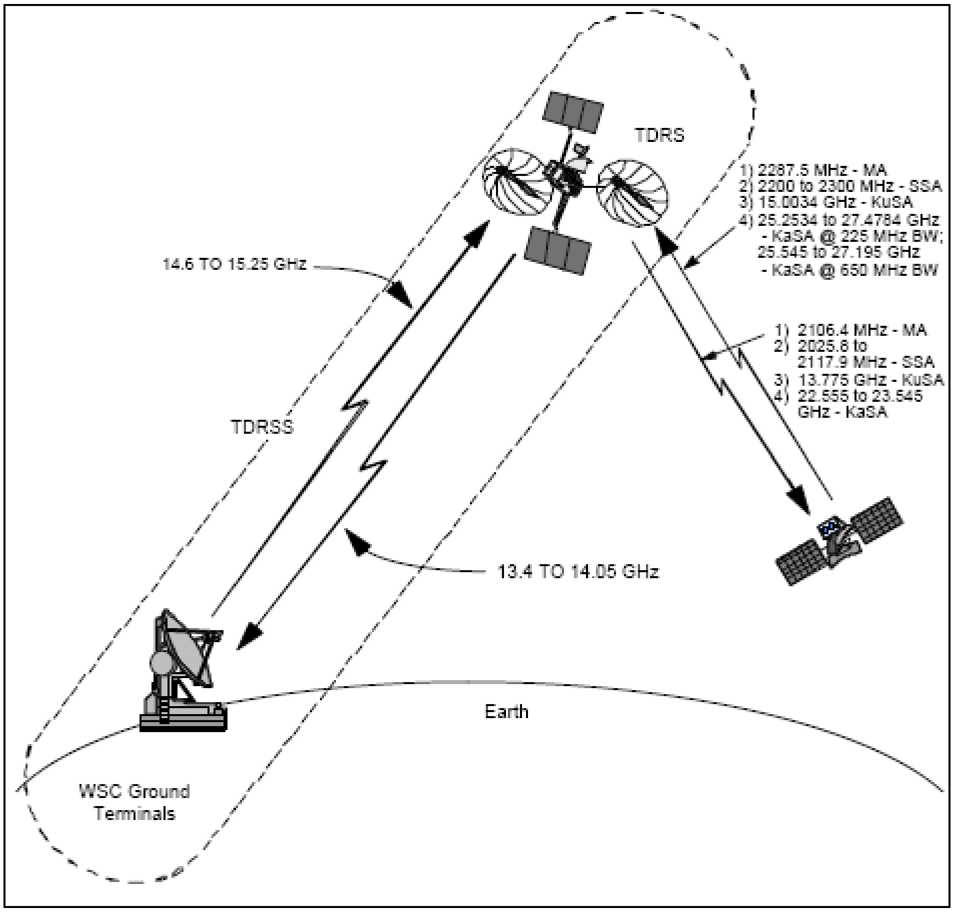

Figure 2-2. Frequency Plan of SGL and SSL Channels

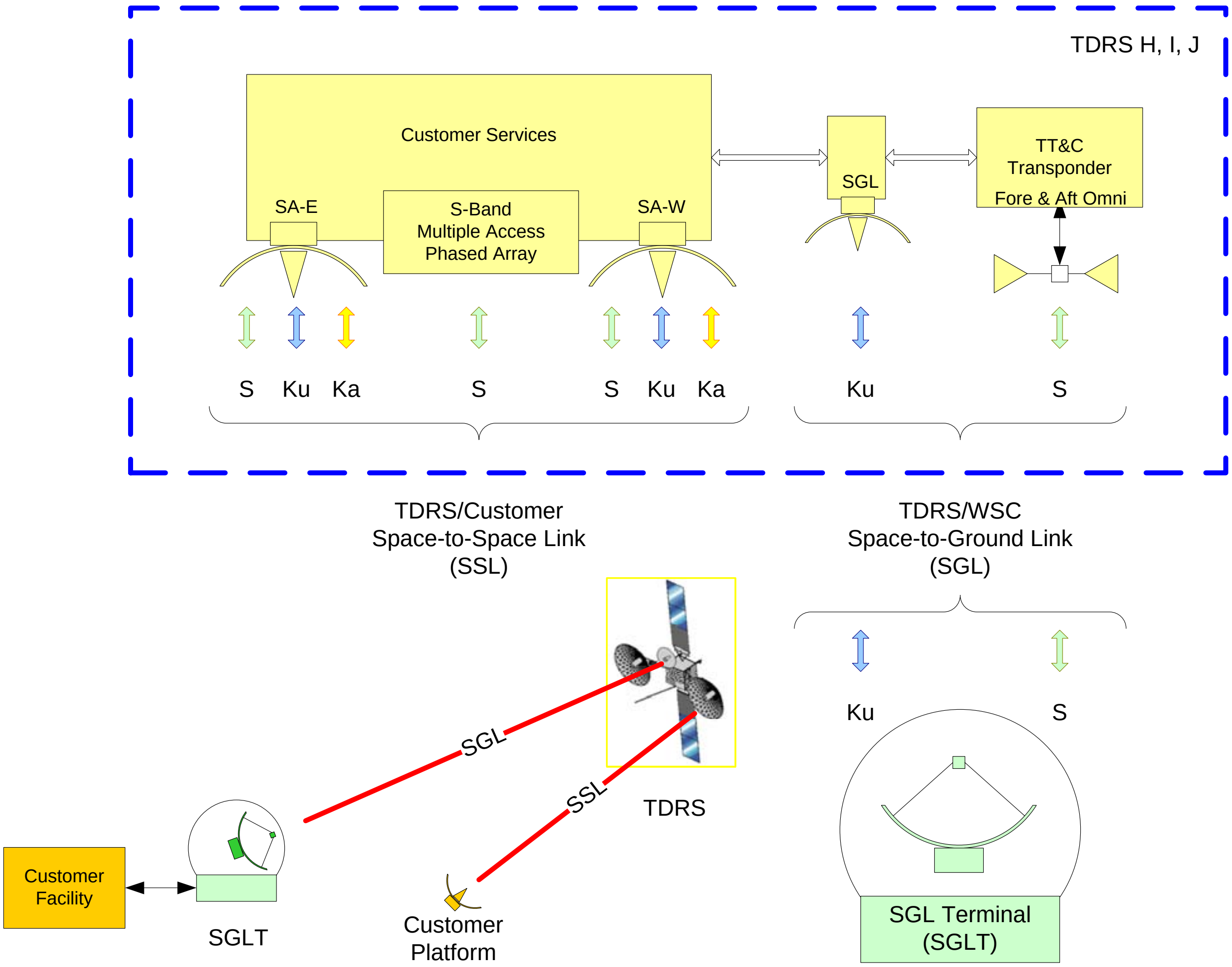

Figure 2-3. Arrangement of TDRSS Communication Systems

2.2 User (Customer) Services Subsystem

Table 2-1 provides a general summary of links available for each SGLT. Essentially, each TDRS is assigned a dedicated SGLT. A single-access (SA) service refers to a service provided by one of the two stearable SA antennas on each TDRS. Multiple-access (MA) services are provided by the 30-element S-Band phased array on TDRS. Each SA antenna can provide an S-Band or a Ku-Band link or a simultaneous, dual S- and Ku-Band link. The Flight 8 through Flight 10 (F8-F10) satellites can also support dual S-Band and Ka-Band services on each SA antenna. (Only one SA antenna on each F8-F10 satellite can provided wideband service, while both can provide narrowband Ka-Band service, as desired.)

Table 2-1. Summary of Current User (Customer) Service Links

SINGLE-ACCESS LINK SUMMARY				
	Forward Link		Return Link	
Band	SGLT – User S/C	Data Rate (Note 1)	SGLT – User S/C	Data Rate (Note 1)
S (F1-F10)	2	0.1 kbps to 7 Mbps	2	6 Mbps, Maximum
Ku (F1-F10)	2	1 kbps to 25 Mbps	2	300 Mbps, Maximum
Ka (F8-F10)	2	1 kbps to 25 Mbps	2	300 Mbps, Maximum
MULTIPLE-ACCESS LINK SUMMARY				
	Forward Link		Return Link	
Band	SGLT – User S/C	Data Rate (Note 1)	SGLT – User S/C	Data Rate (Note 1)
S (F1-F7)	1	0.1 kbps to 300 kbps	5	0.1 kbps to 300 kbps
S (F8-F10)	1	0.1 kbps to 300 kbps	5	3 Mbps, Maximum
Notes: 1. See the SNUG for careful distinctions between bit rates (bps) and symbol rates (sps). S/C = space craft				

The first generation F1-F7 satellites perform return link beamforming on the ground, while the second generation F8-F10 satellites use space based processing to form up to six return link beams of which five are available for operations at any one time. F1-F7 TDRS are limited to one Forward Link beam, while F8-F10 may form two Forward Link beams, although current operations are limited to one Forward Link beam.

Currently, F1-F7 legacy MA services support one Forward Link and five Return Link services, which is the same level of support as provided by F8-F10. While F1-F7 support is limited to only one Forward Link, the original TDRSS architecture envisioned as many as 20 MA Return Links per TDRS and the ground based beamforming concept supports this, however the current ground station implementation on supports six MAR[1] links. TDRS F8-F10 satellites are capable of providing two MA Forward Links but current operations are limited to one MA Forward Link.

Since Ku-Band and Ka-Band simultaneous services are not permitted, a common set of modems is currently used on the ground to support Ku-Band and Ka-Band services. The TKUP demonstration explored the capabilities and limits of the Ku-Band and Ka-Band channels. TKUP showed that both the Ku-Band and the Ka-Band channels can support User Return Service data rates higher than the current legacy limits. This is discussed in detail in the K-Band portion of the USSR web page.

[1] A separate Third Generation Beamformer, which is not part of the STGT-era architecture, provides a separate Demand Access System (DAS) with up to eight links. This system could also support more links if it were augmented with more modems.

2.3 SGLT Architecture

Figure 2-4 shows the general arrangement of the WSC, not including the SNE SGLTs. The subsystems of a typical SGLT are illustrated in Figure 2-5. In the legacy architecture the Multiple Access (MA) subsystem was not implemented in each SGLT. The modernized baseline is expected to have MA capabilities in all SGLTs.

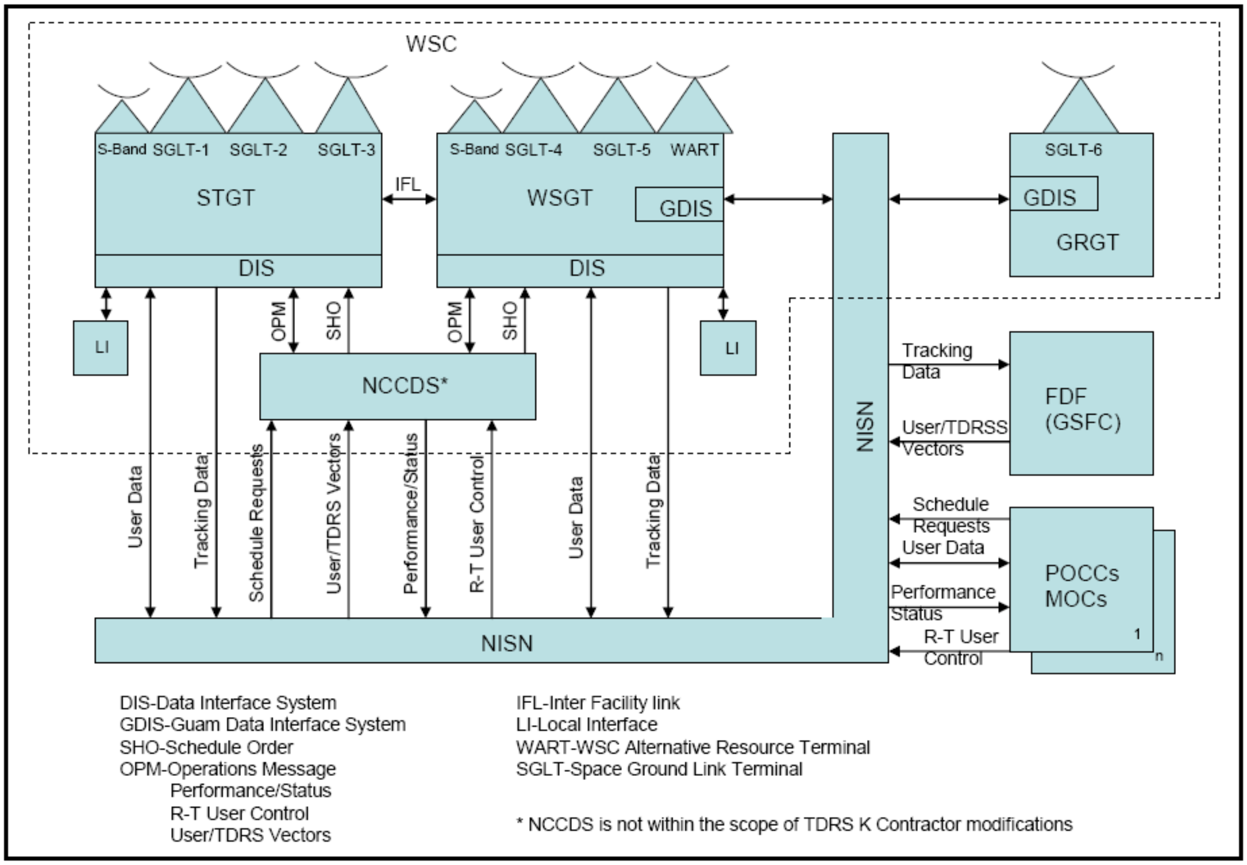

Figure 2-4. The White Sands Complex

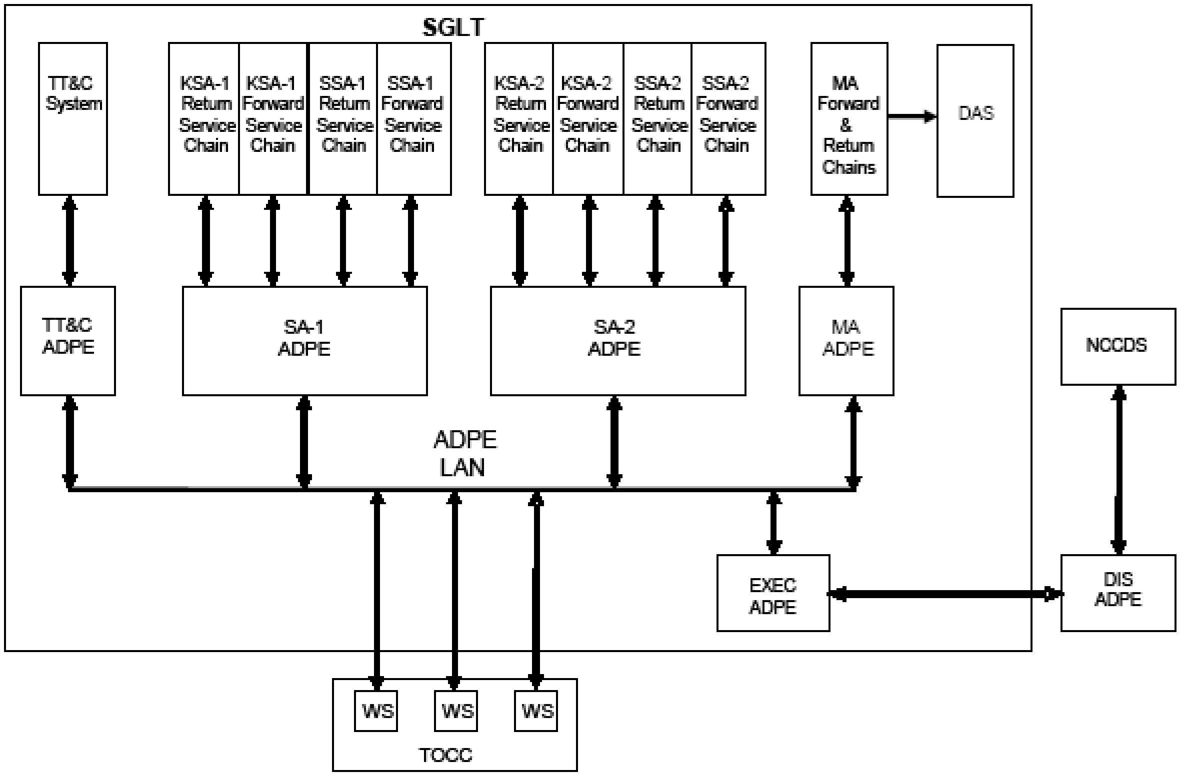

Figure 2-5. General Arrangement of Major SGLT Subsystems

A fully equipped SGLT (one with MA Services) is configured as shown in Figure 2-6 with respect to modems. In the current inventory, two of the six SGLTs were not populated with MA Services. The items highlighted in yellow are not the subject of this RFI, but these items are also under consideration in the larger USSR venue.

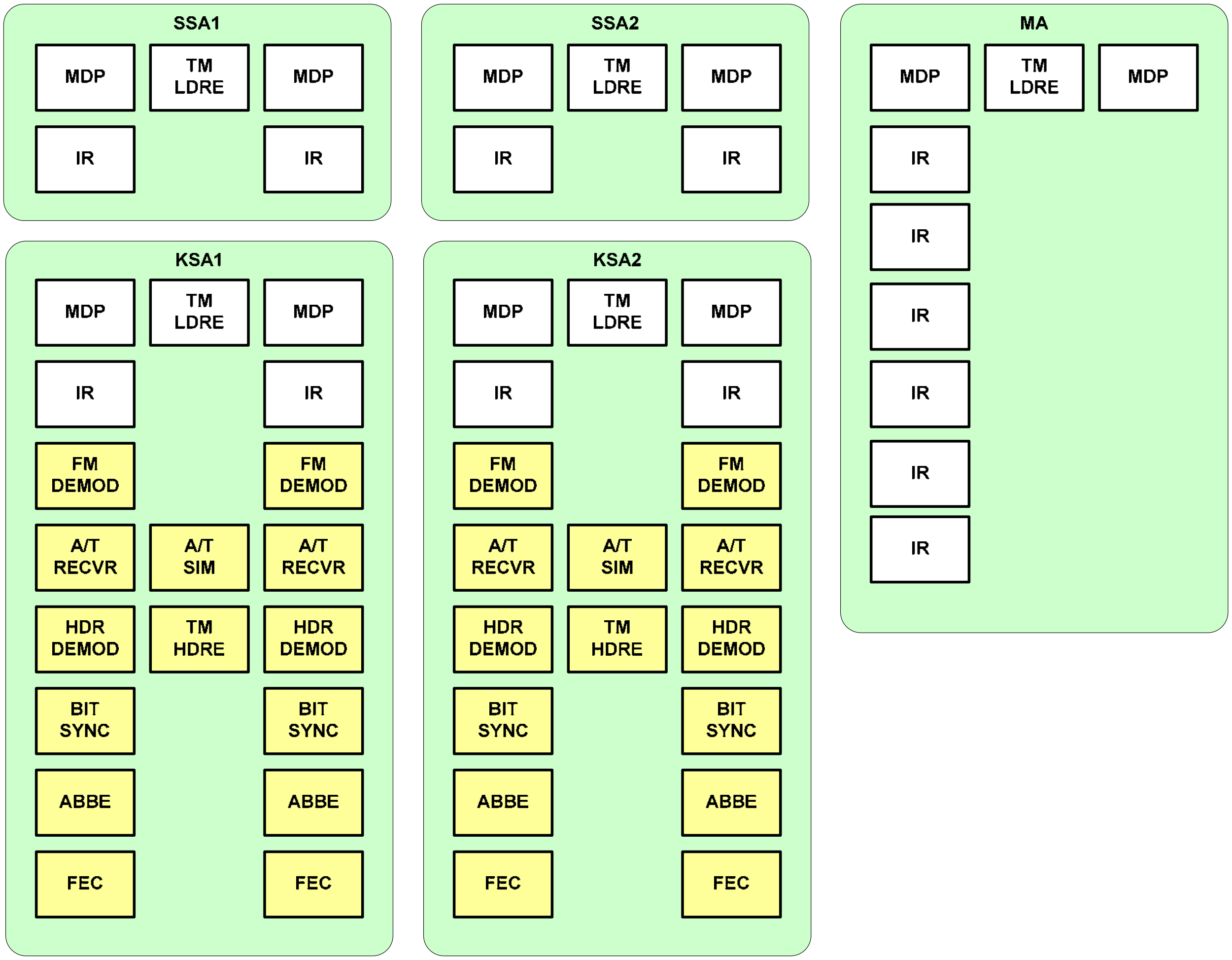

Figure 2-6. Narrowband Modems in a Fully Populated SGLT

For the purposes of this RFI each SGLT service chain can be visualized as in Figure 2-7. A User Forward Service originates in a Modulator/Doppler Predictor. The IF signal from the MDP is upconverted (U/C) to Ku-Band and then amplified by a high power amplifier (HPA) whose radio frequency (RF) energy is coupled to the ground antenna and then radiated in the SGL. Similarly, a User Return Service is received at Ku-Band by the ground antenna and coupled to a low noise amplifier (LNA). The amplified received RF signal from the LNA is downconverted (D/C) to IF and then demodulated by the Integrated Receiver. In the MA return services, the downconversion process also involves the complex combining and pointing of the 30 elements from the TDRS phased array, but the effect is the same: the received RF signal is converted to an IF and input to an IR.

In the current system all Forward Link IF signals are nominally 370 MHz, while Return Links IF signals are 370 MHz for SSAR, 370 MHz for KSAR, 8.5 MHz for KSAR subcarrier, 8.5 MHz for MAR, and 370 MHz for SMAR.

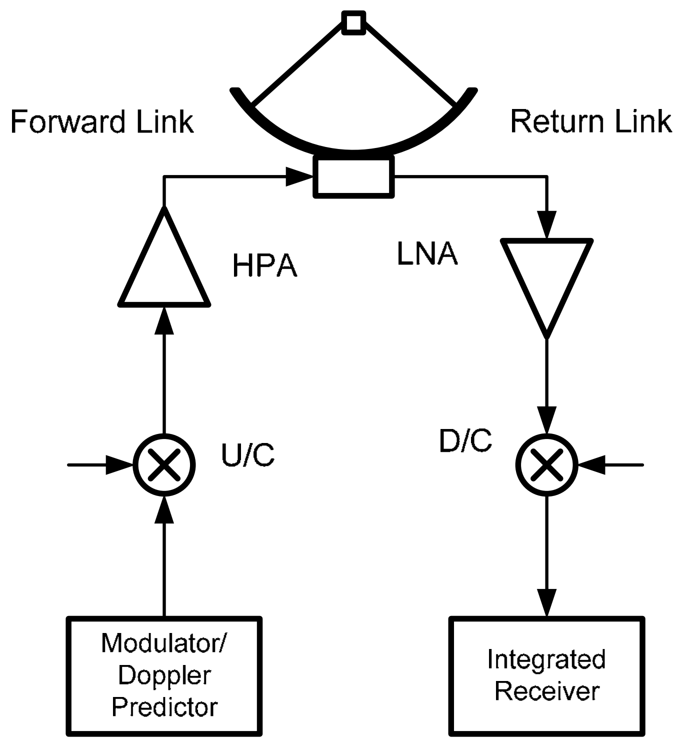

Figure 2-7. Simplified Diagram of a Generic Service Chain in a SGLT

Figure 2-8 shows the Test Modem related to the MDP and the IR in the Short Loop (IF) Test Mode. The TM is a modem in the low rate Performance Monitoring and Measuring System (PMSS). The TM provides a demodulator to verify User Forward Services and a modulator to verify User Return Services. That is, the TM demodulates modulation from the MDP and modulates test signals to be demodulated by the IR. The TM also controls PMMS Test Equipment (PTE) such as bit error rate test sets (BERTS) and a calibrated noise source which enables the Eb/No Test Set.

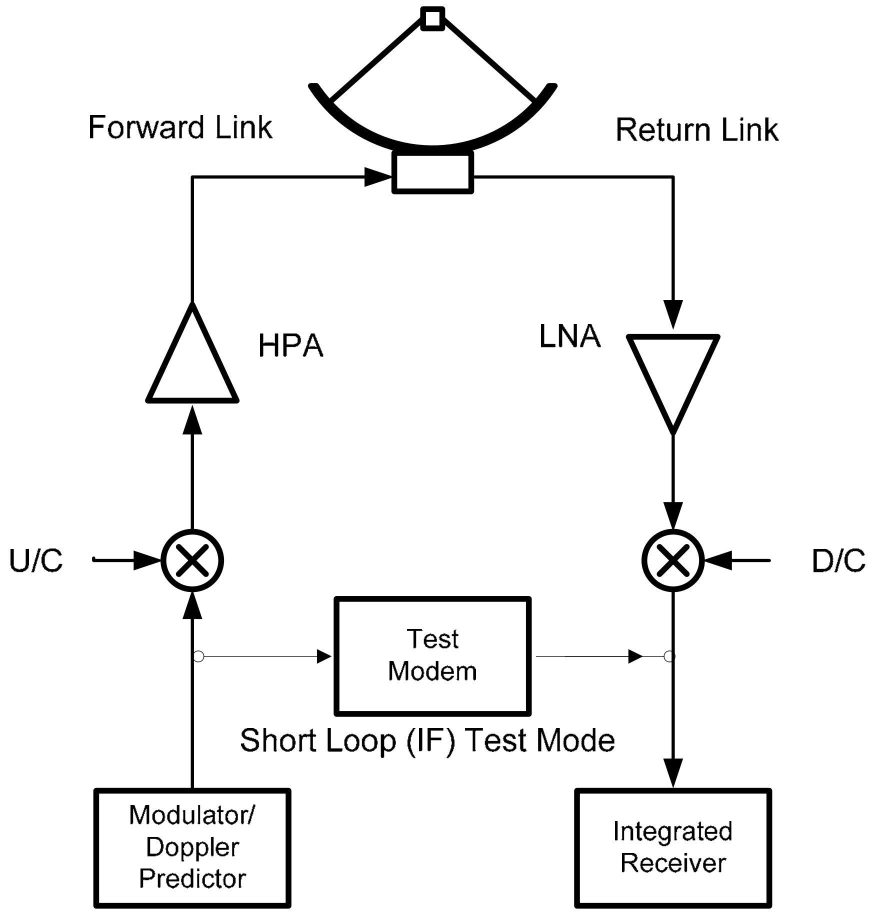

Figure 2-8. Simplified Diagram of the Test Modem in IF Test Mode

SECTION 3. MODEM FUNCTIONS AND PERFORMANCE

3.1 Modem Requirements

This section provides the source of modem requirements, which are divided into three categories.

- Legacy Requirements
- Constellation Program Requirements
- S-Band Signal Enhancements

The Legacy Requirements include requirements for Shuttle Support. These requirements also reflect the current partition between Low Data Rate Equipment (Narrowband Modems) and High Data Rate Equipment (Wideband Modems). The USSR Program makes two assumptions:

1. The USSR Program will not be required to support Shuttle. Vendors may ignore Shuttle Requirements.

2. The USSR Program will partition the Narrowband and Wideband modems so that the Wideband Modems will perform all functions that should logically be performed by the Wideband Modems, such as Autotrack and Tracking Services for High Data Rate Services. The Narrowband Modems shall be able to process all KSAR data rates that are in common with SSAR.

3.1.1 Legacy Requirements

Legacy requirements for modem functions and performance are from the specifications listed in Table 3-1, which are also listed in Section 1.5. The USSR website has copies of these specifications.

Table 3-1. Performance Specifications for STGT-Era Legacy Modems

Drawing Number	Title	Revision and Date
7472106 STGT-HE-06-1 Appendix F	Performance Specification Integrated Receiver Interface Control Document for Integrated Receiver – Subsystem Controller/USS ADPE Status and Control 1553B Interface	Revision C 15 August 1991
7472306 STGT-HE-06-1 Appendix G	Performance Specification Modulator/ Doppler Predictor Interface Control Document for Modulator Doppler Predictor – Subsystem Controller/USS Status and Control 1553B Interface.	Revision C 15 August 1991
7472506 STGT-HE-06-1 Appendix H	Performance Specification, Second TDRSS Ground Terminal (STGT) Test Modem Interface Control Documents for the Performance Measurement Test Equipment (PTE) and the USS Subsystem Controller (SSC)/USS ADPE	Revision C 04 April 1994

The operation and maintenance manuals for the modems, listed in Section 1.5, provide very good descriptions of the legacy equipment. The description of the GMOD card, used in the MDP to provide phase modulation, is not found in MDP performance specification, but is described in detail in 530-STGT-1E314, Operation and Maintenance Manual, GN Modulator Card.

3.1.1.1 Legacy Partition between Low Data Rate Equipment and High Data Rate Equipment

The partition between the LDRE and the High Data Rate Equipment (HDRE) is historic. To some degree it was based on the maturity of technology at the time of the first WSGT in the late 1970s and early 1980s. This technology division continued into the late 1980s and early 1990s with the STGT era. The LDRE consists of all of the spread spectrum ground terminal modems, which are of digital design. The LDRE encompasses all of the MA, SSA, and KSA forward services, and all of the MA and SSA return services. Since there is some overlap between SSA and KSA at the low end of the unspread configurations, the LDRE was partitioned to include all of the data rates that were common to SSA and KSA.

In the current implementation, the MDP, IR, and TM are interchangeable across MA, SSA, and KSA with two minor exceptions that will be described later in this document (3.2.1.1, 3.2.2.1).

3.1.1.2 Modernization Partition

Industry is encouraged to review the results of the TKUP-A demonstrations, and to examine the complete specifications for the WSC given in references of Section 1.5. In 2008, it may be a simple thing to include all modem functions into a single design, or at least into a common design. Or, it may still be practical to maintain the legacy partition between LDRE and HDRE. The partition was in the past driven by technology and not by the top-level ground terminal requirements.

3.1.1.3 Space Network Users' Guide

The Space Network Users' Guide (SNUG), which is listed in the references of Section 1.5, is not a performance specification, but it is (as the name suggests) a very useful users' guide. The SNUG does not describe how the ground terminals are implemented, but it does give a very good description the capabilities of the SN from the Customer's perspective and of the signal set that must be processed by both the space and ground segments.

3.1.1.4 Legacy NASA Requirements

Table 3-2 provides the current WSC baseline requirement. These are called legacy requirements because they do not incorporate the Constellation requirements or the S-Band Signal Enhancements.

Table 3-2. Legacy NASA Requirement

Drawing Number	Title	Revision and Date
530-RSD-WSC	Requirements Specification for the White Sands Complex	DCN 005

3.1.2 Constellation Program

"NASA has recently formed the Constellation Program to achieve the objectives of maintaining American presence in low Earth orbit, returning to the moon for purposes of establishing an outpost, and laying the foundation to explore Mars and beyond in the first half of the 21st century. The Constellation Program's heritage rests on the successes and lessons learned from NASA's previous human spaceflight programs: Mercury, Gemini, Apollo, Space Shuttle and International Space Station (ISS)." Excerpt from NASA/SP-2007-563, Formulation of NASA's Constellation Program, October 2007.

The SN will provide vital infrastructure communications in support of the Constellation Program. Table 3-3 and Table 3-4 show the Forward and Return Service Link configurations that will be supported by the USSR/LDRE. These links will use existing TDRSS signal sets that will be modified to use the Low Density Parity Check (LDPC) code family specified in CCSDS 131.1-O-2, and CxP 70022-01.

Table 3-3. Constellation Program Space Network S-Band Forward Service Links

Link	Data Rate			Modulation	Coding
1	18 kbps			SQPN	R1/2 AR4JA LDPC
2	72 kbps			SQPN	R1/2 AR4JA LDPC
3	1 Mbps			Unspread BPSK	R1/2 AR4JA LDPC

Table 3-4. Constellation Program Space Network S-Band Return Service Links

Link	Data Rate	Data Group	Mode	Modulation	Coding
1	24 kbps	DG1	Mode 1 Or Mode 2	SQPN	R1/2 AR4JA LDPC
2	192 kbps	DG1	Mode 1	SQPN	R1/2 AR4JA LDPC
3	1 Mbps	DG2	N/A	Unspread BPSK	R1/2 AR4JA LDPC

The TSUP Technical Study Report (TSUP TSR) provides implementation loss analysis of the Constellation Program SN Links listed in Table 3-3 and Table 3-4.

3.1.3 S-Band Signal Enhancements

The TSUP TSR addresses the S-Band Signal Enhancements that might make more efficient use of the TDRS S-Band Single Access channels. This includes consideration of bandwidth efficient coding schemes that might increase the maximum SSAR data rate to 15.75 Mbps.

TSUP Technical Study Report will be released by NASA/GSFC contemporary with this RFI. See the USSR web page for details.

3.1.4 Potential Space Network S-Band Service Enhancements

The USSR web page provides references and descriptions of the potential to configure space and ground equipment to implement TDRS arraying in the MAR. Other ground based schemes may be examined that would enable improved multiple access including interference cancellation and multi-user FDM services.

3.2 Modem Configurations and Functions

3.2.1 MDP Configurations and Functions

3.2.1.1 MDP Configurations

In the current configuration, MDP units are interchangeable from service to service with the exception that units used in the SSAF must also have a GMOD card installed to provide Ground Network Phase Modulation. The MDP firmware is common to all services.

The configuration of the MDP is essentially the same as shown in Figure 3-1 for all services. For SSA Forward (SSAF) Services, the MDP can either modulate with phase shift keying (PSK) or phase modulation (PM). For MA Forward (MAF), Ku-Band Single Access Forward (KuSAF), and Ka-Band Single Access Forward (KaSAF), modulation is limited to PSK. The MDP may also be configured to output a continuous wave (CW) signal at a nominal 370 MHz IF. An unmodulated (CW) IF is always available as an MDP output whenever the unit is in the Configured State or higher.

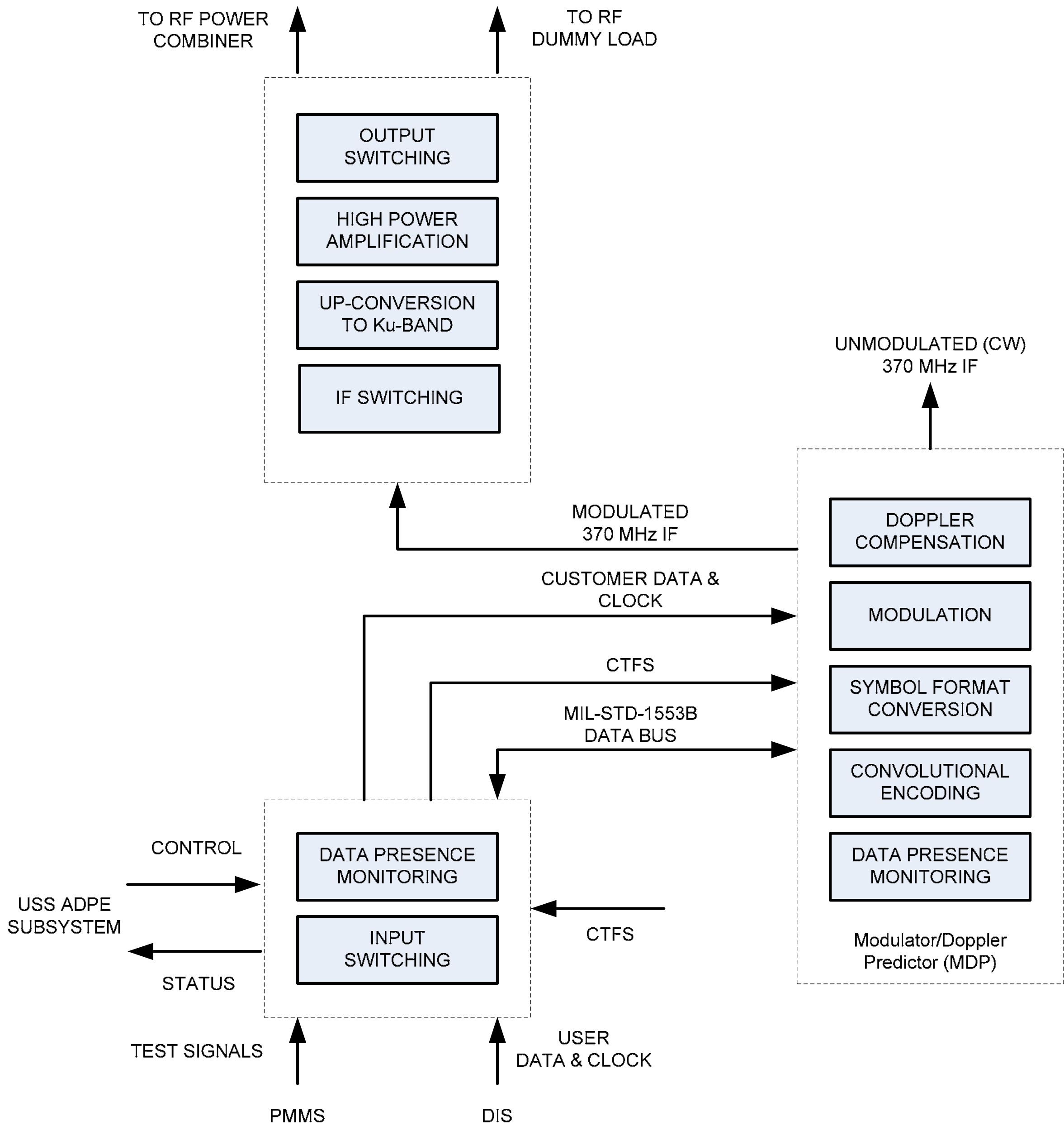

Figure 3-1. General Configuration of MDP for all Services

3.2.1.2 MDP Configurations and Functions

The MDP shall provide the following essential functions, as required, and where applicable:

a. Provide data formatting, symbol formatting, and encoding of forward user data.
b. Provide data presence monitoring.
c. Generate PN codes and clocks.

d. PSK modulate the forward carrier with forward data and PN codes. The output carrier will be a nominal 370 MHz.

e. PM modulate the forward carrier with forward data to accommodate any of three SSAF Ground Network modes. The output carrier will be a nominal 370 MHz.

f. Provide forward link Doppler compensation, including the capability to:

   (1) Simultaneously adjust the forward link carrier frequency and PN code rate in accordance with a commanded profile;

   (2) Independently Doppler compensate the carrier and PN code rate for S-Shuttle support;

   (3) Receive Doppler updates from the USS ADPE data bus;

   (4) Enable and disable Doppler compensation as commanded. This includes the capability to ramp the carrier frequency linearly to a specified target frequency.

g. To assist user satellite (USAT) acquisition or reacquisition, provide the capability to sweep the forward carrier and PN code, or, to force a reacquisition, provide a step in carrier and code frequency to break lock on the forward link.

h. Provide tuning of the carrier frequency to accommodate service assignment (SSA, KSA, and MA) and user frequency assignment.

i. Provide support for tracking services including:

   (1) Time Transfer Measurement;

   (2) Range Zero Set.

j. Generate status data, including self-test and fault isolation data.

k. Generate test signals, including an unmodulated IF carrier output.

l. Communicate with USS ADPE data bus (current interface in MIL-STD-1553B via a subsystem controller).

m. To support maintenance and operations, provide front panel and maintenance panel controls, indicators, and test points, as specified.

3.2.2 IR Configurations and Functions

3.2.2.1 IR Configurations

In the current configuration, IR units are interchangeable from service to service with the exception that units used in the KSAR must also have a High Rate Downconverter card and cable kit installed to provide autotrack and Doppler tracking for High Data Rate services. The IR firmware is common to all services.

In all configurations the IR works closely with its companion MDP to provide Doppler compensation and Doppler correction. All MDP frequency commands are also provided to the

IR, including Forward Sweep and Break Lock, so that the IR has continuous knowledge of the MDP frequency profile enabling the IR to more precisely and accurately support tracking services.

3.2.2.1.1 SSAR IR Configurations

The SSAR IR configuration is shown in Figure 3-2. Dashed lines indicate the SSAR Combining Mode, which uses post detection combining to improve the post detection signal-to-noise ratio (SNR) by approximately 2.5 dB, which provides improvement in bit error rate (BER) performance, but which has no effect on acquisition or tracking performance.
SSAR Combining mode is seldom used.

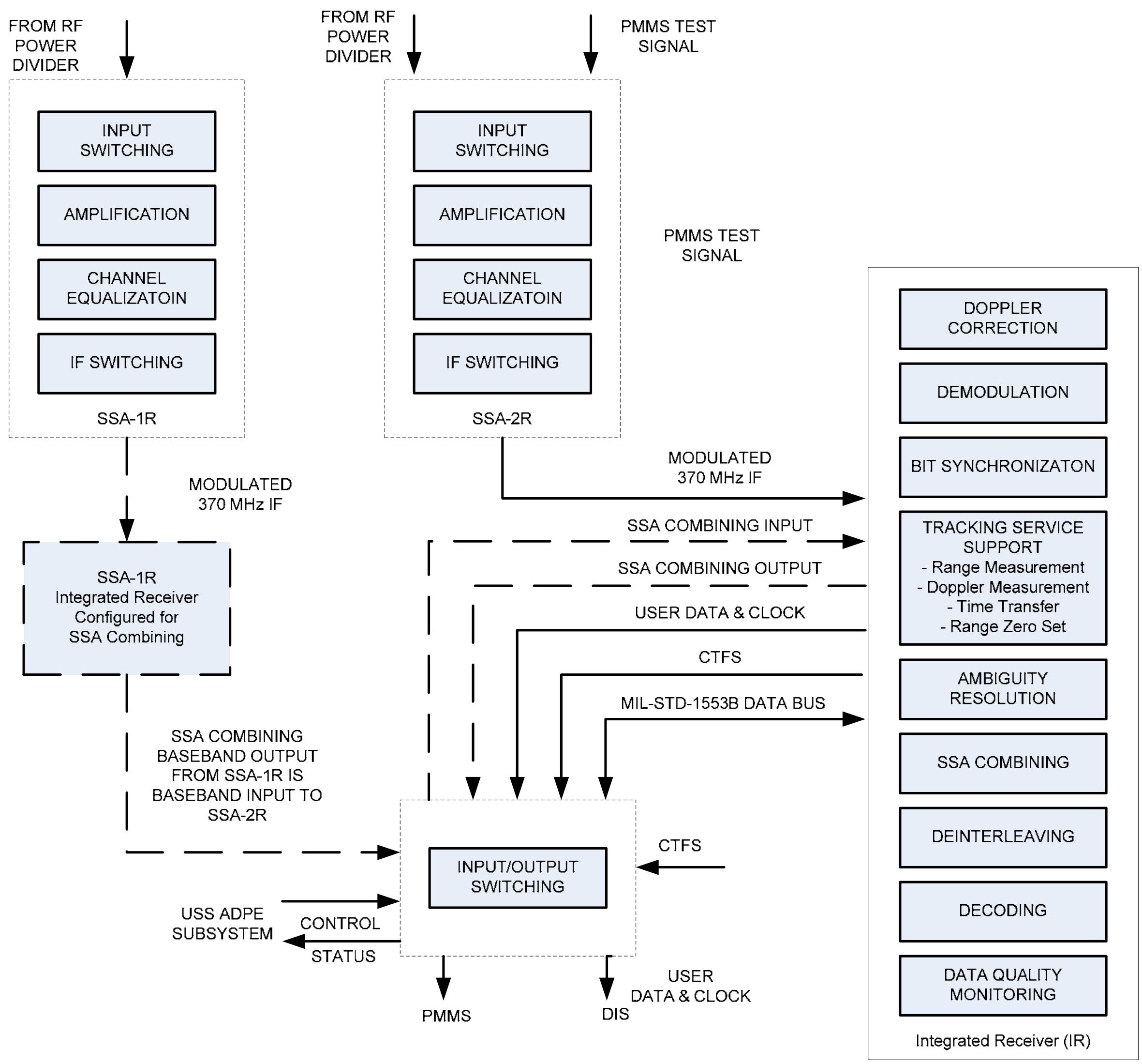

Figure 3-2. SSAR IR Configuration

The matched filter output soft decisions from the SSA-1R IR are combined with the matched filter output soft decisions from the SSA-2R IR. The combined signals are then input to the deinterleaver and the convolutional decoder of each of the two IRs. The USS ADPE commands which IR output to select for User Data & Clock.

3.2.2.1.2 KSAR IR Configurations

The KSAR IR configuration is shown in Figure 3-3. The equipment and configuration are the same for KuSAR and for KaSAR, except the 8.5 MHz subcarrier is never used in KaSAR. That is, the same physical boxes are used for KuSAR and KaSAR. This is possible because User signals for both KuSAR and KaSAR are mapped to the same frequency bands in the space-to-ground link (SGL).

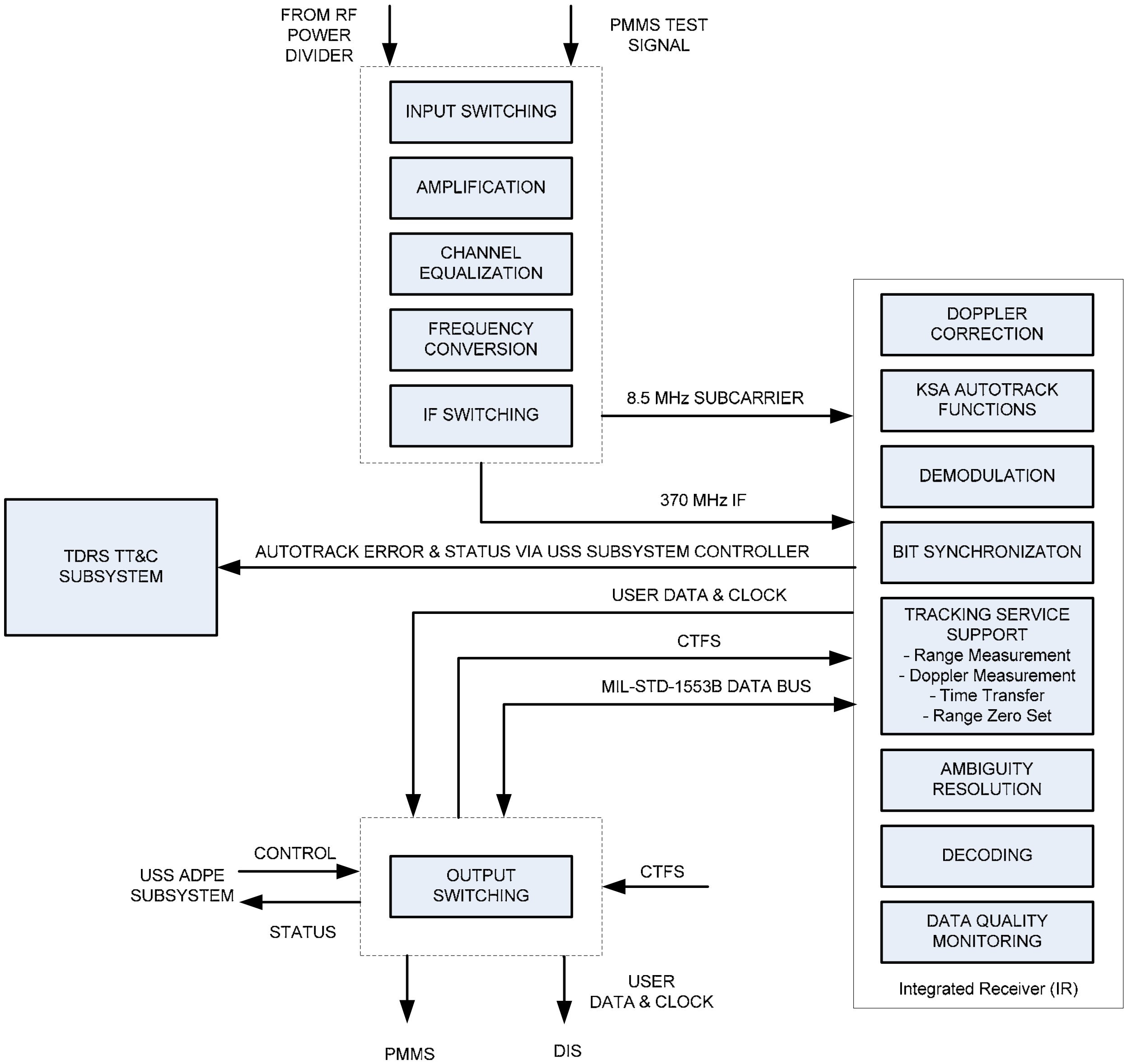

Figure 3-3. KSAR IR Configuration[2]

The KSA IR configuration has an additional High Data Rate Demodulator card and cable kit, which distinguishes KSA IRs from MA and SSA IR configurations. All IR configurations (SSA, KSA, and MA) share a common firmware configuration.

KSA functions include detecting and recovering the KSA Autotrack Error Signal for all PSK KSA signal sets, including High Data Rate services, in which case the KSA IR also provides carrier recovery and Doppler measurement. For High Data Rate KSA Shuttle Services, the IR

[2] The USSR partition between LDRE and HDRE will eliminate the need for the KSAR 8.5 MHz IF.

independently tracks Autotrack and Carrier using the 370 MHz IF while simultaneously independently tracking and demodulating the 8.5 MHz IF from the K-Shuttle subcarrier.

3.2.2.1.3 MAR and SMAR IR Configurations

The MAR/SMAR IR configuration is shown in Figure 3-4. For MAR Services (F1-F7), the ground-based MA Beamforming Equipment (MABE) forms an 8.5 MHz IF signal for each User from the 30 elements of the phased array which are frequency division multiplexed (FDM) with the TDRS Telemetry Carrier in the Ku-Band SGL. Up to six MAR 8.5 MHz IF signals are provided to up to six IRs. One of the six IRs is dedicated as a Calibration Receiver so that only five IRs can support User Services. For SMAR Services (F8-F10) space-based equipment is used to form up to six beams which are then FDM'd in the Ku-Band SGL and downconverted to form up to six SMAR 370 MHz IF signals for the six IRs in the MA. Operationally, usually no more than five beams are used.

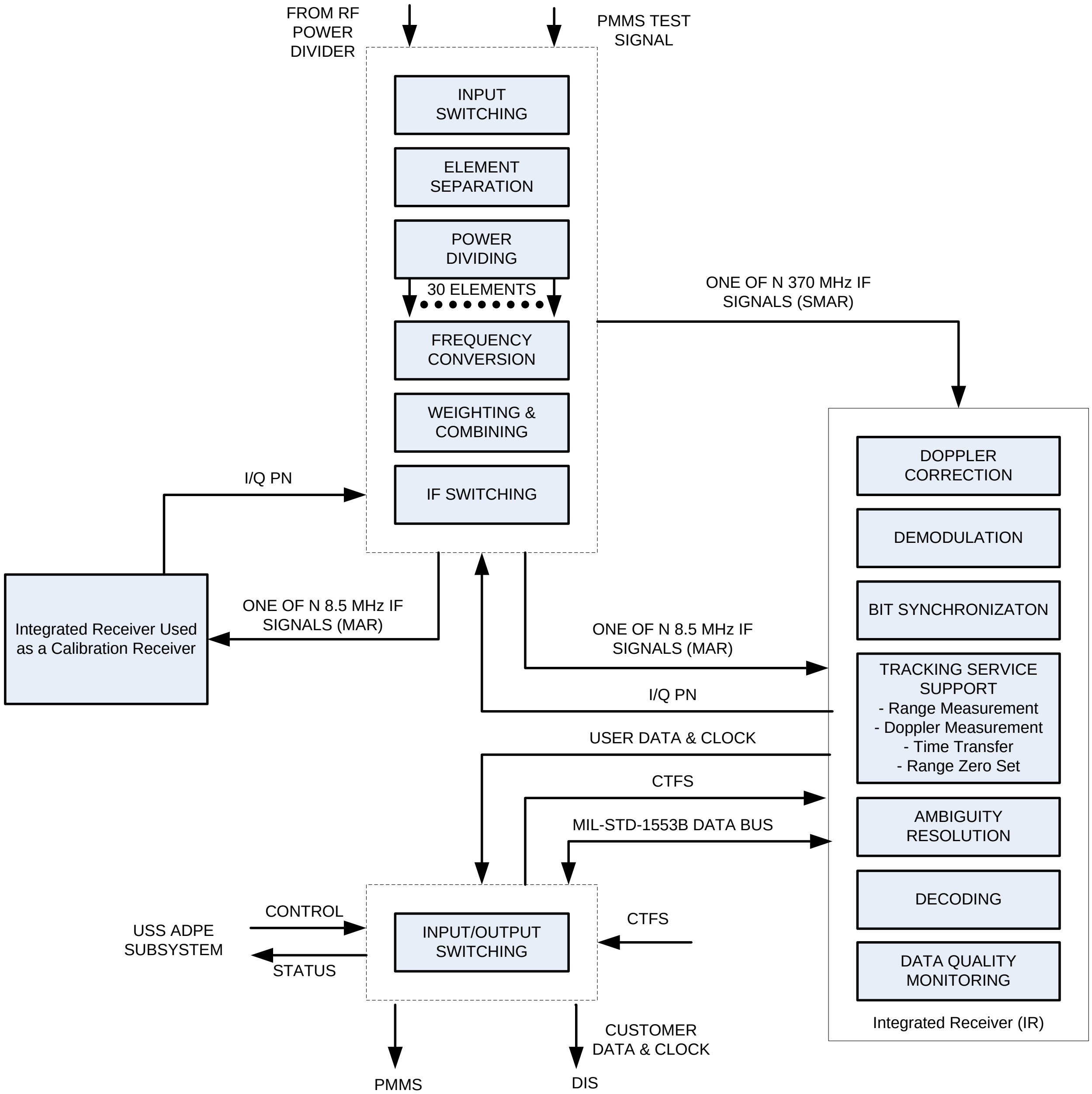

Figure 3-4. MAR/SMAR IR Configuration

3.2.2.2 IR Functions

The IR shall provide the following essential functions as required, and where applicable:

a. Provide Doppler correction, including the capability to:

(1) Receive Doppler updates (ephemeris data) from the data bus;

(2) Maintain a Forward Model of the Doppler compensation and control performed on the forward link.

b. Despread and track the received PN spread signal.

c. Recover PN code epoch and clock and perform Range Measurements and Time Transfer Measurements. For MA Services, provide PN code and lock status as output signals.

d. Demodulate the carrier.

e. Recover carrier and perform Doppler Measurement, including the S-Shuttle case where the return signal is carrier only (no modulation). This includes all USS Return Services except K-Shuttle Mode 2 (frequency modulation mode).

f. Recover symbol clock and detect symbols, including single and dual channel configurations for all USS Return Services except KSA High Data Rate.

g. Support Data Delay Measurements

h. Perform ground terminal delay measurement for Range Zero Set.

i. Resolve data channel and phase ambiguity.

j. Provide deinterleaving and convolutional decoding, including S-Shuttle unique Rate 1/3 decoding. Provide the capability to bypass the decoders.

k. Provide format conversion of recovered symbols and data so that the output data stream is NRZ-L.

l. Provide as outputs the recovered data streams with synchronous data clocks, with the following exceptions:

(1) Clamp the data output (I and Q independently) to a Logical-1 when there is detected loss of data in the channel.

(2) During times when a data channel is clamped to a Logical-1 due to a loss of data in the channel, maintain the data clock output signal.

m. For K-Band Single Access (KSA) return services, including K-Shuttle Mode 1, provide carrier recovery for Doppler Measurements and perform Autotrack Error Signal Detection. Autotrack Error Signal Detection is not available for K-Shuttle Mode 2 (frequency modulation mode).

n. For K-Shuttle Mode 1 (quadrature double sideband mode), perform extraction, acquisition, and demodulation of the subcarrier from the 370 MHz IF input. For K-Shuttle Mode 2, provide data and carrier recovery on the Shuttle subcarrier provided to the IR on the 8.5 MHz IF Input.

o. For S-Band Single Access (SSA) Return Services, including S-Shuttle, provide for SSA Combining.

p. Generate status data, including self-test and fault isolation information. Provide required status data (including Eb/No measurements, channel error rates, and channel lock times) to both the front panel and to the data bus. Additional status data may be provided to the data bus that is not available on the front panel.

q. Communicate with the USS ADPE data bus.

r. To support maintenance and operation, provide front panel and maintenance panel controls, indicators, and test points.

3.2.3 TM Configurations and Functions

3.2.3.1 TM Configurations

Figures F-1 through F-6 in 7472506 show the configuration of the Forward and Return Loop Tests for the TM in SSA, KSA, and MA configurations. Signal flow diagrams for the SSA, KSA, and MA TM configurations are given in figures 1-5 through 1-7 in 530-STGT-IE312. Figure 3-5 shows the configuration of the TM relative to the commercial test equipment it controls.

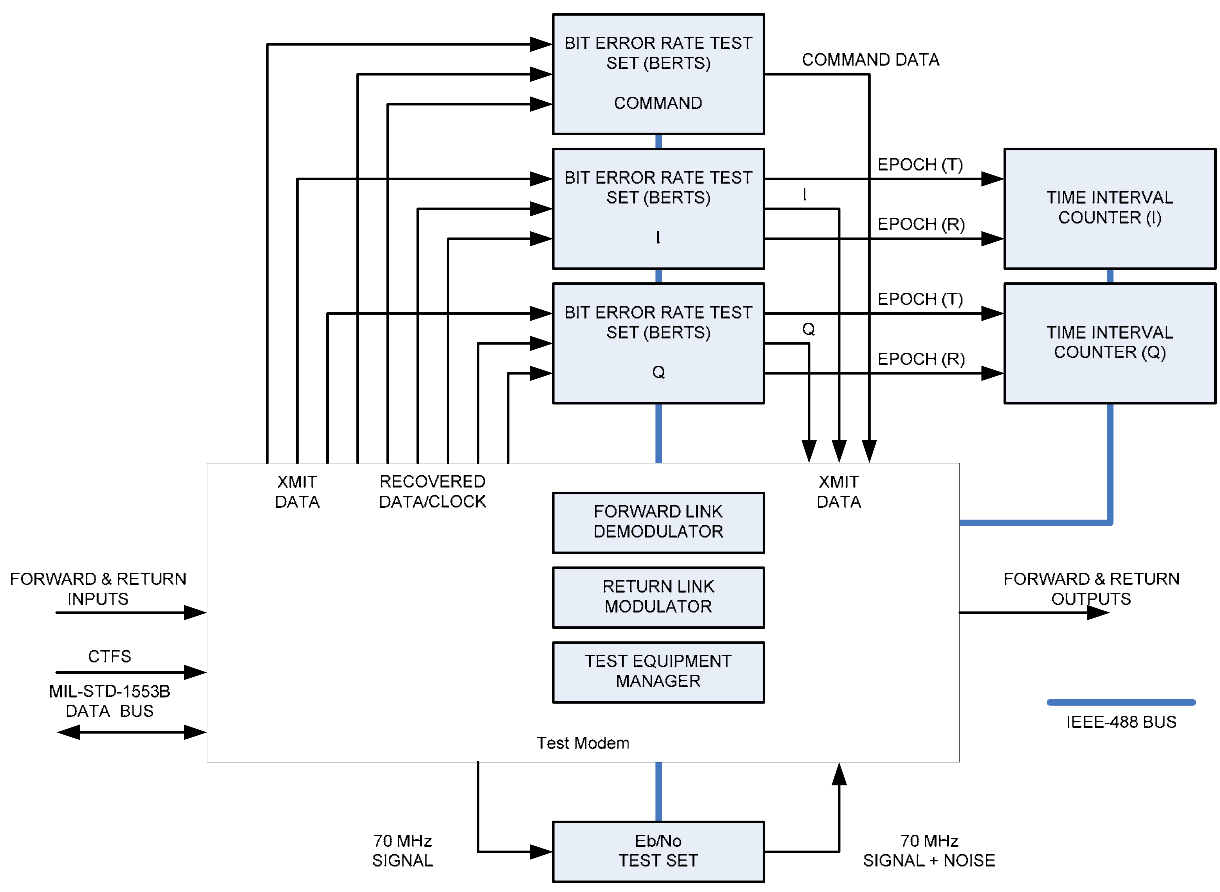

Figure 3-5. Test Modem Configuration with Commercial Test Equipment

3.2.3.2 TM Functions

The TM has three high level functions:

- Demodulate Forward Link test signals which were modulated by the MDP
- Modulate Return Link test signals that will be demodulated by the IR
- Manage the commercial test equipment associated with the Low Date Rate PTE.

The TM's Forward Demodulator functions are given in 7472506, 3.1.b. TM Return Modulator functions are listed in 7472506, 3.1.c. Functions that are common to the Forward and Return links are provided in 7472506, 3.1.d.

SECTION 4. SPECIFIC QUESTIONS FOR VENDORS

Your company is invited to submit a rough order of magnitude (ROM) estimate for cost and schedule based on the information presented in this RFI and the information on the USSR web page, subject to the Disclaimers in Section 5.

If you need more information, submit questions in the First Round Open Questions period. These costs must include the Total Cost of Ownership for, (a) a 10 year period of operation, and (b) a 15 year period of operation for the quantities and types of units provided in Table 1-2. As a minimum, include all Legacy and Constellation requirements. Identify, which, if any S-Band Signal Enhancements would cause significant non-recurring engineering (NRE) beyond the effort required to satisfy the Legacy and Constellation requirements.

RFI 1. Product Line – Give examples of delivered products that your company has designed and delivered that are similar to the items described in this RFI.

RFI 2. Support for Software Defined Products - We fully expect that the USSR equipment will consist of software defined radios. Describe the development, delivery, maintenance philosophy, and practice of your company for your standard product line (in general and specifically for your examples of delivered products), especially with regards to items that include embedded software developed by your company and COTS software develop by others.

RFI 3. State of the Art – How do the TSUP requirements challenge the state of the art? How does TSUP compare to other modern systems (existing/planned) around the world? How does it compare with the state of the art required for your examples of delivered equipment?

RFI 4. COTS Products – Describe how your examples of delivered products utilized commercial-of-the-shelf solutions. Identify to what degree these COTS products had to be modified to be suitable for use in your examples of delivered products.

RFI 5. Legacy Requirements – The current equipment has been supporting the Legacy Requirements for almost 15 years. These requirements have been NASA's TDRSS requirements for over 30 years. Which, if any, of these requirements would require modifications to your examples of delivered products?

RFI 6. Constellation (CxP) Requirements – The Constellation Program adds Low Density Parity Check (LDPC) codes to the Legacy Requirements. Have any of your examples of delivered products used LDPC? Have they used the CCSDS AR4JA code?

RFI 7. S-Band Signal Enhancements, NRE – Which S-Band Signal Enhancements would require significant NRE beyond that required to satisfy the Legacy and Constellation requirements?

RFI 8. S-Band Signal Enhancements, Your Products – Which of the S-Band Signal Enhancements have you implemented in your examples of delivered products?

RFI 9. Performance Data – Please provide actual performance data for your examples of delivered products. This would include such things as bit error rate performance, phase noise performance, mean time to acquire (carrier, PN code, and symbols), mean time to cycle slip, mean time to symbol slip, and similar modem performance metrics.

RFI 10. User Dynamics – Figures 12 through 14 in 7472106 provide the maximum errors in the predicted delay and frequency profiles, which are provided to the IR by the ground terminal ADPE based on the User's dynamics. Additionally, 7472106 describes the range of C/No values over which the IR must perform and the conditions of the expected radio frequency interference environment. How similar are these User Dynamics to those supported by your examples of delivered products?

RFI 11. Tracking Services – The current equipment provides support for all of the Tracking Services specified in 7472106, 3.2.1.5. Additionally, the current equipment allows Forward Link Doppler Compensation to remain on or off while performing these services. This involves coordinating the frequency control of the MDP and the IR in such a manner that the IR maintains precise knowledge of the MDP's frequency control. Comment on your company's approach to providing Tracking Services.

RFI 12. Control and Status Data Bus – The current equipment exchanges control and status with the USS ADPE via a subsystem controller (SSC) over a MIL-STD-1553B data bus. Describe the control and status data bus used in your examples of delivered products.

RFI 13. User Data and Clocks – The current equipment exchanges User Data and User Clocks with external baseband switches in the manner described in 7472106, Table XV, which is essentially over complementary balanced differential TTL using RS-422A extended to 12 MHz. Describe how User Data and Clocks are exchanged between your examples of delivered products and the external peripherals with which they communicate. Note that some SN users require knowledge of the Data Delay between their spacecraft data source and the received data sink at the ground terminal. Other users require stable data latency through the modem.

RFI 14. Standard Solutions – To what degree do your examples of delivered products use industry standards, such as IP, UDP, TCP, XML, SNMP, and Ethernet? Would the use of any of these standards require significant changes to your delivered product examples?

RFI 15. Proprietary Interface Solutions – Did any of the interfaces used in your examples of delivered products use proprietary interface solutions? Did any of the interfaces require the payment of license or royalty fees?

RFI 16. CCSDS Baseband Processing – Have any of your examples of delivered products used CCSDS frame and packet switching. Have they used CCSDS Space Link Expansion? Have they used Advanced Orbital Systems? Have you implemented AOS encapsulation for IP services?

RFI 17. Combined MDP/IR – Does it seem practical to combine the MDP and IR functions into a single unit? Would it be practical to also include the TM functions in that unit? Describe how your examples of delivered products combine transmit and receive functions. Describe if any of these units have self-test and loop back functions. That is, to what degree do your delivered units provide built in test? Do these tests include the ability to test the demodulator by modulating test signals, and to test the modulator by demodulating those signals?

RFI 18. Existing Interface Control Documents – Appendixes F, G, and H to STGT-HE-06-1 and the performance specifications 7472106, 7472306, and 7472506 provide detailed engineering information on the interfaces between the MDP, IR, and the TM, and the rest of the ground terminal equipment. Assuming your company offers a data bus other than a MIL-STD-1553B, how difficult will it be for your proposed data bus to accommodate the control and status of your units by the existing WSC ADPE?

RFI 19. Intermediate Frequency Plan – The current equipment uses a nominal 370 MHz IF for all Forward Services. For the Return Services, a combination of 370 MHz and 8.5 MHz IF signals are used? Would your examples of delivered products require modification to use this frequency plan?

RFI 20. Direct RF Interface – All of the Forward and Return Link Service signals are available at the input to the RF Combiner (Forward Links) after the high power amplifier (HPA) and at the output of the RF Power Divider (Return Links), which is after the low noise amplifier (LNA). These signals are at Ku-Band and have waveguide interfaces.

Do any of your examples of delivered products interface directly at RF? At Ku-Band? Do you propose any signal processing that would eliminate the upconverters and downconverters? Note that there are equalizers in the Return Link waveguide path. Would your solution provide equalization of the RF path? Describe this solution.

RFI 21. Useful Life - The current equipment is approaching obsolescence in its 15th year of service life. This equipment was specified (7472106, 3.2.3.2) for a lifetime of 10 years of continuous operation under the maintainability requirements of 7472106, 3.2.4. Describe the product life cycle of your standard product line. For how many years of continuous operation have your examples of delivered products operated?

RFI 22. ISO and CMMI – What ISO certifications does your company possess? At which CMMI process improvement level is your company?

RFI 23. Training and Skill Level – What amount of training and what skill levels are assumed on the part of the Customer to operate and support your examples of delivered products?

RFI 24. Total Cost of Ownership – Describe the elements of the total cost of ownership that are involved in the acquisition and life cycle operation of your examples of delivered products.

RFI 25. Data Rights – To what degree did your company grant data rights to the customers who purchased your examples of delivered products? To what degree will your company grant data rights to NASA under the production contracts?

RFI 26. EMI Mitigation – With regards to mitigation of electromagnetic emissions (EMI), the current equipment is specified for MIL-STD-461 performance (see 7472106, 3.3.2). Describe your company's standards for managing emissions from your units and for reducing the susceptibility of your units to external emissions. Describe the EMI requirements for which your examples of delivered products were designed and delivered.

RFI 27. Environmental Conditions – The current equipment is specified for the operating and nonoperating environmental conditions of 7472106, 3.2.5. Describe the environmental conditions for which your examples of delivered products were designed and delivered.

RFI 28. MA Interference Cancellation – What changes would be necessary to incorporate MA Interference Cancellation capability to your Modem? See MA Interference Cancellation on the USSR web page.

RFI 29. TDRS Arraying – What changes would be necessary to incorporate the TDRS Arraying capability in your modem? See TDRS Arraying on the USSR web page.

RFI 30. Modem Reconfigurations – The current equipment can quickly accommodate reconfigurations as described in 7472106, 3.1.2.2.7. Describe the degree to which your approach will meet or exceed these requirements.

SECTION 5. RFI ADMINISTRATIVE DETAILS

5.1 RFI Responses

Industry responses are invited for the USSR/LDRE items discussed in this RFI. Industry is encouraged to become familiar with the other RFIs associated with the USSR Project and with Modernization.

Honeywell invites two rounds of RFI Responses. The First Round Open Questions will be the collection of answers to Industry's questions. The Second Round Formal Response will be the formal responses from Industry to HTSI to the Specific Requests for Information listed in Section 4.

Vendors provide a ROM and Delivery Schedule for the USSR/LDRE.

5.1.1 RFI Response Details

All responses should be sent by email to the HTSI Contracting Officer:

Edwin Olson
edwin.olson@honeywell.com
301.805.3632

5.1.1.1 First Round Open Questions

Industry is encouraged to respond to HTSI with questions that might further clarify our general and specific requests for information. This First Round Open Questions period will last for 30 days after which HTSI will provide Answers to each of the questions for which a response can be made. HTSI intends to provide answers within 15 days of the end of the 30 day Open Question period, which is 45 days after the issue of the RFI.

Our intention is to answer all questions in a single response at the end of the 15 days. All members of Industry who request copies of the questions and answers will be provided them.

No Questions will be held as proprietary. If your question cannot be answered without revealing proprietary data, then you are encouraged to make an assumption and include it in your Second Round Formal Response. The entire question and answer set may be placed on the USSR web site.

Questions will not be labeled with Vendor names or identities. Similar questions may be combined to form composite questions.

Please limit your questions to items which are clearly within the scope of the USSR/LDRE arena. Items with larger scope may simply be answered as, "Out of Scope," or may not be included at all in answers to questions.

5.1.1.2 Second Round Formal Response

Formal responses to this RFI are expected 15 days after HTSI completes and posts the question and answer set to Industry. You should begin work on your formal response immediately, and not wait for the Q&A set.

Each Second Round Formal Response should address the Specific Requests for Information from Vendors listed in Section 4, plus any additional Specific RFIs that result from the First Round Q&A. Since this RFI is intended for a broad audience, not every vendor is expected have a complete answer for each question. It is acceptable to not answer each question.

Vendors provide a ROM and Delivery Schedule with the Second Round Formal Response.

5.1.2 Response Format

First Round Open Questions may be informal and shall be transmitted by email to edwin.olson@honeywell.com. No telephone calls or face-to-face technical questions will be accepted. Email attachments shall be either Microsoft Office compatible or Adobe Acrobat files. Administrative questions may be asked by calling Mr. Olson at 301.805.3632.

Second Round Formal Responses should be prepared in narrative format using standard PC desktop computing applications such as Microsoft Office compatible or Adobe Acrobat files with graphics as appropriate. The narrative should provide easy and conclusive traceability to our Specific Requests for Information from Vendors.

Industry is encouraged to include pertinent White Papers, Trade Studies, and Academic Papers which might reasonably compliment their responses to Specific RFIs.

The Second Round Formal Response shall be emailed to edwin.olson@honeywell.com no later than TBD. If a vendor chooses to provide a ROM and Deliver schedule, it should accompany the Second Round Formal Response.

5.2 Disclaimers

The information received in response to this RFI will be reviewed by HTSI and HTSI contractor experts. Some of the summarized and synthesized responses may form the basis of the future HTSI specifications and/or solicitations.

HTSI reserves the right to use submitted information for internal planning, and in doing so may distribute to NENS contract partners. In addition, responses may be distributed to NASA personnel and to NASA contract partners.

Details with the RFI submissions are meant only for use within the context of the HTSI NENS contract. Proprietary material should be portion-marked to clearly indicate proprietary data. No proprietary data should be sent in the First Round Open Questions period.

It is emphasized that this request for information is for preliminary planning purposes only and does not constitute a commitment, implied or otherwise, that HTSI will solicit the submitter for a procurement of any related effort in the future. HTSI will not be responsible for any costs incurred by submitters furnishing this information.

Appendix A. GLOSSARY

AOS	Advanced Orbital Services
A/T	autotrack
A/T RCVR	Autotrack Receiver
A/T SIM	Autotrack Simulator
ABBE	Adaptive Baseband Equalizer
ADPE	automatic data processing equipment
AOS	Advanced Orbital Systems
ASM	Attached Synchronization Marker
BER	bit error rate
BERTS	bit error rate test set
BIT SYNC	Bit Synchronizer
bps	bits per second
C/No	carrier to noise density reference to 1 Hz
CCSDS	Consultative Committee for Space Data Systems
CDR	Critical Design Review
CMMI	Capability Maturity Model Integration
COTS	commercial-off-the-shelf
CTFS	Central Time and Frequency Subsytem
CW	continuous wave
CxP	Constellation Program
D/C	downconverter
DAS	Demand Access System
dB	decibel
DCN	Document Control Number
DEMOD	demodulator
DIS	Date Interface Subsystem
Eb/No	energy per bit ratio to noise referenced to 1 Hz
EMI	electromagnetic interference
EXEC	Executive
FDM	frequency division multiplexed
FEC	Forward Error Correction (Convolutional Decoder)
FM	frequency modulation
FM DEMOD	FM Demodulator (Shuttle Unique Equipment)
GDIS	Guam Data Interface Subsystem
GMOD	Ground Network Modulator
GRGT	Guam Remote Ground Terminal
GSFC	Goddard Space Flight Center
HDR DEMOD	High Data Rate Demodulator
HDRE	High Data Rate Equipment
HPA	high power amplifier
HTSI	Honeywell Technology Solutions Inc.

IEC	Interstate Electronics Corporation
IF	intermediate frequency
IP	Internet Protocol
IR	Integrated Receiver
ISO	International Organization for Standardization
ISS	International Space Station
kbps	kilobits per second
KSA	K-Band Single Access
KSAR	K-Band Single Access Return
LAN	local area network
LDPC	low density parity check
LDRE	low data rate equipment
LI	Local Interface
LNA	low noise amplifier
MA	Multiple Access
MABE	Multiple Access Beamforming Equipment
MAF	Multiple Access Forward
Mbps	megabits per second
MDP	Modulator/Doppler Predictor
MOCC	Mission Operations Control Center
MTTBS	mean-time-to-bit-slip
MTTCS	mean-time-to-cycle-slip
NASA	National Aeronautics and Space Administration
NB	Narrowband
NCC	Network Control Center
NCCDS	Network Control Center Data Systems
NENS	Near-Earth Network System
NRE	nonrecurring engineering
OPM	Operations Message
PM	phase modulation
PMMS	Performance Monitoring and Measuring System
PN	pseudo noise
PN	pseudo noise
POCC	Project Operations Control Center
P_{rec}	power received
PSK	phase shift keying
PTE	PMMS Test Equipment
Q&A	questions and answers
RF	radio frequency
RFI	request for information
RFI	radio frequency interference
RFP	request for proposal
S/C	space craft
SA-E	Single Access East

SA-W	Single Access West
SGL	space-to-ground link
SGLT	space-to-ground link terminal
SHO	Schedule Order
SLE	Space Link Extension
SMAR	S-Band Multiple Access Return
SN	Space Network
SNE	Space Network Expansion
SNMP	Simple Network Management Protocol
SNR	signal-to-noise ratio
SNUG	Space Network Users' Guide
SRD	Systems Requirements Document
SRR	Systems Requirements Review
SSA	S-Band Single Access
SSAF	S-Band Single Access Forward
SSAR	S-Band Single Access Return
SSL	space-to-space link
STGT	Second TDRSS Ground Terminal
TCP	Transmission Control Protocol
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TKUP	TDRSS K-Band Single Access Return Upgrade Project
TM	Test Modem
TM HDRE	Test Modem High Data Rate Equipment
TM LDRE	Test Modem Low Data Rate Equipment
TSUP	TDRSS SSAR Upgrade Project (also known as USSR/LDRE)
TT&C	Tracking Telemetry & Command
U/C	upconverter
UDP	User Datagram Protocol
USAT	user satellite
USSR	User Services Subsystem Replacement
USSR/LDRE	User Services Subsystem Replacement/Low Data Rate Equipment
WART	WSC Alternate Resource Terminal
WSC	White Sands Complex
XML	Extensible Markup Language