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Near Earth Network (NEN) Users' Guide

Revision 2

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Preface

This Users' Guide for the Near Earth Network (NEN) describes the capabilities of the NEN ground stations and provides sufficient data for projects to begin interfacing with the NEN.

This document is under the configuration management of the Goddard Space Flight Center (GSFC) Code 453, Near Earth Network Project Office Configuration Control Board (NEN CCB).

Proposed changes to this document shall be submitted to the Near Earth Network Project Office along with supportive material justifying the proposed change. Changes to this document shall be made by Document Change Notice or by complete revision.

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Section 1. Introduction

1.1 Purpose

The purpose of this document is to describe the technical capabilities of the ground stations that compose the National Aeronautics and Space Administration (NASA) Near Earth Network (NEN).

This document provides sufficient information to enable project engineers and support personnel to begin interfacing with the NEN. It is not intended to be a technical description of network equipment; rather, it defines NEN capabilities and identifies those parameters of particular interest to the user. For more detailed information, see the documents cited in Section 1.3.

NEN capabilities evolve based on user requirements and budget limitations. New projects can be assured of NEN capabilities agreed to in their Radio Frequency Interface Control Document (RFICD).

1.2 Scope

For the purpose of this document, the NEN consists of both the NASA-owned ground stations located in Alaska, Antarctica, Virginia, New Mexico, and Florida. In addition, the NEN consists of the contracted commercial stations run by the Universal Space Network (USN) in Alaska, Australia, and Hawaii; Swedish Space Corporation (SSC) in Santiago, Chile; Kiruna, Sweden; and Weilheim, Germany; Kongsberg Satellite Services (KSAT) in Norway; and Antarctica and the South African National Space Agency (SANSA) in Hartebeesthoek. The NEN also includes support from the Network Integration Center located at the GSFC. The NEN scheduling office, WS1 S/Ka-band antenna, and Very High Frequency (VHF) systems are located at the White Sands Complex, New Mexico.

For each NEN ground station, this document provides the following information:

a. General characteristics, including geographic location, transmit/receive capabilities, and scheduling capabilities.

b. Detailed performance characteristics.

c. User tracking capabilities.

d. Baseband data interfaces.

1.3 Reference Documents

The following documents are referenced herein and/or provide background information:

a. CCSDS 401.0-B-17, *Radio Frequency and Modulation Systems, Part 1, Earth Stations, and Spacecraft,* Blue Book, Issue 25

b. CCSDS 732.0-B-2 Cor. 1, *AOS Space Data Link Protocol*, Blue Book, Issue 2.

c. CCSDS 412.0-G-1, *Radio Frequency and Modulation Systems-Spacecraft-Earth Station Compatibility Test Procedures*, Green Book, Issue 1. (Historical)

d. CCSDS 413.0-G-2, *Bandwidth-Efficient Modulations: Summary of Definition, Implementation, and Performance*, Green Book. Issue 2.

e. NISN 001-001, *NISN Services Document (NSD)*

f. 540-028, *Earth Observing System (EOS) Data and Information System (EOSDIS) Backbone Network (EBnet) Operations Concept*, Revision 1, GSFC.

g. *NEN Compatibility Matrix*.

h. NASA Policy Directive (NPD) 2570.5, *NASA Electromagnetic Spectrum Management Manual*

i. NPD 8074.1, *Management and Utilization of NASA's Space Communication and Navigation Infrastructure.*

j. 453-HDBK-GN, *Ground Network Tracking and Acquisition Data Handbook*.

k. NASA Procedural Requirement (NPR) 2570.1, *NASA Radio Frequency (RF) Spectrum Management Manual*.

l. *NTIA Manual of Regulations & Procedures for Federal Radio Frequency Management (Redbook), May 2014 Revision of the May 2013 Edition*.

m. L7-ICD-40.1, *Interface Control Document between Landsat 7 Mission Operations Center (MOC) and the Landsat 7 Ground Network (LGN)*.

n. 5-1R5, *Space Frequency Coordination Group (SFCG) Recommendations regarding Efficient Spectrum Utilization for Space-To-Earth Links including SFCG Recommendations*: SFCG 5-1R5, SFCG 14-1R1, SFCG 14-3R9, SFCG 21-2R4, SFCG 21-3R1, and others as applicable.

o. 450-OIP-WSC/DSMC, White Sands Complex (WSC)/*Data Service Management Center (DSMC) Operations Interface Procedures (OIP)*.

p. CCSDS 912.1-B-3, *Space Link Extension – Forward CLTU Service Specification*, Blue Book, Issue 3.

q. CCSDS 131.0-B-2, *TM Synchronization and Channel Coding*, Blue Book, Issue 2.

r. 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

s. 700-DOC-007, *NASA Communications Operations Procedures (NASCOP),* Sanitized Version. (Historical – replaced by NISN-SOP)

t. NISN-SOP-0002, *NISN Standard Operating Procedures for Trouble Reporting, Activity Scheduling, Mission Freeze, and Major Outage Notifications*.

u. 450-CMFP-ESC, *Configuration Management Freeze Policy for the Integrated Networks and Supporting Elements*.

v. 450.1-TOOL-0008, *Customer Questionnaire* (new project questionnaire),

w. ITU-R Recommendations SA.1157, SA.1810 and P.618-8, *International Telecommunications Union Radio Regulations*.

x. *NASA Directory of Station Locations, NDOSL*, FDF.

1.4 Related Internet Web Sites

Alaska Satellite Facility (11-m)	https://www.asf.alaska.edu/program/stgs/
FDF Home Page	http://fdf.gsfc.nasa.gov
GSFC Home Page	http://www.nasa.gov/goddard
Exploration and Space Communications Project (ESC) Website	http://ESC.gsfc.nasa.gov/
GSFC Online Library (NGIN)	https://code450ngin.gsfc.nasa.gov
Hartebeesthoek Tracking Station	www.sansa.org.za/spaceoperations/services/antennas
Large File Transfer	https://transfer.ndc.nasa.gov/
International Space Station	http://www.nasa.gov/mission_pages/station
Johnson Space Center	http://www.nasa.gov/centers/johnson/home/index.html
Kennedy Space Center	http://www.nasa.gov/centers/kennedy
Kiruna, SE – Esrange Satellite Station	http://www.sscspace.com/kiruna-satellite-station-4
Kongsberg Satellite Services	http://www.ksat.no/
Mission Set Database	http://msdb.gsfc.nasa.gov
MSFC Home Page	http://www.nasa.gov/centers/marshall
MSFC/Communications Service Office (CSO) Home Page	https://cso.nasa.gov/
NASA NEN Stations	http://esc.gsfc.nasa.gov/space-communications/NEN/nen.html
NASA TV Schedule	http://www.nasa.gov/multimedia/nasatv http://www.nasa.gov/multimedia/nasatv/schedule.html
NEN Compatibility Matrix and NEN Users' Guide	http://esc.gsfc.nasa.gov/space-communications/NEN/NEN-Documents.html
Networks Integration Management Office (NIMO)	http://esc.gsfc.nasa.gov/space-communications/nimo.html
Swedish Space Corporation (SSC)	http://www.SSCSpace.com
SSC, Chile	http://www.sscspace.com/SSC-Chile
SSC, Santiago	www.SSCSpace.com/Santiago-Satellite-Station-4
Universal Space Network	http://www.sscspace.com/usn
Weilheim Tracking Station	http://www.dlr.de/rb/en/desktopdefault.aspx/tabid-4650/4253_read-6299/

Section 2. NEN Overview

2.1 General

This section provides an overview of the NEN, its ground stations, and customer services. The ground station overview provides general characteristics of NEN antenna tracking, telemetry, and command functions and capabilities. Further details on NEN ground station are addressed on a station-by-station basis in the following chapters. The customer service overview describes NEN services and how to obtain NEN services. Further details on services are available from NIMO (GSFC Code 450.1).

To help a flight project quickly examine, evaluate, and compare capabilities of NEN ground station antennas, this section contains several tables summarizing antenna capabilities and specifications. Table 2-1 summarizes general antenna specifications.

2.2 NEN Overview

The NASA NEN is a customer-driven organization that provides comprehensive communications services to space assets. The NEN provides telemetry, commanding, and tracking services for orbital missions and occasionally sub-orbital missions. These NEN customers may have Low-Earth Orbits (LEO), Geosynchronous (GEO) orbits, highly elliptical orbits, Lagrange orbits, Lunar orbits, Lunar surface and transfer, sub-orbital and launch trajectories, at multiple frequency bands through all phases of a mission's lifetime. This diversity of service is listed in Figure 2-1.

NEN Customer Diversity Examples	**Customers**	• NASA • Other Government • International • Commercial
	Phases	• On-orbit • Launch • Early Orbit • Disposal
	Orbits	• Sub-orbital LEO • GEO • Highly Elliptical • Launch • LEO – polar, mid latitude & equatorial • Lagrange
	Frequency	• X-band • S-Band • VHF • Ka-band

Figure 2-1. NEN Services

Table 2-1. NEN Overview[1]

Station Location	Antenna Name	Antenna Diameter	Transmit Frequency (MHz)	EIRP (dBWi)	Receive Frequency[2] (MHz)	G/T[5] (dB/K) (note 1)	Location	Tracking (Note 8)
Fairbanks,Alaska (Alaska Satellite Facility)	**AS1**	11.3-m	2025-2120	64.6	2200-2400 8025-8500	22.0 37.2	64.8587°N 147.8576°W	A,D,R
	AS2 (note 6)	10-m	No Service	No Service	No Service	No Service	No Service	No Service
	AS3	11.0-m	2025-2120	65.7	2200-2400 8025-8500	22.9 36.2	64.8589°N 147.8541°W	A,D,R
North Pole, Alaska (USN)	**USAK01**	13-m	1750-1850 2025-2120	69 68	2200-2400 8000-8500	23.5 37.7	64.8042° N 147.5002° W	A,D,R
	USAK02	5-m	2025-2120	56	2200-2400	16.0	64.8042° N 147.5002° W	D, R (TBD)
	USAK03	5.4-m	2025-2120		2200-2400 8000-8500	15.0 31.50	64.8047° N 147.5042° W	
	USAK04	7.3-m	2025-2120	58.4	2200-2400 8000-8500	19.6 31.0	64.8047° N 147.5042° W	A,D
	USAK05	11-m	2025-2120	65.4	2200-2300 8100-8400	23.2 34.0	64.8034° N 147.5006° W	A,D,
Florida[5]	**KUS (note 5)**	6.1-m	2025-2120	TBD	2200-2400	14.1	28.5°N 80.6°W	A
	PDL (note 5)	6.1-m	2025-2120	TBD	2200-2400	14.1	29.0666°N 80.9130°W	A
Hartebeesthoek, South Africa (SANSA)	**HBKS**	12-m	2025-2150	69	2200-2400 (Note 7)	22.4	25.8870°S 27.7120°E	A,D
	HB5S	10-m	2025-2100	65	2200-2400 8000-8400	19.1 30.5	25.8869°S 27.7067°E	A,D

Station Location	Antenna Name	Antenna Diameter	Transmit Frequency (MHz)	EIRP (dBWi)	Receive Frequency[2] (MHz)	G/T[5] (dB/K) (note 1)	Location	Tracking (Note 8)
South Point, Hawaii (USN)	**USHI01**	13-m	2025-2120	78	2200-2400 8000-8500	23.5 37.7	19.0140° N 155.6633° W	A,D,R
	USHI02	13-m	2025-2120 7025-7200	68 86	2200-2400 8000-8500	23.5 37.7	19.0138° N 155.6629° W	A,D,R
DongaraAustralia (USN)	**AUWA01**	13-m	2025-2120	68	2200-2400 8000-8500	23.5 37.7	29.0457° S 115.3487° E	A,D,R
	AUWA02	7.3-m	7025-7200[3]	85	-	-	29.0457° S 115.3487° E	Slave to AUWA01
Kiruna, Sweden (SSC)	**KU1S (ETX)**	13-m	2025-2120	69	2200-2400 8000-8400	23.0 33.0	67.8896°N 21.0657°E	A,D,R
	KU3S (Balder)	13-m	2025-2120	69	2200-2300 7600-8500	22.5 37.5	67.8791°N 21.0380°E	A,D
Antarctica McMurdo	**MG1 10-m**	10-m	2025-2120	63	2200-2400 7700 – 8500	21.0 32.0	77.8391°S 166.6671°E	Not Available
Antarctica (KSAT)	**TR2 (TrollSat)**	7.3 m	2025-2120	51	2200-2400 7500-8500	19.4 32.0	72.0022°S 2.0575°E	A,D
Norway (KSAT)	**SG1**	11.3-m	2025-2120	63.5	2200-2400 7700-8500	22.1 36.8	78.231°N 15.389°E	A,D
	SG2	11.3-m	2025-2120	59	2200-2400 7500-8500	23.8 35.7	78.230°N 15.398°E	A,D
	SG3	13-m	2025-2120	67	2200-2400 7500-8500	23.0 37.8	78.2297°N 15.4081°E	A,D
Santiago, Chile (SSC)	**AGO 9-m**	9-m	2025-2120	75	2200-2300	23.6	33.1511° S 70.6664° W	A,D,R
	AGO 12-m	12-m	2025-2120	TBD	2200-2300	25.7	33.1515° S 70.6663 W	A,D
	AGO 13-m	13-m	2025-2120	70	2200-2300	24.4	33.1483° S 70.6676° W	A,D,R

Station Location	Antenna Name	Antenna Diameter	Transmit Frequency (MHz)	EIRP (dBWi)	Receive Frequency[2] (MHz)	G/T (dB/K)	Location	User Tracking
Singapore (KSAT)	**SI1**	9.4-m	2025-2120	59	2200-2300 7985 8500	20.5 33.4	1.3962°N 103.8343°E	A,D
Wallops Island, Virginia	**WG1 11.3-m**	11.3-m	2025-2120	64.6	2200-2400 8000-8500	23.6 34.5	37.9249°N 75.4765°W	A,D,R
	LEO-T	4.7-m	2025-2120	59.2	2200-2300	17.0	37.9239°N 75.4761°W	Not Available
	WFF VHF-1	N/A (Quad Yagi)	139.208	43.4	143.625	N/A	37.924°N 75.4764°W	Not Available
	WFF VHF-2	N/A (Quad Yagi)	130.167	43.4	121.750	N/A	37.9236°N 75.4775°W	Not Available
Weilheim, Germany (SSC)	**WU1S**	15-m	2025-2120	78	2200-2300	26.7	47.8800°N 11.0853°E	A,D,R
	WU2S	15-m	2025-2120	78	2200-2300	26.7	47.8812°N 11.0836°E	A,D,R
White Sands, New Mexico	**WSC VHF-1**	N/A (Quad Yagi)	139.208	43.4	143.625	N/A	32.5407°N 106.6121°W	Not Available
	WSC VHF-2	N/A (Quad Yagi)	130.167	37.4	121.750	N/A	32.5047°N 106.6113°W	Not Available
	WS1[4]	18.3-m	2025-2120	72 or 81	2200-2300, 25,500-27,000	29.6 46.0	32.5047°N 106.6108°W	A,D,R

Station Location	Antenna Name	Antenna Diameter	Transmit Frequency (MHz)	EIRP (dBWi)	Receive Frequency[2] (MHz)	G/T (dB/K)	Location	User Tracking

NOTES:

1. The information above describes the typical performance limits of the ground stations. Capabilities are often enhanced and potential users are encouraged to discuss the mission requirements with NIMO to ensure that requirements and capabilities are fully understood. G/T is an estimate for 5º antenna elevation S-band and 10º for X-band and Ka-band (Kiruna elevation is TBD).
2. 8450 – 8500 MHz is allocated for Space Science and 8025-8400 MHz is allocated for Earth Science.
3. The USN X-band transmit feeds on AUWA02 and USHI02 will support 7000-8000 MHz. The Klystron at these stations can be tuned up to 7200 MHz. The USHI01 station has an Solid State Power Amplifier (SSPA) and Klystron for commanding.
4. WS1 has a slew rate limitation of 2 deg/sec. WS1 also has a 2 KW (High Power Amplifier (HPA) and 300W HPA.
5. KUS and PDL antennas are under development and are a future NEN capability.
6. The 10-m AS2 antenna replacement is TBD.
7. The Hartebeesthoek autotrack
8. D is Doppler, A is angle Data, R is ranging.

2.3 NEN Ground Stations Overview

The NEN provides services from a diverse collection of ground station assets located around the world. Many of the NEN sites are located in prime polar locations to provide service to high-inclination polar orbiting spacecraft. Because polar orbiting spacecraft pass over the Earth's poles each orbit, stations in near polar locations, such as Norway, Alaska, and Antarctica, can provide communications to polar orbiting spacecraft nearly every orbit.

NASA's mid-latitude and equatorial ground stations provide support to LEO polar and low-inclination orbital missions, to Lunar and Lagrange orbits and to GEO spacecraft. The ground station assets located at Wallops Island, Virginia, are in a prime location to provide orbital support to low-inclination customers and launch tracking services to the Wallops launch range, as well as to provide some coverage to launches from Kennedy Space Center. Stations are distributed around the globe to provide mission-critical event coverage to missions.

This NEN Users' Guide addresses the NASA owned / maintained stations that are dedicated to NASA customer missions and commercially owned stations. NASA owned assets under the NEN are located at the following stations:

a. Wallops Ground Station (WGS) in Virginia, operated by NASA.
b. McMurdo Ground Station (MGS) in Antarctica, operated by NASA.
c. Alaska Satellite Facility (ASF) in Alaska, operated by the University of Alaska, Fairbanks (UAF).
d. Florida Launch Communications Stations in Florida, operated by NASA.
e. White Sands Complex (WSC) ground station in New Mexico, operated by NASA.

NASA provides a significant portion of its space communications services by contracting with commercial service providers to support NASA missions. The commercial services provided by these contractors are available to NASA's NEN customers through existing contracts. Commercial service providers currently available include:

a. KSAT station in Svalbard, Norway, Singapore, and Antarctica.
b. USN stations in Alaska, Hawaii, and Australia.
c. SSC station in Santiago, Chile.
d. SSC station in Weilheim (Germany) and Kiruna (Sweden)
e. SANSA station in Hartebeesthoek, South Africa.

These commercial service providers and their antenna assets are discussed in detail in this NEN Users Guide, with the exceptions of the Weilheim, Kiruna and Hartebeesthoek station. The Universal Space Network and the SSC Chile stations are wholly-owned subsidiaries of the Swedish Space Corporation. Additional information about the commercial service providers may be acquired on the respective provider's web site in Section 1.4.

The NEN stations are summarized in Table 2-1 and detailed in chapters that follow. Additional information can be found at the following URL http://esc.gsfc.nasa.gov/space-communications/NEN/nen.html. The NEN station hours of operations (Link Commitment Schedule), Antenna Turn-Around times and Compatibility Matrix can be found at URL: http://esc.gsfc.nasa.gov/space-communications/NEN/NEN-Documents.html.

2.4 NEN Customer Services Overview

The NIMO, in conjunction with the NEN, performs analysis, testing, and simulation services that are of direct benefit to the flight projects. Some are mandatory to validate compatibility and to meet launch readiness requirements. Analysis will address such preliminary questions as projected NEN loading, Radio Frequency (RF) link margins, geometric coverage analyses, and preliminary funding and staffing requirements. The *Customer Questionnaire*, 450.1-TOOL-0008, is used as a new project questionnaire to assist the initial analysis phase. The results of such analyses will enable an early assessment of the project's compatibility with the NEN.

2.4.1 Obtaining NEN Services

For all NEN stations, flight projects request NEN support through NASA/GSFC, Code 450.1, NIMO. The NIMO provides its spacecraft and scientific customers with a complement of telecommunications services. NIMO provides options and planning assistance to effectively meet space and ground telecommunications requirements: that is, telemetry, tracking, and command services.

A Networks Integration Manager is assigned as a single point of contact for customer services throughout the mission lifecycle including formulation of trade studies and cost analyses; implementation of radio frequency compatibility testing; NEN telecommunications service definitions and commitments; customer integration testing and ongoing service coordination. Additional information can be found at http://esc.gsfc.nasa.gov/space-communications/nimo.html.

All customers planning on conducting military-oriented activities with the intent of using the NASA Space Communications and Navigation (SCaN) Program Office's NEN assets at the MGS are responsible to be compliant with the Antarctic Treaty in order to obtain service from the SCaN and the antenna site.

Additionally, those customers requiring support from the SCaN NEN MGS are to coordinate directly with the Department of State to obtain a written position, representing permission, from the Department of State indicating that the mission's intended use does not violate the Antarctic Treaty.

The NIMO is the cognizant SCaN organization assigned by the Program Office to ensure compliance to this policy. The NIMO will provide organizations requesting MGS support with the necessary State Department contact information and will immediately notify the SCaN Director of Network Services each time an organization is referred to the State Department.

2.4.2 Network Loading Analysis

To ensure that sufficient NEN resources are available to meet commitments to current and future users, the NIMO provides a representative to each customer flight project as early as possible during mission planning to assist in the definition of customer flight project needs for ESC services. Typical information needed for analyses includes the projected requirements for communications timeline, data rates, and number of data channels. Although this information may initially be of a preliminary nature, the best available information is needed for projecting NEN loading.

2.4.3 RF Link Margin and Coverage Analysis

Information exchange between the customer mission and the NIMO for the RF link margin and coverage analysis begins during the initial flight segment mission analysis phase and continues until firm coverage requirements and flight segment designs are finalized in the mission execution phase. The Communications Link Analysis and Simulation System (CLASS) analysis tool can be used to help achieve a flight segment telecommunications design which is compatible with the NEN, and will achieve the desired level of performance. Design deficiencies and possible trade-offs are defined during these analyses. The results of CLASS are used early in the mission analysis phase to aid in the development of the Radio Frequency Interface Control Document (RFICD), which is a controlling input to the flight segment telecommunications specifications. It should be noted that the RFICD is under NASA's control via the CCB.

The Space Network (SN) has had issues providing service to customers who transmit pattern data or long strings of 1s or 0s. The SN worked with Consultative Committee for Space Data Systems (CCSDS) to develop a recommendation that customers use data randomization during all phases of the mission. The NEN recommends the same strategy for customers requiring NEN services.

2.4.4 Compatibility Testing

RF compatibility testing is performed after the flight radio is integrated into the spacecraft. Risk mitigation testing on the prototype model may be performed earlier to reduce risk, but final compatibility is performed on the flight model Compatibility tests are normally rerun following resolution of significant problems encountered during the original test or following post-test flight segment design modification. Results of these tests are formally published in the mission specific Compatibility Test Report. Satisfactory completion of this testing and certification is required to meet the NASA readiness-for-launch criteria.

2.4.5 NEN Interface Testing and Operational Simulations

Mutually agreed upon end-to-end tests are conducted to validate all telecommunications system functions, as defined in the applicable Interface Control Documents (ICD) and Customer Integration and Test Plans. In addition, operational exercises (i.e., simulations, data flows) are conducted to ensure that operations will satisfy requirements and timelines.

2.4.6 Orbit Analysis

Pre-launch orbital error analyses are performed to determine the frequency with which user spacecraft state vectors are needed to achieve the orbital accuracies required by the user flight project.

2.5 NEN Directive and Reporting

The NENS-GN-PRCD-0208, *NEN Directive Procedure,* provides a formal means of efficiently alerting and/or directing NEN elements to ensure continuity of reliable support in situations that management deems appropriate and/or where other notification methods may not suffice. The NEN Directive will be used as a tool to notify sites of potential systemic conditions that could affect the safety of operations, equipment, or personnel and directs sites to implement associated mitigating actions. The decision to implement the mitigating action at the commercial sites remains under the management control of those sites.

2.6 NEN Outage and Service Loss Notification

2.6.1 Network Advisory Messages

Network Advisory Messages (NAM) are issued as a result of scheduled outage periods and allow the scheduling office and projects to mitigate impacts. The target date for submission is not later than 7 days prior to the event. However, shorter notice emergency notifications are issued as needed. The distribution is controlled via an email "list serve" collective and is controlled by NEN management. See Figure 2-2.

NAM ID : 0000788
Network : NEN
Expires: 4/21/2009
Status: Open
NAM Title: Wallops Flight Facility Main Base Power Outage (April 18-19, 2011)
Advisory Message: This NAM is to notify the NEN customers that there will be a power outage at the Wallops Flight Facility Main Base that will also affect the Wallops Ground Orbital Tracking Station (AWOTS). AWOTS will be down on April 18, 2011 from 1000 Universal Time Code (UTC) to 0100UTC April 19, 2011 and again on April 19, 2011 from 1000UTC to 0100UTC on April 20, 2011. This downtime is inclusive of the time to take the equipment down and bring it back to operational status each day.

Figure 2-2. Example Network Advisory Message

2.6.2 Status Messages

Ground Network Status Messages (GNSTAT) are issued as a result of system or site failures and an e-mail is generated that details the anomaly (see example). The White Sands Operations Supervisor (OS) uses this information to contact management and ensure project personnel are informed of problems. The OS also assures that supports are moved to other sites via the scheduling office whenever possible. The email distribution is controlled by NEN management. A closure status message is e-mailed once the issue is resolved. See Figure 2-3.

TO: GNSTAT
A. SUBJECT: MG1 10M RED
B. START OF ANOMALY: 102/1646Z
C. ETRO: UNKNOWN
D. CHANGE OF STATUS: RED
E. EQUIPMENT AFFECTED: 10M
F. TYPE OF PROBLEM: Loss of communications with remote facility (i.e., Bldg 71 and 10M antenna)
G. COMMENTS: Severe weather conditions in McMurdo prevent the crew from reaching the 10m antenna or Bldg. 71 where the ACU, receivers, combiners, etc. are located.
Current winds at antenna are in excess of 85MPH

Figure 2-3. Example GNSTAT Message

2.6.3 Significant Event Reporting

The Significant Event Reporting System is used to notify management and network users of site/system failures. An email is generated that details the anomaly, repair efforts, current/future impacts and closure information. The email distribution is controlled by NEN management. A closure message is issued once the anomaly is resolved. See Figure 2-4.

2.6.4 Comprehensive Discrepancy System

The Comprehensive Discrepancy System is used for entering and managing operational, test and engineering discrepancies through disposition and resolution. The execution of this database system requires multiple levels and facets of responsibility in order to be efficient and effective. Discrepancy reporting and resolution is initiated and resolved at the respective sites. Discrepancy closure however is administered through a focal point of administrative representatives in order to maintain control and consistency. A closure message is e-mailed once the issue is resolved.

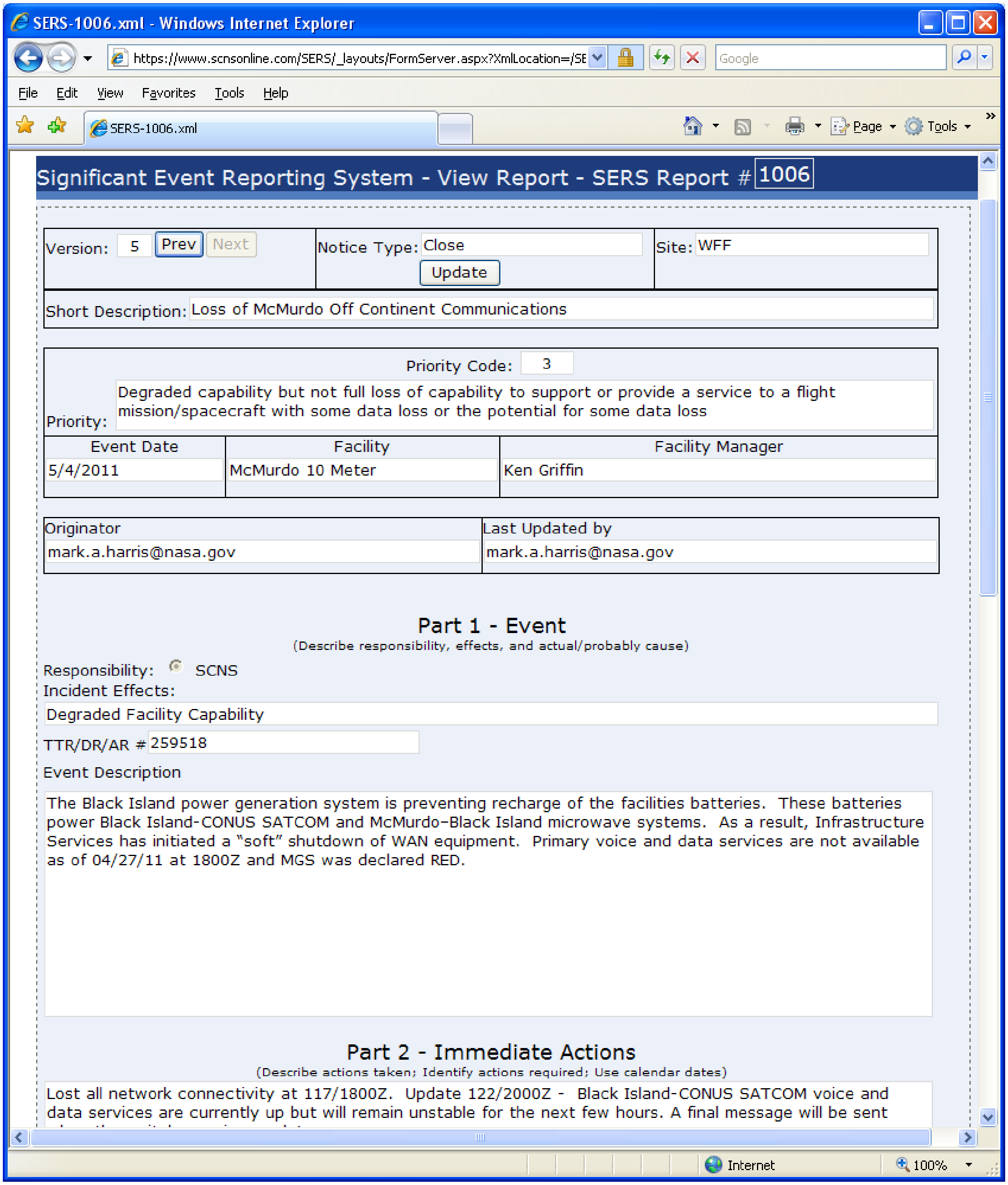
Root Cause / Corrective Action (RCCA) is performed anytime there is a service loss during launch and early orbit phase of a mission and anytime there is a catastrophic system operational failure with regard to the performance of a NEN orbital system. RCCA will also be performed when Discrepancy Report review indicates a possible systemic operational issue, or when management deems it appropriate based on level or potential level of impact. Management serves as the ultimate authority in determining whether or not RCCA is required. See Figure 2-5.

2.7 Status Server Overview

The NEN Remote Status Server (RSS) exists on the Open Internet Protocol Operational Network (IONet) at WGS. The RSS currently receives status data from McMurdo Ground Station (MG1), White Sands Complex (WS1), Wallops Ground Station (WG1), and Alaska Satellite Facility (AS1/AS3).

Data comes in from stations in a fixed field status stream via Transmission Control Protocol/Internet Protocol (TCP/IP) to both servers, one serves as the prime for reporting purposes. Data is placed in a database for feeding a web page interface, custom reports, and a future real time TCP/IP stream. Reports may be generated when the station goes from pre-pass into active track, or active track into post-pass. Reports can also be run on a time basis, such as a daily or weekly summary of operations. Reports may be distributed via email or FTP to the customer.

Customers may request and be granted access to the RSS web pages for real time monitoring of satellite tracks, as well as historical reports. When connecting into Status Server, the user is presented with an entrance page, see Figure 2-6. At any time, the user may return to the entrance page by clicking the NASA meatball. The top list shows all supports that are currently active for each station. If a station does not have an active support, the next support scheduled is displayed. The drop down filters for spacecraft and station will affect the contents of the lower window. A user has permission to see only spacecraft with which they are involved.


SERS-1006.xml - Windows Internet Explorer

https://www.scnsonline.com/SERS/_layouts/FormServer.aspx?XmlLocation=/SE

File Edit View Favorites Tools Help

Significant Event Reporting System - View Report - SERS Report # 1006

Version: 5 Prev Next	Notice Type: Close Update	Site: WFF

Short Description: Loss of McMurdo Off Continent Communications

Priority Code: 3

Priority: Degraded capability but not full loss of capability to support or provide a service to a flight mission/spacecraft with some data loss or the potential for some data loss

Event Date	Facility	Facility Manager
5/4/2011	McMurdo 10 Meter	Ken Griffin

Originator	Last Updated by
mark.a.harris@nasa.gov	mark.a.harris@nasa.gov

Part 1 - Event

(Describe responsibility, effects, and actual/probably cause)

Responsibility: SCNS

Incident Effects:

Degraded Facility Capability

TTR/DR/AR # 259518

Event Description

The Black Island power generation system is preventing recharge of the facilities batteries. These batteries power Black Island-CONUS SATCOM and McMurdo-Black Island microwave systems. As a result, Infrastructure Services has initiated a "soft" shutdown of WAN equipment. Primary voice and data services are not available as of 04/27/11 at 1800Z and MGS was declared RED.

Part 2 - Immediate Actions

(Describe actions taken; Identify actions required; Use calendar dates)

Lost all network connectivity at 117/1800Z. Update 122/2000Z - Black Island-CONUS SATCOM voice and data services are currently up but will remain unstable for the next few hours. A final message will be sent

Internet 100%

Figure 2-4. Significant Event Report Message

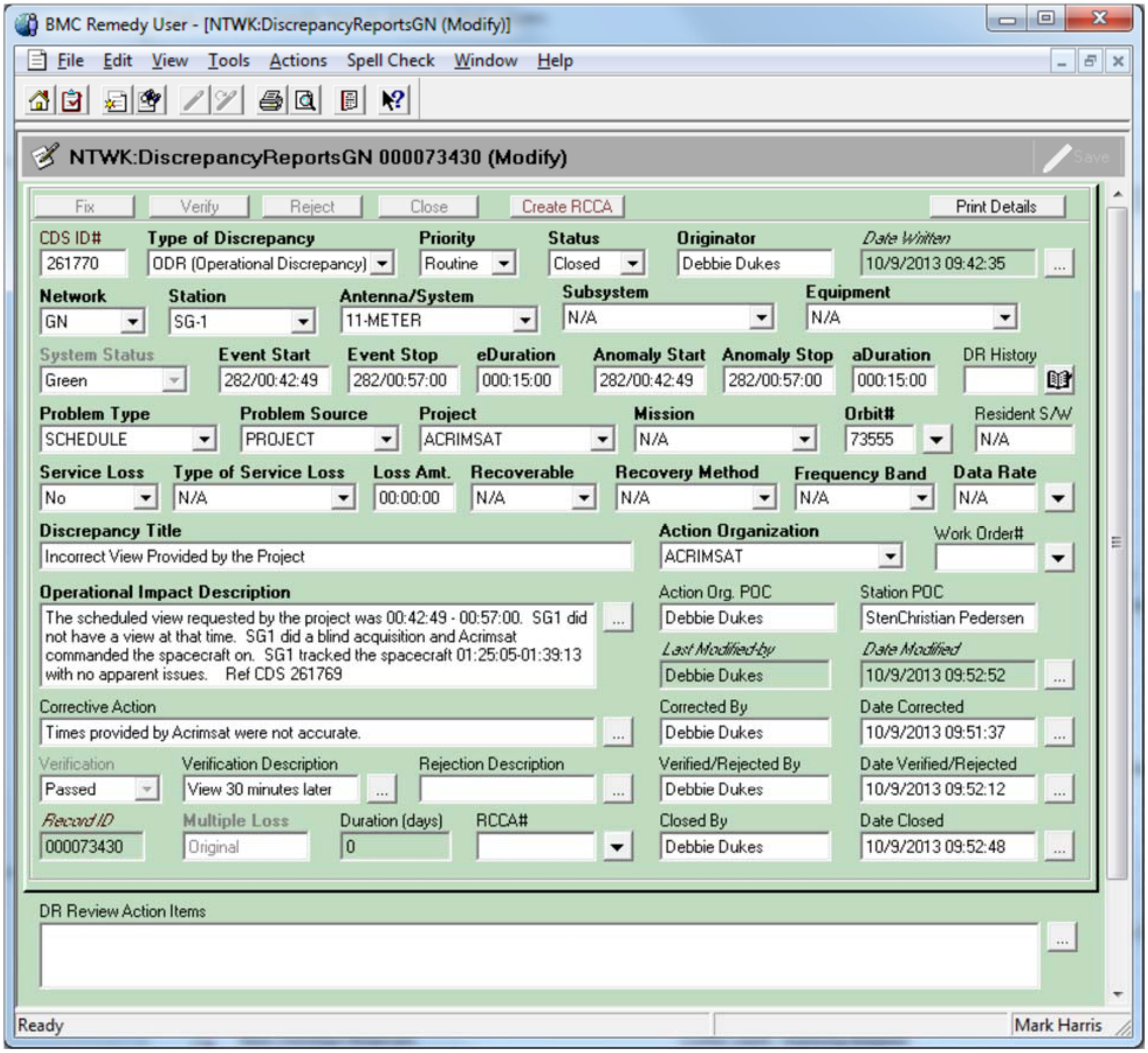


Figure 2-5. Example Discrepancy Report

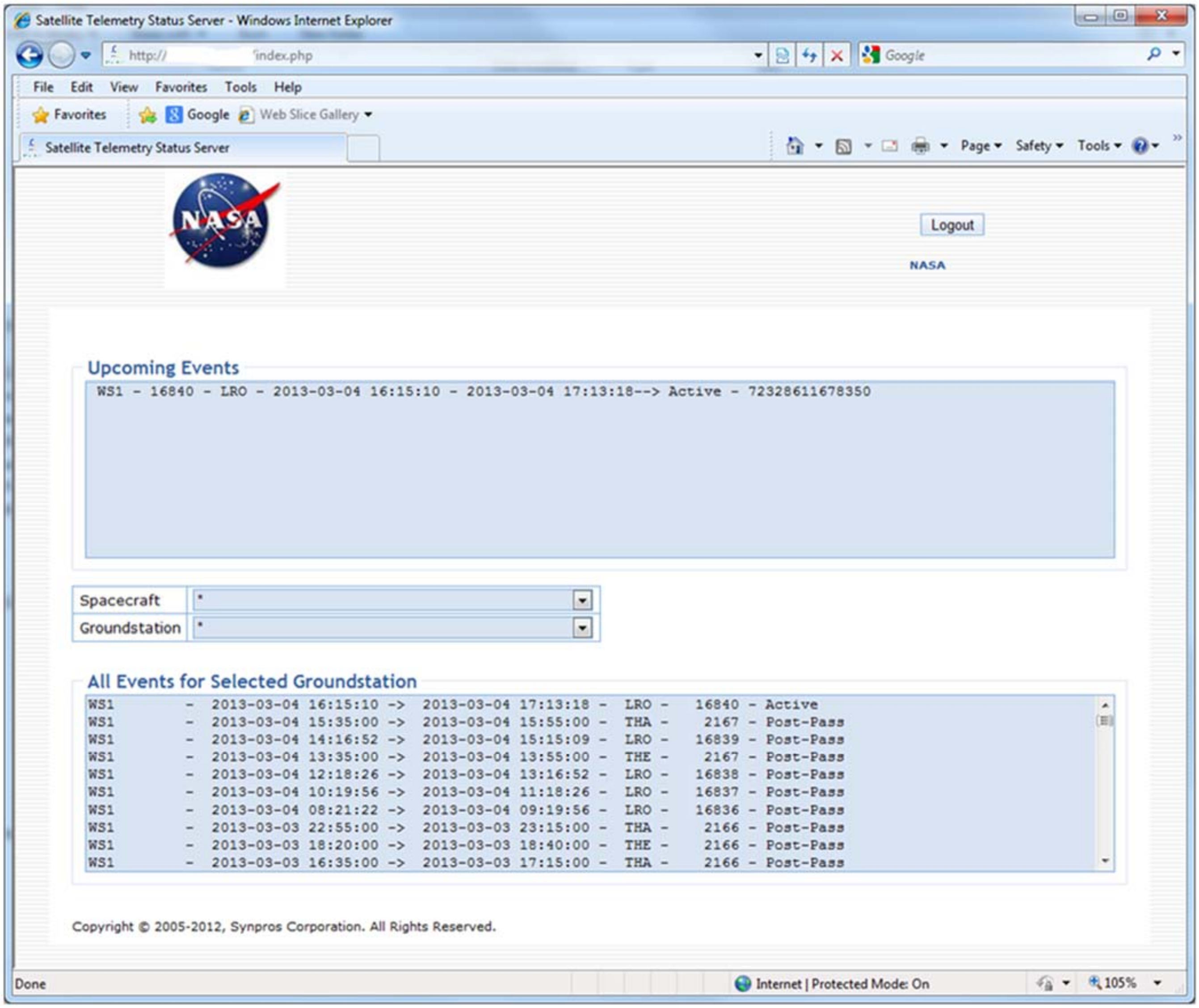


Figure 2-6. RSS Entrance Screen

2.7.1 Selection of an Active Track from the Entrance Page

Clicking on one of the entries in the lower entrance screen window moves the user to the data page. See Figure 2-7. If the pass is active, the data will change in near real time. If the pass is in the past, the data presented is the last data set received from the station during the support. The right side of the screen presents Boolean data points. The color and text is configurable according to station and spacecraft.

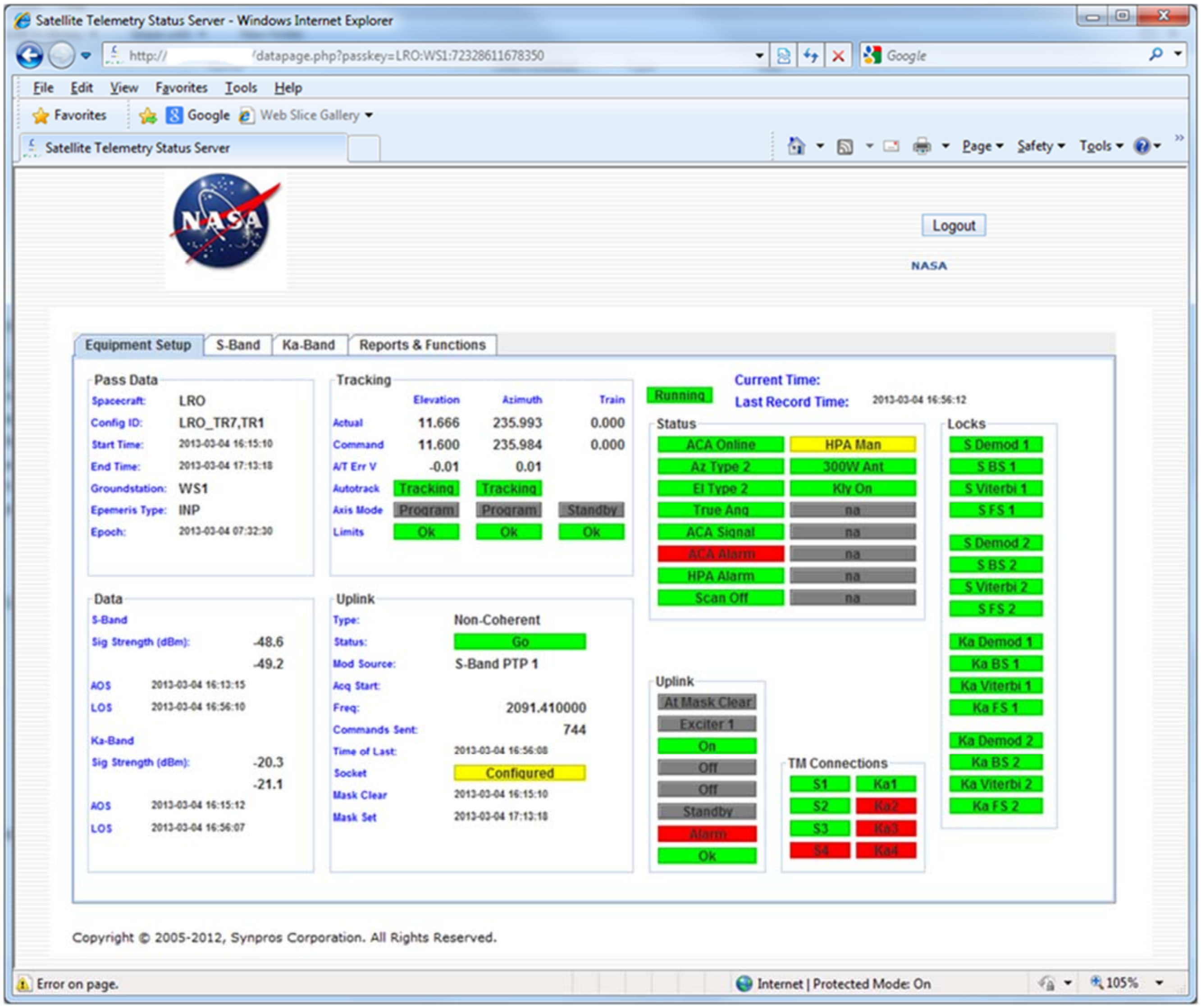


Figure 2-7. Active Track Details

2.7.2 Selection of a VC Tab

The user may select the Virtual Channel (VC) tabs to view VC statistics of the links. See Figure 2-8.

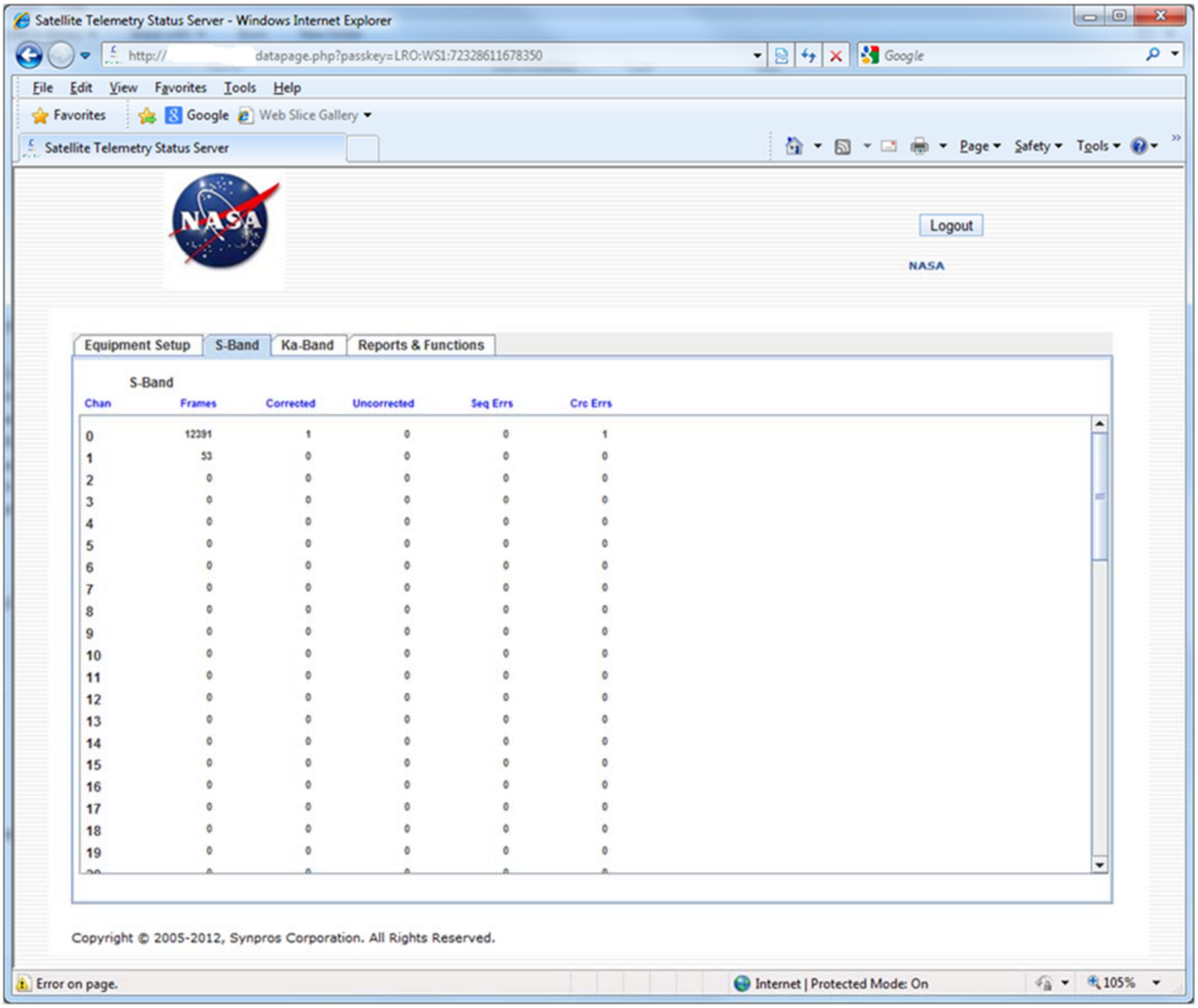


Figure 2-8. Active Track VC Statistics

2.7.3 Selection of the Report Tab

Reports are available from the Reports & Functions tab. See Figure 2-9. The reports are configurable by spacecraft, and may be automatically generated at several status transition points in the event such as pre-pass to active, or active to post-pass. The reports may be regenerated at any time during the event, or after the event for several days. The user may also regenerate the report from the alternate status server. Both status servers receive the same data, but only one will automatically deliver the report. Regeneration will redeliver the report regardless of the server used.

Delivery of reports is via FTP, email, or copy and paste from the web server. Delivery of the report may be conditional, as in the case of a failure to meet certain criteria. The examples below of the dump report show a good dump and a bad dump, where the VC count indicates missing frames. The report is created to email the report when the dump is bad.

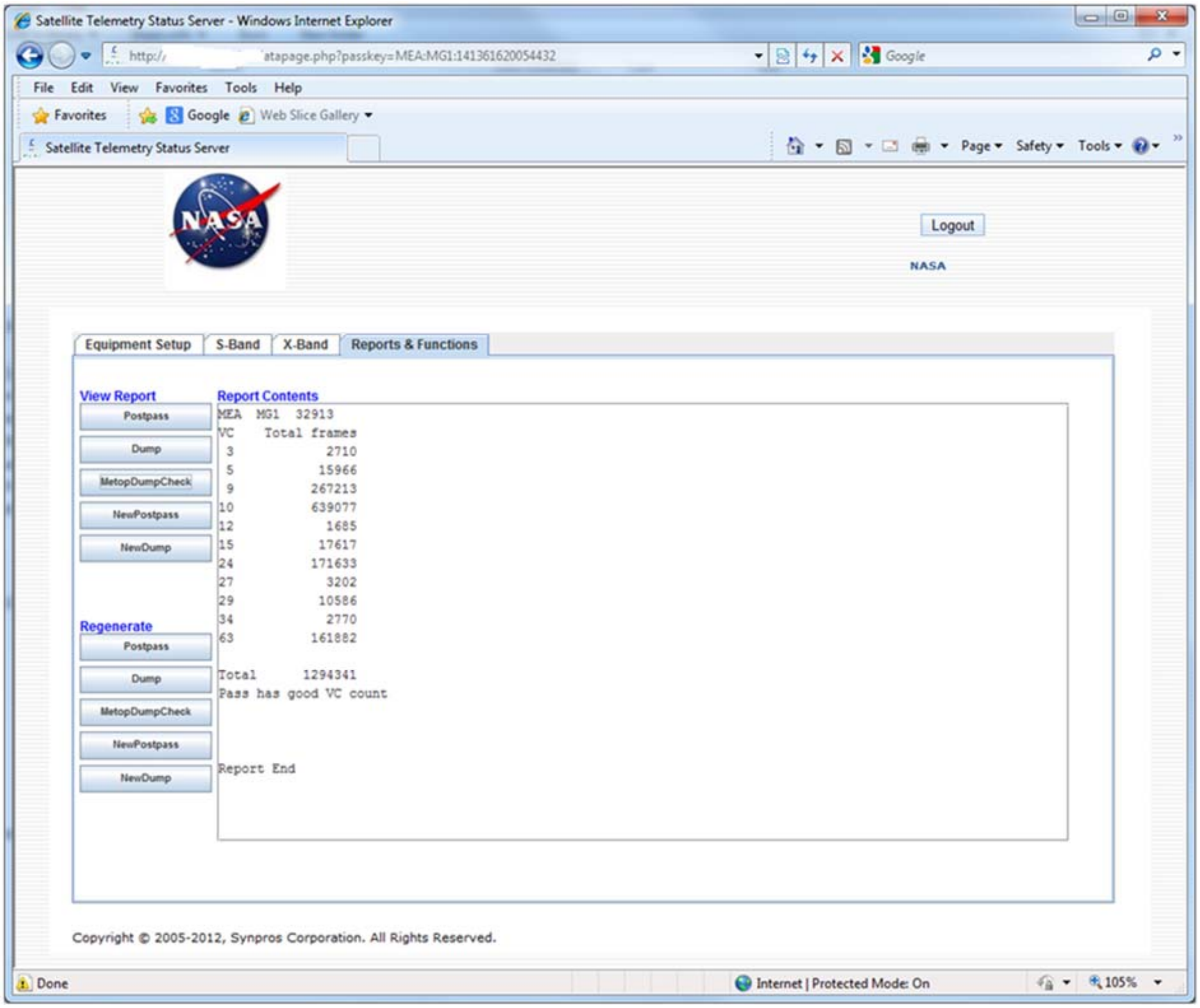


Figure 2-9. Reports Tab for Viewing and Regenerating

Section 3. Kongsberg Satellite Services Ground Stations

3.1 General

This section describes the KSAT ground stations located in Svalbard, Norway, Antarctica and Singapore. Three apertures are available at Norway; SG1, SG2, SG3. A fourth aperture, TR2, is located in Antarctica and a fifth, SI1, at Singapore. These apertures are under KSAT control and are described in the text below. The URL http://www.ksat.no, can be used to link to KSAT website for further information.

3.2 Svalbard, 11.3-m, SG1

The SG1 antenna was replaced in September 2012. The general characteristics of the antenna are as follows:

a. Location: 78° 13′ 51″ N
15° 23′ 22″ E

b. One 11.3-m antenna (Viasat) for simultaneously transmitting at S-band while receiving at S- and X-bands. Figure 3-1 is a photograph of the SG1 antenna.

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: 1- & 2-way Doppler and antenna autotracking angles.

e. Baseband data interfaces: Internet Protocol (IP), serial clock and data, 4800-bit blocks encapsulated in IP packets, and electronic file transfer and parcel shipping.

Sections 3.2.1 through 3.2.3 describe S-band and X-band performance characteristics. Sections 3.2.4 and 3.2.5 describe the tracking services and baseband data interfaces, respectively.

Figure 3-1. SG1 Antenna

3.2.1 SG1 S-band Command

Table 3-1 identifies the S-band command characteristics of the SG1 antenna.

3.2.2 SG1 S-band Telemetry

Table 3-2 identifies the S-band telemetry characteristics of the SG1 antenna.

Table 3-1. SG1 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 63.5 dBW
Polarization	RHC or LHC
Antenna 3dB beamwidth	0.8 deg typical
Antenna Gain	42.5 dBi
HPA Output Power 1 dB compression	+54 dBm
Carrier Modulation	FSK no bit blanking FSK+half-bit blanking. Duty cycle: 50/50 BPSK, BPSK+AM Direct PCM
Modulation Index	0-2.5 Radians
Carrier Data Rate	10 bps – 10 kbps (Low BW) 100 bps – 1 Mbps (Intermediate & High BW)
Subcarrier Frequency	5 kHz-2 MHz (Intermediate & High BW)
Subcarrier Modulation	PCM (Intermediate & High BW)
Subcarrier Data Rate	100 bps – 250 kbps
Data Format	CCSDS, TDM NRZ-M, NRZ-L, S; or Biϕ-L, M
Note: The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

Table 3-2. SG1 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T with radome	22.1 dB/K (clear sky & 5° elevation angle)
Polarization	RHC and LHC
Antenna 3 dB Beamwidth	0.8 deg typical
Antenna Gain	45.1 dBi
Carrier Modulation	FM, PM, BPSK, QPSK, OQPSK, AQPSK
Modulation Index	0 to 2.5 Radians
Carrier Data Rate	100 b/s to 20 Mb/s (up to 40 Mb/s for QPSK demodulation + Viterbi decoding, up to 10 Mb/s in case of Bi-Phase decoding data format)
Carrier Data Format	CCSDS, TDM, NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	40 Hz – 128 kHz, 5 KHz – 2 MHz
Subcarrier Modulation	BPSK, PCM/PM for high BW telemetry
Subcarrier Data Rate	10 bps – 25 kbps, (NRZ) for 40 Hz-128 kHz 1 kbps – 600 Kbps for 5kHz – 2 MHz
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi , Reed-Solomon, Turbo, LDPC 1/2
Note: The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

3.2.3 SG1 X-band Telemetry

Table 3-3 identifies the X-band telemetry characteristics of the SG1 antenna.

Table 3-3. SG1 X-band Telemetry Characteristics

Characteristic	Value
Frequency	7700 – 8500 MHz
G/T with radome	36.8 dB/K (clear sky & 10° elevation angle)
Polarization	RHC and LHC
Antenna 3 dB beamwidth	0.2 deg typical
Antenna Gain	57.5 dBi
Modulation	BPSK, QPSK, SQPSK, UQPSK, or AQPSK*
Data Rate	2 – 320 Mbps; 160 Mbps per channel
Data Format	CCSDS, TDM NRZ-L or NRZ-M
Decoding	Derandomization, Viterbi and/or Reed-Solomon (Section 1.3, ref o.), 7/8 LDPC
* The AQPSK demodulation capability exists only for LANDSAT-7.	

3.2.4 SG1 Tracking Services

3.2.4.1 SG1 Doppler Tracking

The SG1 antenna generates both 1- & 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the SG1 S-band uplink signal with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 3-4.

Table 3-4. SG1 Doppler Tracking Characteristics

Characteristic	Value
Counter Resolution	10 Samp. Pr 1 Sec / 1 Samp. Pr 1 Sec / 1 Sample Pr 10 Sec 0.004 cycles
Doppler Frequency Shift	≤ 0.23 MHz
Doppler Bias Frequency	0.24 MHz
Drift (Δf/f)	4×10^{-11} at 0.1 sec
Accuracy	0.01 Hz
Output Equation	$(f_{transmit} \times [240/221] – f_{received}) + f_{bias}$

3.2.4.2 SG1 Antenna Autotracking Angle Data

The SG1 antenna can record the angle of the ground antenna as it autotracks the user. This data is provided to the user as Universal Tracking Data Format (UTDF) messages. (Refer to Table 4-1 of Reference h in Section 1.3)

3.2.5 SG1 Baseband Data Interfaces

The SG1 antenna can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12). SG1 uses the site's fiber optic (155 Mbps) communication link to support command, telemetry, and ground station control and monitor.

3.3 Svalbard, 11.3-m, SG2

The general characteristics of SG2 are as follows:

a. Location: 78° 13′ 49″ N
   15° 23′ 53″ E

b. One 11.3-m antenna for simultaneously transmitting at S-band while receiving at S-and X-bands. Figure 3-2 is a photograph of the SG2 antenna.

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: 1- and 2-way Doppler and antenna autotracking angle.

e. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets, and mail.

Sections 3.3.1 through 3.3.3 describe S- and X-band performance characteristics. Sections 3.3.4 and 3.3.5 describe the tracking services and baseband data interfaces, respectively.

Figure 3-2. SG2 Antenna

3.3.1 SG2 S-band Command

Table 3-5 identifies the S-band command characteristics of the SG2 antenna.

3.3.2 SG2 S-band Telemetry

Table 3-6 identifies the S-band telemetry characteristics of the SG2 antenna.

Table 3-5. SG2 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 59 dBWi
Polarization	RHC or LHC
Antenna Beamwidth	0.91 deg
Antenna Gain	44.4 dBi
Output Power	50 W
Carrier Modulation	FSK no bit blanking FSK+ hbb. Duty cycle: 50/50 BPSK, BPSK+AM Direct PCM
Modulation Index	0-2.5 Radians
Carrier Data Rate	10 bps – 10 kbps (Low BW) 100 bps – 1 Mbps (Intermediate & High BW)
Subcarrier Frequency	5 kHz – 2 MHz (Intermediate & High BW)
Subcarrier Modulation	PCM (Intermediate & High BW)
Subcarrier Data Rate	100 bps-250 kbps
Data Format	CCSDS, TDM NRZ-M, NRZ-L, S Biϕ-L, M, S
Note: The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

Table 3-6. SG2 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T with radome	23.8 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.84 deg
Antenna Gain	45.1 dBi
Carrier Modulation	FM, PM, BPSK, QPSK, OQPSK, AQPSK
Modulation Index	0 to 2.5 Radians
Carrier Data Rate	100 bps to 20 Mbps (up to 40 Mbps for QPSK demodulation + Viterbi decoding, up to 10 Mbps in case of Bi-Phase data format)
Carrier Data Format	CCSDS, TDM, NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	40 Hz – 128 kHz, 5 kHz – 2 MHz
Subcarrier Modulation	BPSK , PCM/PM for high BW telemetry
Subcarrier Data Rate	10 bps-25 kbps, (NRZ) for 40 Hz-128 kHz 1 kbps – 600 Kbps for 5 kHz – 2 MHz
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon
Note: The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

3.3.3 SG2 X-band Telemetry

Table 3-7 identifies the X-band telemetry characteristics of the SG2 antenna.

3.3.4 SG2 Tracking Services

3.3.4.1 SG2 Doppler Tracking

The SG2 antenna does not support ranging. The SG2 antenna generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the SG2 S-band uplink signal with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 3-8.

Table 3-7. SG2 X-band Telemetry Characteristics

Characteristic	Value
Frequency	7500-8500 MHz (Extends down to 7500 for testing)
G/T with radome	35.7 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.23 deg
Antenna Gain	57 dBi
Modulation	BPSK, QPSK, UQPSK, SQPSK
Data Rate	1 Mbps – 150 Mbps; Capable of 320 Mbps with upgrade)
Data Format	CCSDS, TDM NRZ-L, or NRZ-M
Decoding	Viterbi and/or Reed-Solomon

Table 3-8. SG2 Doppler Tracking Characteristics

Characteristic	Value
Counter Resolution	10 Samp. Pr 1 Sec / 1 Samp. Pr 1 Sec / 1 Sample Pr 10 Sec 0.004 cycles
Doppler Frequency Shift	≤ 0.23 MHz
Doppler Bias Frequency	0.24 MHz
Drift (Δf/f)	4×10^{-11} at 0.1 sec
Accuracy	0.01 Hz
Output Equation	$(f_{transmit} \times [240/221] - f_{received}) + f_{bias}$

3.3.4.2 SG2 Antenna Autotracking Angle Data

The SG2 antenna can record the angle of the ground antenna as it autotracks the user. This data is provided to the user as UTDF messages. (Refer to Table 4-1 of Reference h in Section 1.3)

3.3.5 SG2 Baseband Data Interfaces

The SG2 antenna can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12). SG2 uses the site's fiber optic communication link to support command, telemetry, and ground station control and monitor.

3.4 Svalbard, 13.0-m, SG3

The general characteristics of SG3 are as follows:

a. Location: 78° 13′ 47″ N
   15° 24′ 29″ E

b. One 13.0-m antenna (Datron) for simultaneously transmitting at S-band while receiving at S- and X-band. Figure 3-3 is a photograph of the SG3 antenna.

c. Scheduled by KSAT scheduling office per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: 1- & 2-way Doppler and antenna autotracking angle.

e. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets, and mail.

Sections 3.4.1 through 3.4.3 describe S- and X-band performance characteristics. Sections 3.4.4 and 3.4.5 describe the tracking services and baseband data interfaces, respectively.

Figure 3-3. SG3 Antenna

3.4.1 SG3 S-band Command

Table 3-9 identifies the S-band command characteristics of the SG3 antenna.

3.4.2 SG3 S-band Telemetry

Table 3-10 identifies the S-band telemetry characteristics of the SG3 antenna.

Table 3-9. SG3 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	67 dBW
Polarization	RHC or LHC
Antenna Beamwidth	0. 77 deg
Antenna Gain	45.9 dBi
Output Power	300 W
Carrier Modulation	FSK no bit blanking FSK+hbb Duty cycle: 50/50 BPSK, BPSK+AM Direct PCM
Modulation Index	0-2.5 Radians
Carrier Data Rate	10 bps – 10 kbps (Low BW) 100 bps – 1 Mbps (Intermediate & High BW)
Subcarrier Frequency	5 kHz – 2 MHz (Intermediate & High BW)
Subcarrier Modulation	PCM (Intermediate & High BW)
Subcarrier Data Rate	100 bps – 250 kbps
Data Format	CCSDS, TDM NRZ-M,S Biϕ-L, M
Note: The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

Table 3-10. SG3 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T with radome	23.0 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	≈ 0.71 deg @ 2200 MHz
Antenna Gain	≈ 46.9 dBi
Carrier Modulation	PM, FM, BPSK, QPSK, OQPSK
Modulation Index	0-2.5 Radians
Carrier Data Rate	100 bps to 20 Mbps (up to 40 Mbps for QPSK demodulation + Viterbi decoding, up to 10 Mbps in case of Bi-Phase data format)
Carrier Data Format	CCSDS, TDM, NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	40 Hz – 128 kHz, 5 kHz – 2 MHz
Subcarrier Modulation	BPSK, PCM/PM for high BW telemetry
Subcarrier Data Rate	10 bps- 25 kbps ,(NRZ) for 40 Hz-128 kHz 1 kbps – 600 kbps for 5 kHz – 2 MHz
Subcarrier Data Format	CCSDS, TDM
Decoding	Viterbi and/or Reed-Solomon
Note: The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

3.4.3 SG3 X-band Telemetry

Table 3-11 identifies the X-band telemetry characteristics of the SG3 antenna.

3.4.4 SG3 Tracking Services

3.4.4.1 SG3 Doppler Tracking

The SG3 antenna generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the SG3 S-band uplink signal with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 3-12.

Table 3-11. SG3 X-band Telemetry Characteristics

Characteristic	Value
Frequency	7500 – 8500 MHz (Extends down to 7500 for testing)
G/T with radome	37.8 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.19 deg @8025 MHz
Antenna Gain	≈ 59 dBi
Modulation	BPSK, QPSK, OQPSK (SQPSK), UQPSK (AQPSK)
Data Rate	BPSK & UQPSK (AQPSK): 1 Mbps – 235 Mbps QPSK, OQPSK (SQPSK): 2 Mbps – 470 Mbps
Data Format	CCSDS, TDM, NRZ-L/M/S DNRZ for QPSK
Decoding	Viterbi and/or Reed-Solomon, 7/8 LDPC

***Table 3-12.* SG3 Doppler Tracking Characteristics**

Characteristic	Value
Counter Resolution	10 Samp. Pr 1 Sec / 1 Samp. Pr 1 Sec / 1 Sample Pr 10 Sec 0.004 cycles
Doppler Frequency Shift	≤ 0.23 MHz
Doppler Bias Frequency	0.24 MHz
Drift (Δf/f)	4×10^{-11} at 0.1 sec
Accuracy	0.01 Hz
Output Equation	1000 (ftransmit × [240/221] – freceived) + fbias

3.4.4.2 SG3 Antenna Autotracking Angle Data

The SG3 antenna can record the angle of the ground antenna as it autotracks the user. This data is provided to the user as UTDF messages. (Refer to Table 4-1 of Reference h in Section 1.3)

3.4.5 SG3 Baseband Data Interfaces

The SG3 antenna can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12). SG3 uses the site's fiber optic (155 Mbps) communication link to support command, telemetry, and ground station monitor and control.

3.5 TrollSat, Antarctica, TR2

The general characteristics of TR2 ground station at Antarctica are as follows:

a. Location: -72° 00' 08" S, 02° 31' 27" E.

b. One 7.3-m antenna for simultaneously transmitting at S-band while receiving at S- and X-band. Figure 3-4 is a photograph of the TR2 antenna.

c. Scheduled by KSAT scheduling office per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: 1- and 2-way Doppler and antenna autotracking angles.

e. Baseband data interfaces: Video and/or telemetry.

Sections 3.5.1 through 3.5.3 describe S- and X-band performance characteristics. Sections 3.5.4 and 3.5.5 describe the tracking services and baseband data interfaces, respectively.

Figure 3-4. TR2 Antenna

3.5.1 TR2 S-band Command

Table 3-13 identifies the S-band command characteristics of the TR2 antenna.

3.5.2 TR2 S-band Telemetry

Table 3-14 identifies the S-band telemetry characteristics of the TR2 antenna.

Table 3-13. TR2 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	51 dBW
Polarization	RHC or LHC
Antenna Beamwidth	1.32 deg
Antenna Gain	41.2 dBi
Output Power	50 W
Carrier Modulation	FSK no bit blanking FSK+ hbb BPSK, BPSK+AM Direct PCM
Modulation Index	0-2.5 Radians
Carrier Data Rate	10 bps – 10 kbps(Low BW) 100 bps-1 Mbps (Intermediate & High BW)
Subcarrier Frequency	5 kHz – 2 MHz (Intermediate & High BW)
Subcarrier Modulation	PCM (Intermediate & High BW)
Subcarrier Data Rate	100 bps – 250 kbps
Data Format	CCSDS, TDM NRZ-M, NRZ-L, S; or Biϕ-L, M
Note: The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

Table 3-14. TR2 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	19.4 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC or Diversity Combining
Antenna Beamwidth	≈ 1.16 deg @ 2200 MHz
Antenna Gain	≈ 41.8 dBi
Carrier Modulation	PM, FM, BPSK, QPSK, OQPSK
Modulation Index	0-2.5 Radians
Carrier Data Rate	100 b/s to 20 Mb/s (up to 40 Mb/s for QPSK demodulation + Viterbi decoding, up to 10 Mb/s in case of Bi-Phase decoding data format)
Carrier Data Format	CCSDS, TDM, NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	40 Hz-128 kHz, 5 kHz-2 MHz
Subcarrier Modulation	BPSK, PCM/PM for high BW telemetry
Subcarrier Data Rate	10 bps- 25 kbps, (NRZ) for 40 Hz-128 kHz 1 kbps – 600 kbps for 5 kHz – 2 MHz
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon
Note: The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

3.5.3 TR2 X-band Telemetry

Table 3-15 identifies the X-band telemetry characteristics of the TR2 antenna.

3.5.4 TR2 Tracking Services

3.5.4.1 TR2 Doppler Tracking

The TR2 antenna generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the TR2 S-band uplink signal with a frequency ratio of 240/221.

Table 3-15. TR2 X-band Telemetry Characteristics

Characteristic	Value
Frequency	8000 – 8500 MHz (Extends down to 7500 for testing)
G/T with radome	32 dB/K (at 60° elevation)
Polarization	RHC or LHC
Antenna Beamwidth	0.32 deg @8025 MHz
Antenna Gain	≈ 54 dBi
Modulation	BPSK, QPSK, OQPSK (SQPSK), UQPSK (AQPSK),
Data Rate	BPSK & UQPSK (AQPSK): 1 Mbps – 235 Mbps QPSK, OQPSK (SQPSK): 2 Mbps – 470 Mbps
Data Format	CCSDS, TDM, NRZ-L/M/S DNRZ for QPSK
Decoding	Viterbi and/or Reed-Solomon, 7/8 LDPC

3.5.4.2 TR2 Antenna Autotracking Angle Data

The TR2 antenna can record the angle of the ground antenna as it autotracks the user. This data is provided to the user as UTDF messages. (Refer to Table 4-1 of Reference h in Section 1.3)

3.5.5 TR2 Baseband Data Interfaces

The TR2 antenna can send and receive baseband data in any of the following formats: Video and telemetry.

3.6 Singapore, 9-m S- and X-band Antenna, SI1

The general characteristics of the Singapore ground station are as follows:

a. Location: 1° 23’ 46” N, 103° 50’ 03”E. *(KSAT #; - NDOSL wrong)*

b. One 9.1-m antenna for simultaneously transmitting at S-band while receiving at S- and X-band. Figure 3-5 is a photograph of the Singapore antenna.

c. Scheduled by KSAT scheduling office per 453-UG-NEN Scheduling, Users’ Guide for Near Earth Network Scheduling.

d. Tracking services: 1- and 2-way Doppler and antenna autotracking angles.

e. Baseband data interfaces: Video and/or telemetry.

Sections 3.6.1 through 3.6.3 describe S- and X-band performance characteristics. Sections 3.6.4 and 3.6.5 describe the tracking services and baseband data interfaces, respectively.

Figure 3 5. Singapore 9.1-m S- and X-band Antenna

3.6.1 Singapore S-band Command

Table 3-16 identifies the S-band command characteristics of the Singapore antenna.

Table 3-16. Singapore S-band Command Characteristics

Characteristic	Value
Frequency	2025 -2120 Mhz
EIRP	59 dBW
Polarization	RHC or LHC
Antenna Beamwidth	1.07°
Antenna Gain	41.6 dBi
Output Power	59 dBW
Carrier Modulation	FSK no bit blanking FSK+half-bit blanking. Duty cycle: 50/50 BPSK, BPSK+AM Direct PCM
Modulation Index	0-2.5 Radians
Carrier Data Rate	10 bps – 10 kbps (Low BW) 100 bps – 1 Mbps (Intermediate & High BW)
Subcarrier Frequency	5 kHz-2 MHz (Intermediate & High BW)
Subcarrier Modulation	PCM (Intermediate & High BW)
Subcarrier Data Rate	100 bps – 250 kbps
Data Format	CCSDS, TDM NRZ-M, NRZ-L, S; or Bi□-L, M
Note: The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

3.6.2 Singapore S-band Telemetry

Table 3-17 identifies the S-band telemetry characteristics of the Singapore antenna.

Table 3-17. Singapore S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2300 Mhz
G/T	20.5 dB/K (clear sky & 5° elevation angle)
Polarization	RHC and LHC
Antenna Beamwidth	0.98°
Antenna Gain	43.13 dBi
Carrier Modulation	FM, PM, BPSK, QPSK, OQPSK, AQPSK
Modulation Index	0 to 2.5 Radians
Carrier Data Rate	100 b/s to 20 Mb/s (up to 40 Mb/s for QPSK demodulation + Viterbi decoding, up to 10 Mb/s in case of Bi-Phase decoding data format)
Carrier Data Format	CCSDS, TDM, NRZ-L, M, or S; or Bi□-L, M, or S
Subcarrier Frequency	40 Hz – 128 kHz, 5 KHz – 2 MHz
Subcarrier Modulation	BPSK, PCM/PM for high BW telemetry
Subcarrier Data Rate	10 bps – 25 kbps, (NRZ) for 40 Hz-128 kHz 1 kbps – 600 Kbps for 5kHz – 2 MHz
Subcarrier Data Format	NRZ-L, M, or S; or Bi□-L, M, or S
Decoding	Viterbi and/or Reed-Solomon
Note: The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

3.6.3 Singapore X-band Telemetry

Table 3-18 identifies the X-band telemetry characteristics of the Singapore antenna.

Table 3-18. Singapore X-band Telemetry Characteristics

Characteristic	Value
Frequency	7985 – 8500 MHz
G/T	35.4 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.24°
Antenna Gain	55.42 dBi
Modulation	BPSK, QPSK, OQPSK (SQPSK), UQPSK
Data Rate	BPSK & UQPSK: 1 Mbps – 235 Mbps QPSK, OQPSK (SQPSK): 2 Mbps – 470 Mbps
Data Format	CCSDS, TDM, NRZ-L/M/S DNRZ for QPSK
Decoding	Viterbi and/or Reed-Solomon, 7/8 LDPC

3.6.4 Singapore Tracking Services

3.6.4.1 Singapore Doppler Tracking

The Singapore antenna generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the Singapore S-band uplink signal with a frequency ratio of 240/221.

3.6.4.2 Singapore Antenna Autotracking Angle Data

The Singapore antenna can record the angle of the ground antenna as it autotracks the user.

3.6.5 Singapore Baseband Data Interfaces

The Singapore antenna can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12).

Section 4. Wallops Flight Facility Ground Station

4.1 General

This section describes the NEN station located at the Wallops Flight Facility (WFF).

This satellite ground station consists of the following assets:

a. WG1 11-m (Section 4.2).
b. WG2 Low Earth Orbiter-Terminal (LEO-T) (Section 4.3).
c. WG3/WG4 Two VHF Ground Stations (Section 4.4).
d. Remote Operations Status and Execution Service computers for remote monitoring of the McMurdo MG1 and White Sands WS1 antennas.

4.2 Wallops 11-m, S- and X-band, WG1

The general characteristics of the WG1 ground station at WFF are as follows:

a. Location: 37º 55′ 28″ N
   75º 28′ 35″ W
b. One 11.3-m antenna for simultaneously transmitting at S-band while receiving at S- and/or X-bands. Figure 4-1 is a photograph of the WG1 antenna.
c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.
d. Remote monitoring of the McMurdo 10-m system and the White Sands 18-m system.
e. Tracking services: 1- & 2-way Doppler, Tone Ranging and antenna autotracking angles.
f. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets, and mail.

Sections 4.2.1 and 4.2.2 describe S-band and X-band performance characteristics. Sections 4.2.3 and 4.2.4 describe the tracking services and baseband data interfaces, respectively.

4.2.1 S-band Command

Table 4-1 identifies the S-band command characteristics of the WG1. Contact NEN management for further details as S-band system upgrades are planned.

4.2.2 S-band Telemetry

Table 4-2 identifies the S-band telemetry characteristics of the WG1. Contact NEN management for further details as S-band system upgrades are planned.

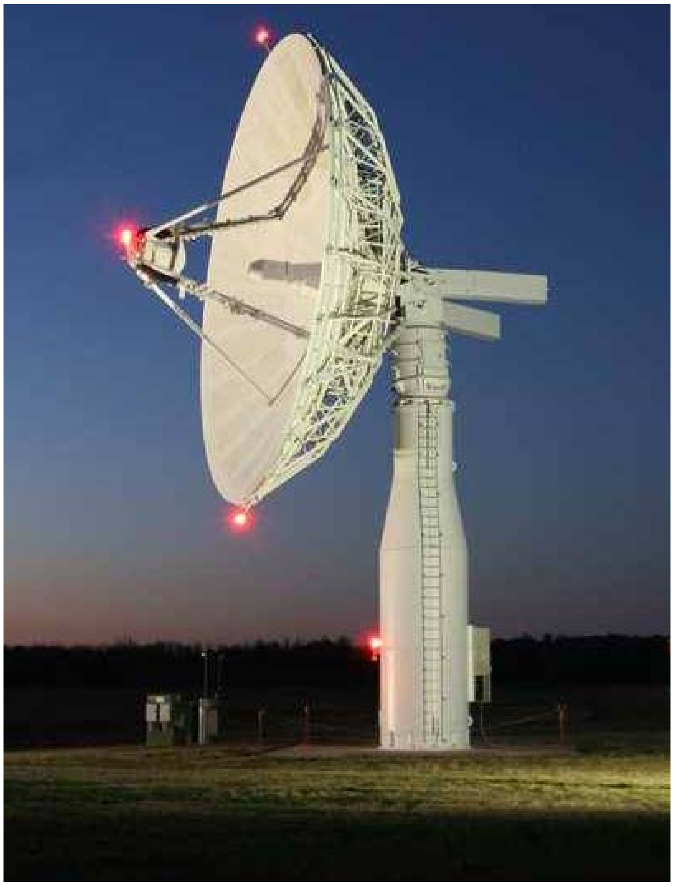


Figure 4-1. WG1 Antenna

Table 4-1. WG1 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 64.6 dBWi
Polarization	RHC or LHC
Antenna Beamwidth	0.95 deg
Antenna Gain	44.8 dBi
Output Power	300 W
Carrier Modulation	PM, FM, BPSK or QPSK
Modulation Index	FM: 1-KHz – 50 KHz deviation PM: 0.01-2.50 Radians BPSK: ±90°
Carrier Data Rate	1 Kbps – 1 Mbps
Subcarrier Frequency	5 KHz – 2 MHz
Subcarrier Modulation	FSK and BPSK
Subcarrier Data Rate	100 bps – 250 Kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 4-2. WG1 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	23.6 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.85 deg
Antenna Gain	45.8 dBi
Carrier Modulation	PM/PCM, FM/PCM, BPSK, or QPSK / OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate (High Rate Telemetry Channel)	1 Kbps – 10 Mbps (FM/PCM) 100 bps – 20 Mbps (PM/PCM, BPSK, OQPSK) 1 Kbps – 40 Mbps (QPSK) [$\leq$ 20 Mbps per channel]
Carrier Data Format	NRZ-L, M or S, Biϕ-L, M or S; DM-M or S; DBP-M or S; RNRZ
Subcarrier Frequency	5 kHz – 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	100 bps – 600 Kbps
Subcarrier Data Format	Passes all NRZ or Biϕ or DM
Decoding	Derandomization, Viterbi and/or Reed-Solomon (Ref Para 1.3 s)

4.2.3 X-band Telemetry

Table 4-3 identifies the X-band telemetry characteristics of the WG1.

4.2.4 Tracking Services

4.2.4.1 Doppler Tracking

WG1 generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the WG1 S-band uplink signal with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 4-4.

Table 4-3. WG1 X-band Telemetry Characteristics

Characteristic	Value
Frequency	8000-8500 MHz
G/T	33.8 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.23 deg
Antenna Gain	56.8 dBi
Modulation	BPSK, QPSK, UQPSK, OQPSK, 8PSK
Demodulator Data Rate	500 Kbps – 350 Mbps (QPSK, OQPSK) 250 Kbps – 150 Mbps (BPSK, UQPSK) 750 Kbps – 200 Mbps (8PSK)
Data Format	NRZ-L, M, S. Biϕ-L, M, S, DNRZ
Decoding	Derandomization, Viterbi, and or Reed-Solomon (Section 1.3, ref o), 7/8 LDPC

Table 4-4. WG1 Doppler Tracking Characteristics

Characteristic	Value
Counter Resolution	0.00054 cycles
Doppler Frequency Shift	≤ 0.25 MHz
Doppler Bias Frequency (fbias)	0.24 MHz
Drift (Δf/f)	3×10^{-11} at 0.1 sec
Accuracy	0.0031 Hz
Output Equation	$(f_{transmit} \times [240/221] - f_{received}) + f_{bias}$

4.2.4.2 Antenna Autotracking Angle Data

The WG1 can record the angle of the ground antenna as it autotracks the user. This data is provided to the user as UTDF messages. (Refer to Table 4-1 or Reference h in Section 1.3)

4.2.4.3 Range Tracking

Ranging capability has been successfully implemented at WG1. Tracking characteristics are shown in Table 4-5.

4.2.5 Baseband Data Interfaces

The WG1 can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12). WG1 currently has a T-1 (1.544 Mbps) communications link with GSFC to support command, low-rate telemetry, and ground station control and monitor.

High rate X-band telemetry data is recorded on the Cortex HDR-XXL.

Table 4-5. WG1 Ranging Characteristics

Characteristic	Value
Modulation	PM
Supported standards	ESA standard ESA like standard (includes USB) ESA code standard Continuous Tone standard
Major Tone	500 KHz (Tone Ranging) or 450 KHz (Code Ranging)
Minor Tones	Minor Tones are each a programmable ratio of the major tone. Up to 6 minor tones for ESA standard or up to 8 minor tones for ESA like standard. ESA code and Continuous Tone standards do not use minor tones.
Modulation Index	0.1 – 2.5 Radians
Resolution	30.0 CM

4.3 Wallops LEO-T – 5-m, S-band, WG2

4.3.1 General

The general characteristics of the WG2 LEO-T (low Earth orbit) antenna at WFF are as follows:

a. Location: 37º 55′ 25″ N (see NDOSL "LE2S" for details)
75º 28′ 34″ W

b. One 5-m antenna for simultaneously transmitting and receiving at S-band. Figure 4-2 is a photograph of the LEO-T antenna.

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: None.

e. Baseband data interfaces: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets.

Sections 4.3.1 and 4.3.2 describe S-band performance characteristics, and Section 4.3.3 describes the baseband data interfaces.

4.3.2 S-band Command

Table 4-6 identifies the S-band command characteristics of the LEO-T – WFF antenna system.

4.3.3 S-band Telemetry

Table 4-7 identifies the S-band telemetry characteristics of the LEO-T – WFF antenna system station.

Figure 4-2. LEO-T WFF Antenna

Table 4-6. LEO-T – WG2 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 59.2 dBWi
Polarization	RHC or LHC
Antenna Beamwidth	1.8 deg
Antenna Gain	38.6 dBi
Output Power	200 W
Carrier Modulation	PM, BPSK, or FM
Modulation Index	PM: 0.2 – 1.5 Radians (peak)
Carrier Data Rate	N/A
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	10 bps – 1 Mbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 4-7. LEO-T – WG2 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2300 MHz
G/T	17.0 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	1.83 deg
Antenna Gain	39.4 dBi
Carrier Modulation	PM, FM, BPSK, or QPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	Uncoded: 10 bps – 8 Mbps Rate-½ coded: 10 bps – 4 Mbps
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	≤ 4 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	N/A
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon (CCSDS Ver 1 & 2, Ref Para 1.3 v)

4.3.4 Baseband Data Interfaces

The LEO-T – WG2 antenna system can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12). The station currently has a T-1 (1.544 Mbps) communications link with GSFC to support command, low-rate telemetry, and ground station control and monitor.

4.4 Wallops WG3/WG4 VHF Air/Ground Antenna Systems

The two VHF Air/Ground (A/G) antenna systems at WFF are used only to support the International Space Station and Soyuz spacecraft. The VHF-1 system can transmit and receive voice and support packet data on the uplink. The VHF-2 system supports only voice. The general characteristics of the two VHF A/G Ground Stations at WFF are as follows:

a. Location: 37 º N (see NDOSL “WP2Z for VHF-1 and “WP3Z” for VHF-2)
   75 º W

b. Two Quad Yagi antennas (WG3 VHF-1 and WG4 VHF-2) for simultaneously transmitting voice at VHF while receiving voice at VHF.

c. Manually scheduled by Wallops via NEN schedulers per 453-UG-NEN Scheduling, *Users’ Guide for Near Earth Network Scheduling*. Only Johnson Space Center – Mission Control Center (JSC-MCC) is allowed to request support.

d. Tracking services: None.

e. Baseband interfaces: Dedicated NASA Integrated Services Network (NISN) communications voice loops.

Sections 4.4.1 and 4.4.2 describe the VHF-1 and VHF-2 voice A/G characteristics, respectively. Section 4.4.3 describes the baseband voice interfaces.

4.4.1 VHF-1 A/G Voice Antenna Systems, WG3

Tables 4-8 and 4-9 identify the A/G Full Duplex uplink and downlink characteristics of the WFF VHF-1 Ground Station, respectively.

Table 4-8. WFF VHF-1 A/G Uplink Characteristics

Characteristic	Value
Frequency	139.208 MHz
EIRP	≥ 43.4 dBWi
Polarization	N/A
Antenna Beamwidth	20 deg
Antenna Gain	18.0 dBi
Output Power	350 W
Carrier Modulation	FM
FM Deviation	± 10 kHz
Carrier Data Rate	N/A (Voice only on the uplink)

Table 4-9. WFF VHF-1 A/G Downlink Characteristics

Characteristic	Value
Frequency	143.625 MHz
G/T	N/A
Polarization	RHC
Antenna Beamwidth	20 deg
Antenna Gain	18.0 dBi
Carrier Modulation	FM
FM Deviation	± 10 kHz
Carrier Data Rate	N/A (Voice only on downlink)

4.4.2 VHF-2 A/G Voice Antenna Systems, WG4

Tables 4-10 and 4-11 identify the A/G Full Duplex voice uplink and downlink characteristics of the WFF VHF-2 Ground Station, respectively.

Table 4-10. WFF VHF-2 A/G Uplink Characteristics

Characteristic	Value
Frequency	130.167 MHz
EIRP	43.4 dBWi
Polarization	N/A
Antenna Beamwidth	20 deg
Antenna Gain	18.0 dBi
Output Power	350 W
Carrier Modulation	FM
FM Deviation	± 10 kHz
Carrier Data Rate	N/A (Voice only on the uplink)

***Table 4-11.* WFF VHF-2 A/G Downlink Characteristics**

Characteristic	Value
Frequency	121.750 MHz
G/T	N/A
Polarization	RHC
Antenna Beamwidth	20 deg
Antenna Gain	18.0 dBi
Carrier Modulation	FM
FM Deviation	± 10 kHz
Carrier Data Rate	N/A (Voice only on downlink)

4.4.3 Baseband Voice Interfaces

The WFF VHF-1 and WFF VHF-2 A/G antennas can send and receive baseband voice and receive packet data from only the JSC-MCC via dedicated NISN communications voice loops.

Section 5. McMurdo Ground Station

5.1 General

This section describes the MGS in Antarctica. The general characteristics of the station are as follows:

a. Location: 77° 50′ 21″ S (for details see NDOSL "MC1S")
166° 40′ 01″ E

b. One 10-m antenna (MG1) for simultaneously transmitting at S-band while receiving at S-and X-bands. Figure 5-1 is a photograph of the MG1 antenna.

c. Future upgrade to McMurdo TDRS Relay System (MTRS).

d. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

e. Remotely monitored via Wallops (24x7).

f. Tracking services: No tracking data capability but the antenna does have "auto track" capability.

g. Baseband data interfaces: IP, 4800-bit blocks encapsulated in IP packets, and mail.

h. MG1 cannot be considered a launch MANDATORY project required site.

Sections 5.2 through 5.4 describe the current S- and X-band performance characteristics. Section 5.5 describes the baseband data interfaces.

Figure 5-1. McMurdo 10-m, MG1 Antenna

5.2 S-band Command

Table 5-1 identifies the S-band command characteristics of the MG1.

Table 5-1. MG1 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 63 dBWi
Polarization	RHC or LHC
Antenna Beamwidth	1.05 deg
Antenna Gain	44 dBi
Output Power	200 W
Carrier Modulation	PM, FM, BPSK, QPSK
Modulation Index	FM: 1 kHz – 5.0 MHz deviation PM 0.01 – 2.50 Radians
Carrier Data Rate	1 Kbps – 1 Mbps
Subcarrier Frequency	5 KHz – 2 MHz
Subcarrier Modulation	FSK and BPSK
Subcarrier Data Rate	100 bps – 250 Kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

5.3 S-band Telemetry

Table 5-2 identifies the S-band telemetry characteristics of the MG1.

Table 5-2. McMurdo 10-m MG1 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T with radome	21 dB/K (clear sky & 5° elevation angle)
Polarization	RHC, LHC or Diversity Combining
Antenna Beamwidth	0.91 deg
Antenna Gain	45 dBi
Carrier Modulation	PM/PCM, FM/PCM, BPSK, QPSK, or OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	1 kbps – 10 Mbps (FM/PCM) 100 bps – 20 Mbps (PM/PCM, BPSK, OQPSK) 1 kbps – 40 Mbps (QPSK) [<20 Mbps per channel]
Carrier Data Format	NRZ-L, M, or S; Biϕ-L, M, or S; DM-M or S; DBP-M or S; RNRZ-L
Subcarrier Frequency	5 kHz – 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	100 bps – 600 kbps
Subcarrier Data Format	NRZ, Biϕ, or DM
Decoding	Derandomization, Viterbi and/or Reed-Solomon (Section 1.3 ref s.)

5.4 X-band Telemetry

Table 5-3 identifies the X-band telemetry characteristics of the MG1.

Table 5-3. MG1 X-band Telemetry Characteristics

Characteristic	Value
Frequency	7700 – 8500 MHz
G/T with radome	32.0 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.26 deg
Antenna Gain	56 dBi
Modulation Type	BPSK, QPSK, OQPSK, UQPSK, 8PSK
Demodulator Data Rate	500 kbps – 300 Mbps (QPSK, OQPSK) 250 kbps – 150 Mbps (BPSK, UQPSK) 750 kbps – 200 Mbps (8PSK)
Data Format	NRZ-L, M, S, Biϕ-L, M, S, DNRZ
Decoding	Derandomization, Viterbi and/or Reed-Solomon (Para 1.3 ref s.)

5.5 Baseband Data Interfaces

MG1 can send and receive baseband data in either of the following formats: IP or 4800-bit blocks encapsulated in IP packets (see Section 12). MG1 currently has a 1 Mbps outbound and 500 kbps inbound slice of the National Science Foundation's communications link for McMurdo Station to support operations. This includes command, low-rate telemetry, ground station monitor/control and Goddard voice link.

Due to the limited outbound bandwidth, high-rate X-band telemetry data recorded by MG1 can be transferred to flash drives and then shipped (except during the austral winter) to the end user via international carrier from Christchurch, New Zealand.

5.6 Upgrade/Depot Level Maintenance

The 10-m underwent an Upgrade/ Depot Level Maintenance (DLM) in mid-November 2010. The upgrade included Cortex HDR-XXL for X-band, and the Cortex CRT for S-band. The DLM included new electronic controls, motors, and rebuilt gearboxes and the Cortex CRT for S-band.

Section 6. Universal Space Network Ground Stations

6.1 General

The USN, a wholly owned subsidiary of the Swedish Space Corporation, is a commercial service provider with three primary stations; North Pole in Alaska, Hawaii, and Western Australia. USN also has collaborative agreements for access to other stations located at various sites around the world. Further details concerning these sites are available at URL: http://www.sscspace.com/usn.

This section describes the NEN stations at North Pole, Hawaii, and Australia. The antennas at Poker Flat has were moved to North Pole, Alaska.

This section describes the North Pole (a suburb of Fairbanks), Alaska, 13-m system referred to as USAK01. The antenna manufacturer support is provided by L-3/Datron.

The general characteristics of the USAK01 aperture are as follows:

a. Location: 64° 48′ 15″ N (for details see NDOSL “USAS”)
   147° 30′ 01″ W

b. 13-m antenna for simultaneously transmitting at L-band or S-band while receiving at S- and X-band. Figure 6-1 is a photograph of the USAK01 antenna.

c. Supports S-band and X-band CCSDS services. Supports L-band Space-to-Ground Link Subsystem and United States Air Force services.

d. Manually scheduled by USN via NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

e. Tracking services: 1- & 2-way Doppler, Ranging, and antenna auto tracking angles.

f. Baseband data interfaces: TCP/IP, 4800-bit blocks encapsulated in IP packets, and mail.

g. Site Power: Commercial power. UPS power to RF and baseband equipment only. 200-KW back-up power generator.

Figure 6-1. USAK01 Antenna

6.1.1 USAK01 L/S-band Command

Table 6-1 identifies the L/S-band command characteristics of the USAK01 aperture.

6.1.2 USAK01 S-band Telemetry

Table 6-2 identifies the S-band telemetry characteristics of the USAK01 aperture.

Table 6-1. USAK01 L/S-band Command Characteristics

Characteristic	Value
Frequency	L-band: 1750-1850 MHz S-band: 2025 – 2120 MHz
EIRP	L-band: 69 dBW S-band: 68 dBW
Polarization	RHC or LHC
Antenna Beam-width	L-band: 0.90 deg S-band: 0.78 deg
Antenna Gain	L-band: 45.9 dBi S-band: 47.1 dBi
Transmitter Power	L-band: 27.7 dBW SSPA S-band: 24.7 dBW SSPA
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 Radians (peak) BPSK: ±90 deg
Carrier Data Rate	10 bps – 10 Mbps
Subcarrier Frequency	≤ 5 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	32 bps - 1 Mbps
Data Format	NRZ-L, M, or S; or Biφ-L, M, or S

Table 6-2. USAK01 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	23.5 dB/K (clear sky & 5° elevation angle)
Polarization	RHC and LHC
Antenna Beam-width	0.70 deg
Antenna Gain	48.0 dBi
Carrier Modulation	PM, FM, BPSK, QPSK, or OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	100 bps – 20 Mbps Uncoded
Carrier Data Format	NRZ-L, M, or S; or Biφ-L, M, or S
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	10 bps – 256 bps
Subcarrier Data Format	NRZ-L, M, or S; or Biφ-L, M, or S
Decoding	Viterbi (Rate-1/2) and/or Reed-Solomon

6.1.3 USAK01 X-band Telemetry

Table 6-3 identifies the X-band telemetry characteristics of the USAK01 aperture.

Table 6-3. USAK01 X-band Telemetry Characteristics

Characteristic	Value
Frequency	8000 – 8500 MHz
G/T	37.7 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beam-width	0.17 deg
Antenna Gain	59.1 dBi
Modulation	BPSK,QPSK,SQPSK or AQPSK
Data Rate	1 bps – 150 bps Uncoded
Data Format	NRZ-L or M
Decoding	Viterbi (Rate-½)

6.1.4 USAK01 Tracking Services

The USAK01 aperture can provide Doppler, Ranging, and Angular tracking measurements. The measurement message format can be delivered in the native USN format or in customer-defined formats such as UTDF format.

6.1.4.1 USAK01 Doppler Tracking

The USAK01 aperture can collect 1-way and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier.

6.1.4.2 USAK01 Ranging

The USAK01 aperture can collect 2-way ranging measurements. Ranging can be accomplished with either tone ranging or European Space Agency (ESA) code ranging. Cortex-NT or Cortex-XL equipment is used to collect these measurements.

6.1.4.3 USAK01 Antenna Autotrack Angle Data

The USAK01 aperture records the angle of the ground antenna as it autotracks.

6.1.5 USAK01 Baseband Data Interfaces

The USAK01 aperture sends and receives baseband data using the TCP/IP protocol. The NASA legacy standard of 4800 bit blocks is supported by encapsulating the blocks into TCP/IP frames.

The North Pole site is supported by a 3-Mbps Multiprotocol Label Switching (MPLS) service for transporting the TCP/IP data to the USN Network Management Centers (NMC) in California and Pennsylvania.

NASA accesses the USAK01 ground station via the Restricted IONet interface between GSFC and the NMC in Horsham, Pennsylvania.

Additional services are available at the USAK01 site as required. Services available in the area include open Internet, MPLS, and private line via fiber and copper media.

6.2 North Pole, Alaska, 5-m, S-band, USAK02

This section describes the North Pole, Alaska, 5-m system referred to as USAK02. The antenna manufacturer support is provided by L-3/Datron.

The general characteristics of the USAK02 aperture are as follows:

a. Location: 64° 48′ 15″ N (not in NDOSL, previously LE1S?))
   147° 30′ 01″ W

b. 5-m antenna for simultaneously transmitting S-band while receiving at S-band. Figure 6-2 is an old photograph of the USAK02 antenna, behind the old USAK01 Radome.

c. Supports S-band CCSDS services.

d. Manually scheduled by USN via NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

e. Tracking services: 1- & 2-way Doppler and Ranging available (not certified by NASA Flight Dynamics Facility (FDF) at this time).

f. Baseband data interfaces: TCP/IP, 4800-bit blocks encapsulated in IP packets, and mail.

g. Site Power: Commercial power. UPS power to RF and baseband equipment only. 200-KW back-up power generator.

Figure 6-2. North Pole Ground Station (USAK02 in Foreground within Radome, USAK01 in Background)

6.2.1 USAK02 S-band Command

Table 6-4 identifies the S-band command characteristics of the USAK02 aperture.

6.2.2 USAK02 S-band Telemetry

Table 6-5 identifies the S-band telemetry characteristics of the USAK02 aperture.

Table 6-4. USAK02 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	56 dBWi
Polarization	RHC or LHC
Antenna Beam-width	2.03 deg
Antenna Gain	38.8 dBi
Transmitter Power	20 dBW SSPA
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 Radians (peak) BPSK: ±90 deg
Carrier Data Rate	10 bps – 32 Kbps
Subcarrier Frequency	≤ 1.2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	10 bps – 10 kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 6-5. USAK02 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	16.0 dB/K (clear sky & 5° elevation angle)
Polarization	RHC and LHC
Antenna Beam-width	1.83 deg
Antenna Gain	39.7 dBi
Carrier Modulation	PM, FM, BPSK, QPSK, or OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	2 kbps – 10 Mbps Uncoded
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	≤ 1.2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	1 kbps – 250 Kbps Uncoded
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon

6.2.3 USAK02 Tracking Services

The USAK02 aperture can provide Doppler and ranging measurements, but it is not certified by any flight dynamics facilities at this time. Angular measurements (autotrack) are also available, but the small aperture's beam-width may not provide the necessary tolerances for certification. The measurement message format can be delivered in the native USN format or in customer-defined formats such as UTDF format.

6.2.3.1 USAK02 Doppler Tracking

The USAK02 aperture can collect 1-way and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier.

6.2.3.2 USAK02 Ranging

The USAK02 aperture can collect 2-way ranging measurements. Ranging can be accomplished with either tone ranging or ESA code ranging. Cortex-NT or Cortex-XL equipment is used to collect these measurements.

6.2.3.3 USAK02 Antenna Autotrack Angle Data

The USAK02 aperture records the angle of the ground antenna as it autotracks.

6.2.4 USAK02 Baseband Data Interfaces

The USAK02 aperture sends and receives baseband data using the TCP/IP protocol. The NASA legacy standard of 4800 bit blocks is supported by encapsulating the blocks into TCP/IP frames.

The North Pole site is supported by a 3-Mbps MPLS service for transporting the TCP/IP data to the USN NMCs in Virginia and Pennsylvania.

NASA accesses the USAK01 ground station via the Restricted IONet interface between GSFC and the NMC in Horsham, Pennsylvania.

Additional services are available at the USAK02 site as required. Services available in the area include open Internet, MPLS, and private line via fiber and copper media.

6.3 North Pole, Alaska, UASK03 (TBD)

This section describes the North Pole, Alaska, 5.4-m system referred to as USAK03. The general characteristics of the antenna system:

a. Location: 64° 48′ 17″ N (for details see NDOSL “U3AS”)
   147° 30′ 15″ W

b. One 5.4-m antenna (ViaSat) for simultaneously transmitting at S-band while receiving at S- and X-bands. Figure 6-3 is a photograph of the USAK03 antenna. TBD

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: 1- & 2-way Doppler and antenna auto tracking angles.

e. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets, and mail.

f. Site Power: Commercial power. Uninterruptable Power Source (UPS) power to RF and baseband equipment only. Backup (500 KVA) Generator.

6.3.1 USAK03 S-band Command

Table 6-6 identifies the S-band command characteristics of the USAK03 aperture.

6.3.2 USAK03 S-band Telemetry

Table 6-7 identifies the S-band telemetry characteristics of the USAK03 aperture.

Figure 6-3. North Pole, Alaska 5.4 Antenna (USAK03)

Table 6-6. USAK03 S-Band Command Characteristics

Characteristic	Value
Frequency	S-Band: 2025 – 2120 MHz
EIRP	S-Band: ≥ 55 dBW
Polarization	RHC or LHC
Transmitter Power	S-Band: 100 W SSPA
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 radians (peak) BPSK: ±90°
Carrier Data Rate	10 bps - 10 Mbps
Subcarrier Frequency	≤ 1.2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	≤ 32 kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 6-7. USAK03 S-Band Telemetry characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	17.2 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Carrier Modulation	PM, FM, BPSK, or QPSK
Modulation Index	PM: 0.2 – 2.8 radians (peak)
Carrier Data Rate	NRZ:100 bps - 36 Mbps
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	≤ 1 Mbps
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon (CCSDS Ver. 1 & 2, Ref Para 1.3 v)

6.3.3 USAK03 Tracking Services

The USAK03 aperture can provide Doppler and ranging measurements, but it is not certified by any flight dynamics facilities at this time. Angular measurements (autotrack) are also available, but the small aperture's beam-width may not provide the necessary tolerances for certification. The measurement message format can be delivered in the native USN format or in customer-defined formats such as UTDF format.

6.3.3.1 USAK03 Doppler Tracking

The USAK03 aperture can collect 1-way and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier.

6.3.3.2 USAK03 Ranging

The USAK03 aperture can collect 2-way ranging measurements. Ranging can be accomplished with either tone ranging or ESA code ranging. Cortex-NT or Cortex-XL equipment is used to collect these measurements.

6.3.3.3 USAK03 Antenna Autotrack Angle Data

The USAK03 aperture records the angle of the ground antenna as it autotracks.

6.3.3.4 USAK03 Baseband Data Interfaces

The USAK03 aperture sends and receives baseband data using the TCP/IP protocol. The NASA legacy standard of 4800 bit blocks is supported by encapsulating the blocks into TCP/IP frames.

The North Pole site is supported by a 3-Mbps MPLS service for transporting the TCP/IP data to the USN NMCs in Virginia and Pennsylvania.

NASA accesses the USAK01 ground station via the Restricted IONet interface between GSFC and the NMC in Horsham, Pennsylvania.

Additional services are available at the USAK03 site as required. Services available in the area include open Internet, MPLS, and private line via fiber and copper media.

6.4 North Pole, Alaska, 7.3-m S- and X-band Antenna System, USAK04

This section describes the North Pole, Alaska, Datron, 7.3-m system referred to as USAK04. The antenna manufacturer support is provided by L-3/Datron.

The general characteristics of the station are as follows:

a. Location: 64° 48′ 17″ N for more detail, see NDOSL "U4AS"
147° 30′ 15″ W

b. One 7.3-m antenna for simultaneously transmitting at S-band while receiving at S- and X-bands. Figure 6-4 is a photograph of the USAK04 antenna.

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: 1- & 2-way Doppler and antenna auto tracking angles.

e. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets, and mail.

f. Site Power: Commercial power. Uninterruptable Power Source (UPS) power to RF and baseband equipment only. Backup (500 KVA) Generator.

Figure 6-4. USAK04 Antenna (old photo)

6.4.1 USAK04 S-band Command

Table 6-8 identifies the S-band command characteristics of the USAK04 aperture.

6.4.2 USAK04 S-band Telemetry

Table 6-9 identifies the S-band telemetry characteristics of the USAK04 aperture.

Table 6-8. USAK04 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	58.4 dBW
Polarization	RHC or LHC
Antenna Beam-width	1.39 deg
Antenna Gain	42.1 dBi
Transmitter Output Power	20 dBW (SSPA)
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 Radians (peak) FM: 50 kHz – 50 MHz deviation BPSK: ±90 deg
Carrier Data Rate	100 bps – 1 Mbps
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	1 bps – 32 kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 6-9. USAK04 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	19.6 dB/K (clear sky & 5° elevation angle)
Polarization	RHC and LHC
Antenna Beam-width	1.25 deg
Antenna Gain	42.4 dBi
Carrier Modulation	PM, FM, BPSK, QPSK, or OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	100 bps – 20 Mbps
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	100 bps – 1 Mbps
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon

6.4.3 USAK04 X-band Telemetry

Table 6-10 identifies the X-band telemetry characteristics of the USAK04 aperture.

Table 6-10. USAK04 X-band Telemetry Characteristics

Characteristic	Value
Frequency	8000 – 8500 MHz
G/T	31.0 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beam-width	0.29 deg
Antenna Gain	54.2 dBi
Modulation	BPSK, QPSK, SQPSK or PM
Data Rate	10 Mbps – 150 Mbps
Data Format	NRZ-L or M
Decoding	Viterbi (R-½) and/or Reed-Solomon

6.4.4 USAK04 Tracking Services

6.4.4.1 USAK04 Doppler Tracking

The USAK04 generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the USAK04 S-band uplink signal with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 6-11.

Table 6-11. USAK04 UTDF Doppler Tracking Characteristics

Characteristic	Value
Counter Resolution	0.004 cycles
Doppler Frequency Shift	≤ 0.23 MHz
Doppler Bias Frequency	0.24 MHz
Drift (Δf/f)	4×10^{-11} at 0.1 sec
Accuracy	0.01 Hz
Output Equation	$1000 (f_{transmit} \times [240/221] – f_{received}) + f_{bias}$

6.4.4.2 USAK04 Antenna Autotracking Angle Data

The USAK04 records the angle of the ground antenna as it autotracks the user. This data is provided to the user as UTDF messages.

6.4.5 USAK04 Baseband Data Interfaces

The USAK04 can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12). USAK04 currently has a 768 Kbps TCP/IP communications link and 52 Mbps (clock and data) fiber communications link with GSFC to support command, telemetry, and ground station control and monitor. USAK04 will also mail high-rate, recorded X-band telemetry data to the user as required. Data is recorded on Universal Serial Bus (USB) Flash drives.

6.5 North Pole, Alaska, 11.0-m S- and X-band Antenna System, USAK05

This section describes the North Pole, Alaska, 11.0-m system referred to as USAK05. The antenna manufacturer support is provided by L-3/Datron.

The general characteristics of the station are as follows:

a. Location: 65° 7′ 4″ N
   147° 26′ 01″ W

b. One 11-m antenna for simultaneously transmitting at S-band while receiving at S- and X-band. Figure 6-5 is a photograph of the USAK05 antenna with the Radome installed. Figure 6-6 is a photograph of the USAK05 antenna before Radome installation.

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: 1- & 2-way Doppler and antenna auto tracking angles.

e. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets, and mail.

f. Site Power: Commercial power. UPS power to RF and baseband equipment only. No back-up power generator.

Figure 6-5. USAK05 Antenna Radome

Figure 6-6. USAK05 Antenna before Radome Installation

6.5.1 USAK05 S-band Command

Table 6-12 identifies the S-band command characteristics of the USAK05.

6.5.2 USAK05 S-band Telemetry

Table 6-13 identifies the S-band telemetry characteristics of the USAK05 aperture.

Table 6-12. USAK05 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	65.4 dBW
Polarization	RHC or LHC
Antenna Beam-width	0.92 deg
Antenna Gain	45.7 dBi
Output Power	23 dBW (SSPA)
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 Radians (peak) FM: 50 kHz – 50 MHz deviation BPSK: ±90 deg
Carrier Data Rate	100 bps – 1 Mbps
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	1 bps – 32 kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 6-13. USAK05 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2300 MHz
G/T with Radome	23.2 dB/K (clear sky & 5° elevation angle)
Polarization	RHC and LHC
Antenna Beam-width	0.85 deg
Antenna Gain	46.0 dBi
Carrier Modulation	PM, FM, BPSK, or QPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	100 bps – 36 Mbps
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	100 bps – 1 Mbps
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon

6.5.3 USAK05 X-band Telemetry

Table 6-14 identifies the X-band telemetry characteristics of the USAK05 aperture.

Table 6-14. USAK05 X-band Telemetry Characteristics

Characteristic	Value
Frequency	7000 – 9000 MHz Receive 8100 – 8400 MHz Autotrack
G/T with Radome	34.0 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beam-width	0.20 deg
Antenna Gain	56.86 dBi
Modulation	BPSK,QPSK,SQPSK or AQPSK
Data Rate	10 Mbps – 150 Mbps
Data Format	NRZ-L or M
Decoding	Viterbi (R-½) and/or Reed-Solomon

6.5.4 USAK05 Tracking Services

6.5.4.1 USAK05 Doppler Tracking

The USAK05 generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the USAK05 S-band uplink signal with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 6-15.

Table 6-15. USAK05 UTDF Doppler Tracking Characteristics

Characteristic	Value
Counter Resolution	0.004 cycles
Doppler Frequency Shift	≤ 0.23 MHz
Doppler Bias Frequency	0.24 MHz
Drift (Δf/f)	4×10^{-11} at 0.1 sec
Accuracy	0.01 Hz
Output Equation	$1000 (f_{transmit} \times [240/221] – f_{received}) + f_{bias}$

6.5.4.2 USAK05 Antenna Autotrack Angle Data

The USAK05 records the angle of the ground antenna as it autotracks the user. This data is provided to the user as UTDF messages.

6.5.5 USAK05 Baseband Data Interfaces

The USAK05 can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12). USAK05 currently has a 768 Kbps TCP/IP communications link and 52 Mbps (clock and data) fiber communications link with GSFC to support command, telemetry, and ground station control and monitor. USAK05 will also mail high-rate, recorded X-band telemetry data to the user as required. Data is recorded on USB Flash drives.

6.6 South Point, Hawaii, 13-m, S- and X-band Antenna System, USHI01

This section describes the South Point, Hawaii, 13-m system referred to as USHI01. The antenna manufacturer support is provided by L-3/Datron.

The general characteristics of the USHI01 aperture are as follows:

a. Location: 19° 00′ 50″ N
   155° 39′ 47″ W
b. 13-m antenna for simultaneously transmitting at S-band while receiving at S- and X-band. Figure 6-7 is a photograph of the USHI01 antenna.
c. High Power S-band uplink (2500-W Transmitter).
d. Manually scheduled by USN via NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.
e. Tracking services: 1- and 2-way Doppler, Ranging, and antenna auto tracking angles.
f. Baseband data interfaces: TCP/IP, 4800-bit blocks encapsulated in IP packets, and mail.
g. Site Power: Commercial power. UPS power to RF and baseband equipment only. 350-KW back-up power generator.

Figure 6-7. USHI01 Antenna

6.6.1 USHI01 S-band Command

Table 6-16 identifies the S-band command characteristics of the USHI01 aperture.

6.6.2 USHI01 S-band Telemetry

Table 6-17 identifies the S-band telemetry characteristics of the USHI01 aperture.

Table 6-16. USHI01 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	78 dBW
Polarization	RHC or LHC
Antenna Beam-width	0.78 deg
Antenna Gain	47.1 dBi
Transmitter Power	23 dBW
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 Radians (peak) BPSK: ±90 deg
Carrier Data Rate	10 bps – 10 Mbps
Subcarrier Frequency	≤ 5 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	32 bps – 1 Mbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 6-17. USHI01 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	23.5 dB/K (clear sky & 5° elevation angle)
Polarization	RHC and LHC
Antenna Beam-width	0.70 deg
Antenna Gain	48.0 dBi
Carrier Modulation	PM, FM, BPSK, QPSK, or OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	100 bps – 20 Mbps Uncoded
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	≤ 2 MHz
Subcarrier Demodulation	BPSK
Subcarrier Data Rate	10 bps – 256 bps
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi (Rate-1/2) and/or Reed-Solomon, Rate-½ Turbo

6.6.3 USHI01 X-band Telemetry

Table 6-18 identifies the X-band telemetry characteristics of the USHI01 aperture.

Table 6-18. USHI01 X-band Telemetry Characteristics

Characteristic	Value
Frequency	8000 – 8500 MHz
G/T	37.7 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beam-width	0.17 deg
Antenna Gain	59.1 dBi
Modulation	BPSK,QPSK,SQPSK or AQPSK
Data Rate	1 Mbps – 150 Mbps, Uncoded
Data Format	NRZ-L or M
Decoding	Viterbi (Rate-1/2) and/or Reed-Solomon

6.6.4 USHI01 Tracking Services

The USHI01 aperture can provide Doppler, Ranging, and Angular tracking measurements. The measurement message format can be delivered in the native USN format or in customer-defined formats such as UTDF format.

6.6.4.1 USHI01 Doppler Tracking

The USHI01 aperture can collect 1-way and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier.

6.6.4.2 USHI01 Ranging

The USHI01 aperture can collect 2-way ranging measurements. Ranging can be accomplished with either tone ranging or ESA code ranging. Cortex-NT or Cortex-XL equipment is used to collect these measurements.

6.6.4.3 USHI01 Antenna Autotrack Angle Data

The USHI01 aperture records the angle of the ground antenna as it autotracks.

6.6.5 USHI01 Baseband Data Interfaces

The USHI01 aperture sends and receives baseband data using the TCP/IP protocol. The NASA legacy standard of 4800 bit blocks is supported by encapsulating the blocks into TCP/IP frames.

The South Point site is supported by a 3-Mbps MPLS service for transporting the TCP/IP data to the USN NMCs in California and Pennsylvania.

NASA accesses the USHI01 ground station via the Restricted IONet interface between GSFC and the NMC in Horsham, Pennsylvania.

CCSDS Space Link Extension is available at this station.

Additional services are available at the USHI01 site as required. Services available in the area include open Internet and private line via copper media. Back-up communications services are available at the site via 128-Kbps Integrated Services Digital Network (ISDN) lines.

6.7 South Point, Hawaii, 13-m S- and X-band Antenna System, USHI02

This section describes the South Point, Hawaii, 13-m system referred to as USHI02. The antenna manufacturer support is provided by L-3/Datron.

The general characteristics of the USHI02 aperture are as follows:

a. Location: 19° 00′ 50″ N
   155° 39′ 47″ W
b. 13-m antenna for simultaneously transmitting at S-band while receiving at S- and X-band. Figure 6-8 is a photograph of the USHI02 antenna.
c. High Power X-band uplink (3000-W Transmitter). X-band transmit – or – X-band receive.
d. Manually scheduled by USN via NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.
e. Tracking services: 1- and 2-way Doppler, Ranging, and antenna auto tracking angles.
f. Baseband data interfaces: TCP/IP, 4800-bit blocks encapsulated in IP packets, and mail.
g. Site Power: Commercial power. UPS power to RF and baseband equipment only. 350-KW back-up power generator.

Figure 6-8. USHI02 Antenna

6.7.1 USHI02 S-band Command

Table 6-19 identifies the S-band command characteristics of the USHI02 aperture.

6.7.2 USHI02 X-band Command

Table 6-20 identifies the X-band command characteristics of the USHI02 aperture.

Table 6-19. USHI02 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	68 dBW
Polarization	RHC or LHC
Antenna Beam-width	0.78 deg
Antenna Gain	47.1 dBi
Transmitter Power	24.7 dBW SSPA
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 Radians (peak) BPSK: ±90 deg
Carrier Data Rate	10 bps – 10 Mbps
Subcarrier Frequency	≤ 5 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	32 bps – 1 Mbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 6-20. USHI02 X-band Command Characteristics

Characteristic	Value
Frequency	7025 – 7200 MHz
EIRP	86 dBW
Polarization	RHC or LHC
Antenna Beam-width	0.19 deg
Antenna Gain	57.8 dBi
Transmitter Power	34.8 dBW Klystron
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 radians (peak) BPSK: ±90 deg
Carrier Data Rate	10 bps – 32 Kbps
Subcarrier Frequency	≤ 1.2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	32 bps – 1 Mbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

6.7.3 USHI02 S-band Telemetry

Table 6-21 identifies the S-band telemetry characteristics of the USHI02 aperture.

Table 6-21. USHI02 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	23.5 dB/K (clear sky & 5° elevation angle)
Polarization	RHC and LHC
Antenna Beam-width	0.70 deg
Antenna Gain	48.0 dBi
Carrier Modulation	PM, FM, BPSK, QPSK, or OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	100 bps – 20 Mbps
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	10 bps – 256 bps
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi (Rate-1/2) and/or Reed-Solomon, Rate-½ Turbo

6.7.4 USHI02 X-band Telemetry

Table 6-22 identifies the X-band telemetry characteristics of the USHI02 aperture.

Table 6-22. USHI02 X-band Telemetry Characteristics

Characteristic	Value
Frequency	8000 – 8500 MHz
G/T	37.7 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beam-width	0.17 deg
Antenna Gain	59.1 dBi
Modulation	BPSK,QPSK,SQPSK or AQPSK
Data Rate	1 Mbps – 150 Mbps, Uncoded
Data Format	NRZ-L or M
Decoding	Viterbi (Rate-1/2)

6.7.5 USHI02 Tracking Services

The USHI02 aperture can provide Doppler, Ranging, and Angular tracking measurements. The measurement message format can be delivered in the native USN format or in customer-defined formats such as UTDF format.

6.7.5.1 USHI02 Doppler Tracking

The USHI02 aperture can collect 1-way and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier.

6.7.5.2 USHI02 Ranging

The USHI02 aperture can collect 2-way ranging measurements. Ranging can be accomplished with either tone ranging or ESA code ranging. Cortex-NT or Cortex-XL equipment is used to collect these measurements.

6.7.5.3 USHI02 Antenna Autotrack Angle Data

The USHI02 aperture records the angle of the ground antenna as it autotracks.

6.7.6 USHI02 Baseband Data Interfaces

The USHI02 aperture sends and receives baseband data using the TCP/IP protocol. The NASA legacy standard of 4800 bit blocks is supported by encapsulating the blocks into TCP/IP frames.

The South Point site is supported by a 3-Mbps MPLS service for transporting the TCP/IP data to the USN NMCs in California and Pennsylvania.

NASA accesses the USHI02 ground station via the Restricted IONet interface between GSFC and the NMC in Horsham, Pennsylvania.

CCSDS Space Link Extension is available at this station.

Additional services are available at the USHI02 site as required. Services available in the area include open Internet and private line via copper media. Back-up communications services are available at the site via 128-Kbps ISDN lines.

6.8 Dongara, Australia, 13-m S- and X-band Antenna System, AUWA01

This section describes the Dongara, Western Australia, 13-m system referred to as AUWA01. The antenna manufacturer support is provided by L-3/Datron.

The general characteristics of the AUWA01 aperture are as follows:

a. Location: 29° 02′ 44.780″ S NDOSL details TBD
115° 20′ 55.240″ E
b. 13-m antenna for simultaneously transmitting at S-band while receiving at S- and X-band. Figure 6-9 is a photograph of the AUWA01 antenna.
c. Manually scheduled by USN via NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.
d. Tracking services: 1- and 2-way Doppler, Ranging, and antenna auto tracking angles.
e. Baseband data interfaces: TCP/IP, 4800-bit blocks encapsulated in IP packets, and mail.
f. Site Power: Commercial power. UPS power to RF and baseband equipment only. 100-KW back-up power generator.

Figure 6-9. AUWA01 Antenna

6.8.1 AUWA01 S-band Command

Table 6-23 identifies the S-band command characteristics of the AUWA01 aperture.

6.8.2 AUWA01 S-band Telemetry

Table 6-24 identifies the S-band telemetry characteristics of the AUWA01 aperture.

Table 6-23. AUWA01 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	68 dBW
Polarization	RHC or LHC
Antenna Beam-width	0.78 deg
Antenna Gain	47.1 dBi
Transmitter Power	24.7 dBW SSPA
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 Radians (peak) BPSK: ±90 deg
Carrier Data Rate	10 bps – 10 Mbps
Subcarrier Frequency	≤ 5 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	32 bps – 1 Mbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 6-24. AUWA01 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	23.5 dB/K (clear sky & 5° elevation angle)
Polarization	RHC and LHC
Antenna Beam-width	0.70 deg
Antenna Gain	48.0 dBi
Carrier Modulation	PM, FM, BPSK, QPSK, or OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	100 bps – 20 Mbps Uncoded
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	≤ 2 MHz
Subcarrier Demodulation	BPSK
Subcarrier Data Rate	10 bps – 256 bps
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi (Rate-½) and/or Reed-Solomon, Rate-½ Turbo

6.8.3 AUWA01 X-band Telemetry

Table 6-25 identifies the X-band telemetry characteristics of the AUWA01 aperture.

Table 6-25. AUWA01 X-band Telemetry Characteristics

Characteristic	Value
Frequency	8000 – 8500 MHz
G/T	37.7 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beam-width	0.17 deg
Antenna Gain	59.1 dBi
Modulation	BPSK,QPSK,SQPSK or AQPSK
Data Rate	1 Mbps – 150 Mbps, Uncoded
Data Format	NRZ-L or M
Decoding	Viterbi (Rate-½)

6.8.4 AUWA01 Tracking Services

The AUWA01 aperture can provide Doppler, Ranging, and Angular tracking measurements. The measurement message format can be delivered in the native USN format or in customer-defined formats such as UTDF format.

6.8.4.1 AUWA01 Doppler Tracking

The AUWA01 aperture can collect 1-way and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier.

6.8.4.2 AUWA01 Ranging

The AUWA01 aperture can collect 2-way ranging measurements. Ranging can be accomplished with either tone ranging or ESA code ranging. Cortex-NT or Cortex-XL equipment is used to collect these measurements.

6.8.4.3 AUWA01 Antenna Autotrack Angle Data

The AUWA01 aperture records the angle of the ground antenna as it autotracks.

6.8.5 AUWA01 Baseband Data Interfaces

The AUWA01 aperture sends and receives baseband data using the TCP/IP protocol. The NASA legacy standard of 4800 bit blocks is supported by encapsulating the blocks into TCP/IP frames.

The Dongara site is supported by a 2-Mbps Virtual Private Network (VPN)/Internet service for transporting the TCP/IP data to the USN NMCs in Virginia and Pennsylvania.

NASA accesses the AUWA01 ground station via the Restricted IONet interface between GSFC and the NMC in Horsham, Pennsylvania.

CCSDS Space Link Extension is available at this station.

Additional services are available at the AUWA01 site as required. Services available in the area include open Internet and private line via copper or fiber media. Back-up communications services are available at the site via 128-Kbps ISDN lines.

6.9 Dongara, Australia, 7.3-m X-band Antenna System, AUWA02

This section describes the Dongara, Western Australia, 7.3-m system referred to as AUWA02. The antenna manufacturer support is provided by Viasat.

The general characteristics of the AUWA02 aperture are as follows:

a. Location: 29° 02′ 44.5″ S
   115° 20′ 56.5″ E

b. 7.3-m antenna X-band uplink only. Figure 6-10 is a photograph of the AUWA02 antenna.

c. Manually scheduled by USN via NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. High Power X-band uplink (3000-W Transmitter).

e. Program track or slaved to AUWA01 13-m for tracking satellites services:

f. Baseband data interfaces: TCP/IP, 4800-bit blocks encapsulated in IP packets.

g. Site Power: Commercial power. UPS power to RF and baseband equipment only. 100-KW back-up power generator.

Figure 6-10. AUWA02 (left) and AUWA01 (right) Antennas

6.9.1 AUWA02 X-band Command

Table 6-26 identifies the X-band command characteristics of the AUWA02 aperture.

Table 6-26. AUWA02 X-band Command Characteristics

Characteristic	Value
Frequency	7025 – 7200 MHz
EIRP	85 dBW
Polarization	RHC or LHC
Antenna Beam-width	0.34 deg
Antenna Gain	52.8 dBi
Transmitter Power	34.8 dBW Klystron
Carrier Modulation	PM, FM, or BPSK
Modulation Index	PM: 1.5 Radians (peak) BPSK: ±90 deg
Carrier Data Rate	10 bps – 10 Mbps
Subcarrier Frequency	≤ 5 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	1 Mbps – 150 Mbps Uncoded
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

6.9.2 AUWA02 Baseband Data Interfaces

The AUWA02 aperture sends and receives baseband data using the TCP/IP protocol. The NASA legacy standard of 4800 bit blocks is supported by encapsulating the blocks into TCP/IP frames.

The Dongara site is supported by a 2-Mbps VPN/Internet service for transporting the TCP/IP data to the USN NMCs in Virginia and Pennsylvania.

NASA accesses the AUWA02 ground station via the Restricted IONet interface between GSFC and the NMC in Horsham, Pennsylvania.

CCSDS Space Link Extension is available at this station.

Additional services are available at the AUWA02 site as required. Services available in the area include open Internet and private line via copper and fiber media. Back-up communications services are available at the site via 128-Kbps ISDN lines.

Section 7. Alaska Satellite Facility

7.1 General

This section describes the University of Alaska Ground Station in Fairbanks, Alaska. The station is operated by the University and consists of 3 NASA antenna systems. The NASA-owned systems at ASF include:

a. AS2 – (Section 7.2) additional information available at https://www.asf.alaska.edu/ground-station/antennas/

b. AS1 – (Section 7.3) additional information available at https://www.asf.alaska.edu/ground-station/antennas/

b. AS3 – (Section 7.4) additional information available at https://www.asf.alaska.edu/ground-station/antennas/

7.2 ASF 10-meter – AS2 (upgrade TBD)

The ASF 10-m antenna is currently not operational.

7.3 ASF 11.3-meter – AS1

This section describes the Alaska Satellite Facility 11.3-m system referred to as AS1.

The general characteristics of the system are as follows:

a. Location: 64º 51′ 31″ N for more detail see NDOSL, "ASFS"
147º 51′ 27″ W

b. The 11.3-m antenna for simultaneously transmitting at S-band while receiving at S- and X-band. Figure 7-1 is a photograph of the AS1 antenna.

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: 1- & 2-way Doppler and antenna auto tracking Angles.

e. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets.

Sections 7.3.1 through 7.3.3 describe S- and X-band performance characteristics. Sections 7.3.4 and 7.3.5 describe the tracking services and baseband data interfaces, respectively.

7.3.1 S-band Command

Table 7-1 identifies the S-band command characteristics of the AS1.

7.3.2 S-band Telemetry

Table 7-2 identifies the S-band telemetry characteristics of the AS1.

7.3.3 X-band Telemetry

Table 7-3 identifies the X-band telemetry characteristics of the AS1.

Figure 7-1. AS1 Antenna

Table 7-1. AS1 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 62.6 dBWi
Polarization	RHC or LHC
Antenna Beamwidth	0.95 deg
Antenna Gain	42.8 dBi
Output Power	300 W
Carrier Modulation	PM, FM, BPSK or QPSK
Modulation Index	PM: 0.01 – 2.5 Radians FM: 1 kHz – 50 kHz deviation BPSK: ±90 deg
Carrier Data Rate	1 kbps – 1 Mbps
Subcarrier Frequency	5 kHz- 2 MHz
Subcarrier Modulation	FSK and BPSK
Subcarrier Data Rate	100 bps – 250 kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Table 7-2. AS1 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	22 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.85 deg
Antenna Gain	45.8 dBi
Carrier Modulation	PM/PCM, FM/PCM, BPSK, or QPSK / OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate (High Rate Telemetry Channel)	1 Kbps – 10 Mbps (FM/PCM) 100 bps – 20 Mbps (PM/PCM, BPSK, OQPSK) 1 Kbps – 40 Mbps (QPSK) [≤ 20 Mbps per channel]
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S; DM-M or S; DBP-M or S; RNRZ
Subcarrier Frequency	5 kHz – 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	100 bps – 600 Kbps
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon (CCSDS Ver. 1 & 2, Ref Para 1.3 v)

Table 7-3. AS1 X-band Telemetry Characteristics

Characteristic	Value
Frequency	8025 – 8500 MHz
G/T	37.2 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.23 deg
Antenna Gain	56.8 dBi
Modulation	BPSK, QPSK, OQPSK, UQPSK, or 8PSK
Demodulator Data Rate	500 Kbps – 350 Mbps (QPSK, OQPSK) 250 Kbps – 150 Mbps (BPSK, UQPSK) 750 Kbps – 200 Mbps (8PSK)
Data Format	NRZ-L, M, S. Biϕ-L, M, S, DNRZ
Decoding	Derandomization, Viterbi (R-½) or Reed-Solomon, Rate 7/8 LDPC

7.3.4 Tracking Services

7.3.4.1 Doppler Tracking

AS1 generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the AS1 S-band uplink signal with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 7-4.

7.3.4.2 Antenna Autotrack Angle Data

The AS1 can record the angle of the ground antenna as it autotracks. This data is provided to the user as UTDF messages. (See Reference h in Section 1.3)

7.3.5 Baseband Data Interfaces

AS1 can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12). AS1 currently has a T-1 (1.544 Mbps) communications link with GSFC to support command, telemetry, and ground station control and monitor.

Table 7-4. AS1 Doppler Tracking Characteristics

Characteristic	Value
Counter Resolution	0.004 cycles
Doppler Frequency Shift	≤ 0.23 MHz
Doppler Bias Frequency	0.24 MHz
Drift (Δf/f)	4×10^{-11} at 0.1 sec
Accuracy	0.01 Hz
Output Equation	$1000 (f_{transmit} \times [240/221] – f_{received}) + f_{bias}$

7.4 ASF 11.0-meter – AS3

This section describes the Alaska Satellite Facility 11.0-m system referred to as AS3. The general characteristics of the system are as follows:

a. Location: 64º 51’ 32’’ N
   147º 51’ 15’’ W

b. The 11-m antenna for simultaneously transmitting at S-band while receiving at S- and X-band. Figure 7-2 is a photograph of the AS3 antenna.

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users’ Guide for Near Earth Network Scheduling*.

d. Tracking services: 1- & 2-way Doppler and antenna auto tracking Angles.

e. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets.

Sections 7.4.1 through 7.4.3 describe S- and X-band performance characteristics. Sections 7.4.4 and 7.4.5 describe the tracking services and baseband data interfaces, respectively.

Figure 7-2. New AS3 erected on new foundation at ASF (foreground) Existing AS1 (background)

7.4.1 S-band Command

Table 7-5 identifies the S-band command characteristics of the AS3.

Table 7-5. AS3 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 65.7 dBWi
Polarization	RHC or LHC
Antenna Beamwidth	0.95 deg
Antenna Gain	40.6 dBi
Output Power	330 W
Carrier Modulation	PM, FM, BPSK or QPSK
Modulation Index	PM: 0.01 – 2.5 Radians FM: 1 kHz – 50 kHz deviation BPSK: ±90 deg
Carrier Data Rate	1 kbps – 1 Mbps
Subcarrier Frequency	5 kHz- 2 MHz
Subcarrier Modulation	FSK and BPSK
Subcarrier Data Rate	100 bps – 250 kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

7.4.2 S-band Telemetry

Table 7-6 identifies the S-band telemetry characteristics of the AS3.

Table 7-6. AS3 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	22.9 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.85 deg
Antenna Gain	45.8 dBi
Carrier Modulation	PM/PCM, FM/PCM, BPSK, or QPSK / OQPSK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate (High Rate Telemetry Channel)	1 Kbps – 10 Mbps (FM/PCM) 100 bps – 20 Mbps (PM/PCM, BPSK, OQPSK) 1 Kbps – 40 Mbps (QPSK) [≤ 20 Mbps per channel]
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S; DM-M or S; DBP-M or S; RNRZ
Subcarrier Frequency	5 kHz – 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	100 bps – 600 Kbps
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon (CCSDS Ver. 1 & 2, Ref Para 1.3 v)

7.4.3 X-band Telemetry

Table 7-7 identifies the X-band telemetry characteristics of the AS3.

Table 7-7. AS3 X-band Telemetry Characteristics

Characteristic	Value
Frequency	8025 – 8500 MHz
G/T	36.2 dB/K (clear sky & 10° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.23 deg
Antenna Gain	56.8 dBi
Modulation	BPSK, QPSK, OQPSK, UQPSK, or 8PSK
Demodulator Data Rate	500 Kbps – 350 Mbps (QPSK, OQPSK) 250 Kbps – 150 Mbps (BPSK, UQPSK) 750 Kbps – 200 Mbps (8PSK)
Data Format	NRZ-L, M, S. Biϕ-L, M, S, DNRZ
Decoding	Derandomization, Viterbi (R-½) or Reed-Solomon, Rate 7/8 LDPC

7.4.4 Tracking Services

7.4.4.1 Doppler Tracking

AS3 generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the AS1 S-band uplink signal with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 7-8.

Table 7-8. AS3 Doppler Tracking Characteristics

Characteristic	Value
Counter Resolution	0.004 cycles
Doppler Frequency Shift	≤ 0.23 MHz
Doppler Bias Frequency	0.24 MHz
Drift (Δf/f)	4×10^{-11} at 0.1 sec
Accuracy	0.01 Hz
Output Equation	$1000 (f_{transmit} \times [240/221] – f_{received}) + f_{bias}$

7.4.4.2 Antenna Autotrack Angle Data

The AS3 can record the angle of the ground antenna as it autotracks. This data is provided to the user as UTDF messages. (See Reference h in Section 1.3)

7.4.5 Baseband Data Interfaces

AS3 can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets (see Section 12). AS3 currently has a T-1 (1.544 Mbps) communications link with GSFC to support command, telemetry, and ground station control and monitor.

Section 8. Florida Launch Communications Stations (LCS)

[Note: The Florida Launch Communications Stations are a future capability of the NEN. Service from these stations is not expected to be available until the year 2017.]

8.1 General

This section describes the two NEN LCS in Florida.

8.2 Kennedy Uplink Station, KUS

This section describes KUS, located at the Environment Health Facility at Kennedy Space Center on the east coast of Florida. KUS is one of the Near Earth Network's LCS, put in place to support human spaceflight launches from Cape Canaveral.

The general characteristics of the station are as follows:

a. Location: 28° 32' 34.26" N
80° 38' 37.16" W

b. One 6.1-meter antenna capable of simultaneously transmitting and receiving at S-band. Figure 8-1 is a photograph of the KUS Ground Station.

c. Automatically scheduled by the NEN schedulers at White Sands Complex using Near Earth Network Scheduling System.

d. Tracking services: Antenna autotracking angles.

Note: Doppler and Ranging capabilities could be made available if required.

e. Baseband data interfaces: IP (CCSDS SLE)

f. Best Frame Select Capability

Sections 8.2.1 and 8.2.2 describe the S-band performance characteristics. Sections 8.2.3, 8.2.4, and 8.2.5 describe the tracking services, baseband data interfaces, and best frame select capability, respectively.

Figure 8-1. Kennedy Uplink Station

Table 8-1 identifies the S-band command characteristics of KUS.

Table 8-1. KUS S-Band Command Characteristics

Characteristic	Value
Frequency	2025-2120 MHz
EIRP	56 dBWI
Polarization	RHC or LHC
Antenna Beamwidth	1.7° (TBR)
Antenna Gain	39 dBi (TBR)
HPA	200 W
Carrier Modulation	PM, FM BPSK, QPSK, OQPSK/SQPSK, AQPSK, GMSK, SS-UQPSK [MPCV]
Modulation Index	PM: 1 – 2.5 radians FM: 0 to +/- 5 MHz
Carrier Data Rate	7 bps to 10 kbps (Low Bandwidth Command Mode) 100 bps to 600 kbps (High Bandwidth Subcarrier Command Mode) 100 bps to 1 Mbps (High Bandwidth PCM Command Mode)
Carrier Data Format	NRZ: L,M,S BiΦ: L, M, S R-NRZ
Subcarrier Frequency	40 Hz to 100 kHz (Low Bandwidth Command Mode) 5 kHz to 2 MHz (High Bandwidth Subcarrier Command Mode)
Subcarrier Modulation	BPSK (with PCM/PM or PCM/FM as carrier modulation)

Characteristic	Value
Subcarrier Data Rate	7 bps to 10 kbps (Low Rate Command Mode) 100 bps to 600 kbps (High Rate Command Mode)
Subcarrier Data Format	NRZ: L,M,S BiΦ: L, M, S R-NRZ
Coding	Convolutional ½, LDPC ½ [MPCV]

8.2.1 S-Band Telemetry

Table 8-2 identifies the S-band telemetry characteristics of KUS.

Table 8-2. KUS S-Band Telemetry Characteristics

Characteristic	Value
Frequency	2200-2400 MHz
G/T	14.1 dB/K (clear sky and 5 degrees elevation angle; including pointing loss and random loss)
Polarization [1]	RHC or LHC Diversity combination of RHCP/LHCP (pre/post detection)
Antenna Gain	TBD
Antenna Beamwidth (3-dB)	TBD
Carrier Demodulation	PCM/PM, PCM/FM BPSK, QPSK, OQPSK/SQPSK [SLS], AQPSK, GMSK, SQPN [MPCV]
PM Modulation Index	0 to 2.5 radians
FM Deviation	0 MHz to +/- 500 kHz
Carrier Information Rate	100 bps to 40 Mbps **Modulation and coding dependent*
Carrier Line Coding	NRZ: L,M,S BiΦ: L, M, S DBP: M, S DM: M, S R-NRZ V35
Subcarrier Frequency	40 Hz to 128 kHz (Low Bandwidth Telemetry Mode) 5 kHz to 2 MHz (High Bandwidth Telemetry Mode)

[1] Post Detection Diversity Combining is available for the following modulations schemes: Video Mode (PM), PCM Mode (PCM/PM, PCM/BPSK, PCM/QPSK, or PCM/OQPSK). Pre Detection Diversity Combining is available for the following modulations schemes: Video Mode (PM, FM, Coherent/Non-Coherent FM), PCM Mode (PCM/PM, PCM/BPSK, PCM/QPSK, or PCM/OQPSK).

Characteristic	Value
Subcarrier Demodulation	BPSK (with PCM/PM or PCM/FM as carrier modulation)
Subcarrier Information Rate	7 bps to 25 kbps (Low Bandwidth Telemetry Mode) 100 bps to 600 kbps (High Bandwidth Telemetry Mode) **Modulation and coding dependent*
Subcarrier Line Coding	NRZ: L,M,S (Low or High Bandwidth Telemetry Mode) BiΦ: L, M, S (Low or High Bandwidth Telemetry Mode) DBP: M, S (High Bandwidth Telemetry Mode) DM: M, S (High Bandwidth Telemetry Mode) R-NRZ (High Bandwidth Telemetry Mode)
Decoding	Viterbi ½ Reed-Solomon (255, 223) i = 1 to 5 Concatenated (Reed-Solomon/Convolutional) LDPC ½ [MPCV] LDPC 7/8, (8160, 7136) [SLS] Turbo Code 1/2

8.2.2 Tracking Services

8.2.2.1 Antenna Autoracking Angle Data

KUS can record the angle of the ground antenna as it autotracks the user. This data is provided to the FDF as Universal Tracking Data Format (UTDF) files or CCSDS Tracking Data Messages (TDM) [TBR]. See Table 4-1 of the *Tracking and Acquisition Data Handbook for the Ground Network*, 453-HDBK-GN.

8.2.3 Baseband Data Interfaces

KUS can send and receive baseband data in IP formats. Real-time data and commands are transferred using the CCSDS Space Link Extension (SLE) format. Post-pass playbacks will be made available for post-support retrieval using the SLE offline mode. The SLE services well adhere to the following CCSDS Blue and Orange books; CCSDS 910.4-B-2 SLE, CCDSD 911.1-B-3 RAF, CCSDS 911.2-B-2 RCF, CCSDS 912.11-O-1 EFCLTU, and CCSDS 912.1-B-3 FCLTU. KUS has a fiber connection with the CD&SC to support uplink and telemetry.

8.2.4 Best Frame Select Capability

KUS has been equipped with a Best Frame Select Capability, which in conjunction with the PDL and BDA stations can mitigate frame errors generated by plume effects (e.g., attenuation and diffraction model fades and scintillation), multipath, antenna pointing errors, and Radio Frequency Interference. The Best Frame Select Capability provides the launch customer with a complete set of Virtual Channel data received by all of the connect ground stations (i.e., KUS, PDL, and BDA).

8.3 PDL

This section describes the PDL ground station in Florida. PDL serves as a wing site to KUS, providing an off-axis view of a launch vehicle to avoid potential solid rocket motor plume induced communications outages at KUS. KUS and PDL have favorable look angles to launch complex 39A and B and the Shuttle Landing Facility. Analyses of look angles to other launch complexes are ongoing.

a. The general characteristics of the station are as follows:

   Location: 29° 4' 0" N 80° 54' 47" W

b. One 6.1-meter antenna capable of simultaneously transmitting and receiving at S-band. Figure 8-2 is a photograph of the PDL Ground Station.

c. Automatically scheduled by the NEN schedulers at White Sands Complex using WOTIS.

d. Tracking services: Antenna autotracking angles. Note: Doppler and Ranging capabilities could be made available if required.

e. Baseband data interfaces: IP (CCSDS SLE).

f. Best Frame Select Capability

Sections 8.3.1 and 8.3.2 describe the S-band performance characteristics. Sections 8.3.3, 8.3.4, and 8.3.5 describe the tracking services, baseband data interfaces, and best frame select capability, respectively.

Figure 8-2. PDL Ground Station

8.3.1 S-band Command

Table 8-3 identifies the S-band command characteristics of PDL.

Table 8-3. PDL S-band Command Characteristics

Characteristic	Value
Frequency	2025-2120 MHz
EIRP	56 dBWI
Polarization	RHC or LHC
Antenna Beamwidth	1.7º (TBR)
Antenna Gain	39 dBi (TBR)
HPA	200 W
Carrier Modulation	PM, FM BPSK, QPSK, OQPSK/SQPSK, AQPSK, GMSK, SS-UQPSK [MPCV]
Modulation Index	PM: 1 – 2.5 radians FM: 0 to +/- 5 MHz
Carrier Data Rate	7 bps to 10 kbps (Low Bandwidth Command Mode) 100 bps to 600 kbps (High Bandwidth Subcarrier Command Mode) 100 bps to 1 Mbps (High Bandwidth PCM Command Mode)
Carrier Data Format	NRZ: L,M,S BiΦ: L, M, S R-NRZ
Subcarrier Frequency	40 Hz to 100 kHz (Low Bandwidth Command Mode) 5 kHz to 2 MHz (High Bandwidth Subcarrier Command Mode)
Subcarrier Modulation	BPSK (with PCM/PM or PCM/FM as carrier modulation)
Subcarrier Data Rate	7 bps to 10 kbps (Low Rate Command Mode) 100 bps to 600 kbps (High Rate Command Mode)
Subcarrier Data Format	NRZ: L,M,S BiΦ: L, M, S R-NRZ
Coding	Convolutional ½, LDPC ½ [MPCV]

8.3.2 S-band Telemetry

Table 8-4 identifies the S-band telemetry characteristics of PDL.

Table 8-4. PDL S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200-2400 MHz
G/T	14.1 dB/K (clear sky and 5 degrees elevation angle; including pointing loss and random loss)
Polarization [2]	RHC or LHC Diversity combination of RHCP/LHCP (pre/post detection)
Antenna Gain	TBD
Antenna Beamwidth (3-dB)	TBD
Carrier Demodulation	PCM/PM, PCM/FM BPSK, QPSK, OQPSK/SQPSK [SLS], AQPSK, GMSK, SQPN [MPCV]
PM Modulation Index	0 to 2.5 radians
FM Deviation	0 MHz to +/- 500 kHz
Carrier Information Rate	100 bps to 40 Mbps *Modulation and coding dependent*
Carrier Line Coding	NRZ: L,M,S BiΦ: L, M, S DBP: M, S DM: M, S R-NRZ V35
Subcarrier Frequency	40 Hz to 128 kHz (Low Bandwidth Telemetry Mode) 5 kHz to 2 MHz (High Bandwidth Telemetry Mode)
Subcarrier Demodulation	BPSK (with PCM/PM or PCM/FM as carrier modulation)
Subcarrier Information Rate	7 bps to 25 kbps (Low Bandwidth Telemetry Mode) 100 bps to 600 kbps (High Bandwidth Telemetry Mode) *Modulation and coding dependent*
Subcarrier Line Coding	NRZ: L,M,S (Low or High Bandwidth Telemetry Mode) BiΦ: L, M, S (Low or High Bandwidth Telemetry Mode) DBP: M, S (High Bandwidth Telemetry Mode) DM: M, S (High Bandwidth Telemetry Mode) R-NRZ (High Bandwidth Telemetry Mode)
Decoding	Viterbi ½

[2] Post Detection Diversity Combining is available for the following modulations schemes: Video Mode (PM), PCM Mode (PCM/PM, PCM/BPSK, PCM/QPSK, or PCM/OQPSK). Pre Detection Diversity Combining is available for the following modulations schemes: Video Mode (PM, FM, Coherent/Non-Coherent FM), PCM Mode (PCM/PM, PCM/BPSK, PCM/QPSK, or PCM/OQPSK).

Characteristic	Value
	Reed-Solomon (255, 223) i = 1 to 5 Concatenated (Reed-Solomon/Convolutional) LDPC ½ [MPCV] LDPC 7/8, (8160, 7136) [SLS] Turbo Code 1/2

8.3.3 Tracking Services

8.3.3.1 Antenna Autotracking Angle Data

PDL can record the angle of the ground antenna as it autotracks the user. This data is provided to the FDF as Universal Tracking Data Format (UTDF) files or CCSDS Tracking Data Messages (TDM) [TBR]. See Table 4-1 of the *Tracking and Acquisition Data Handbook for the Ground Network*, 453-HDBK-GN.

8.3.4 Baseband Data Interfaces

PDL can send and receive baseband data in IP formats. Real-time data and commands are transferred using the CCSDS SLE format. Post-pass playbacks will be made available for post-support retrieval using the SLE offline mode. The SLE services well adhere to the following CCSDS Blue and Orange books; CCSDS 910.4-B-2 SLE, CCDSD 911.1-B-3 RAF, CCSDS 911.2-B-2 RCF, CCSDS 912.11-O-1 EFCLTU, and CCSDS 912.1-B-3 FCLTU. PDL has a CSO connection with the CD&SC to support uplink and telemetry.

8.3.5 Best Frame Select Capability

PDL has been equipped with a Best Frame Select Capability, which in conjunction with the KUS and BDA stations can mitigate frame errors generated by plume effects (e.g., attenuation and diffraction model fades and scintillation), multipath, antenna pointing errors, and Radio Frequency Interference. The Best Frame Select Capability provides the launch customer with a complete set of Virtual Channel data received by all of the connect ground stations (i.e., PDL, KUS, and BDA).

Section 9. White Sands Complex Ground Stations

9.1 General

This section describes the Ground Stations located at WSC, White Sands, New Mexico. The stations available at WSC include the 18-m system referred to as WS1, and the VHF A/G stations used for International Space Station support.

9.2 WS1

WS1 is an 18-m S/Ka-band satellite ground station located at the White Sands Complex. The Lunar Reconnaissance Orbiter (LRO) is the primary mission supported by WS1. LRO's primary objective is Lunar mapping and scientific investigation in support of future human exploration of the Moon. WS1 is S-band multi-mission capable, with supports limited between LRO views or when the Moon is not in view until after the LRO mission is complete.

The general characteristics of the station are as follows:

a. Location: 32 º 32′ 27″ N
   106 º 36′ 44″ W (see NDOSL "WS1S" for details)

b. 18.3-m azimuth/elevation antenna for simultaneously transmitting at S-band while receiving at S- and Ka-bands. Figure 9-1 is a photograph of the WS1 antenna.

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: 1 & 2-way Doppler, Range, and antenna auto tracking angles.
   (Note: Ka is non-coherent).

e. Baseband data interfaces: IP (Small Explorer/LEO-T and Internet Protocol Data Unit [IPDU]).

f. WS1 is a dual axis (azimuth/elevation) antenna with a maximum axis velocity of 2 degrees per second. Due to the rate limitation, the antenna will lag the spacecraft in azimuth at high antenna elevations. The actual elevation at which this drive limitation keyhole will impact support is dependent on the spacecraft altitude. (For most near earth orbiting satellites this will be above 75 degrees).

g. There is also an RF interference keyhole around 180 degrees azimuth on the horizon due to the White Sands Ground Terminal SN Multiple Access Calibration which radiates at 2287.5 MHz. This will impact supports from 2280 MHz to 2295 MHz. The size on this radio frequency interface Keyhole varies with the spacecraft depending on downlink frequency; spacecraft (S/C) transmit power and S/C modulation type. Tests will be performed to determine potential impact for each new S/C. Generally, a spacecraft at 2280 MHz will encounter impacting interference within 10 degrees of south; at 2287.5 MHz, this could increase to 40 degrees.

Sections 9.2.1 through 9.2.3 describe WS1 S-band and Ka-band performance characteristics. Sections 9.2.4 and 9.2.5 describe WS1 tracking services and baseband data interfaces, respectively.

Figure 9-1. WS1 Antenna

9.2.1 WS1 S-band Command

Table 9-1 identifies the S-band command characteristics of the WS1.

9.2.2 WS1 S-band Telemetry

Table 9-2 identifies the S-band telemetry characteristics of the WS1.

Table 9-1. WS1 S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	81 dBW (with 2 KW HPA) 72 dBW (with 300 Watts SSPA)
Polarization	RHC or LHC
Antenna Beamwidth	0.56 Deg.
Antenna Gain	49 dBi
Output Power	Redundant 300 and 2000 Watts
Carrier Modulation	PCM Encoding FM or PM[1] FSK, BPSK[2] CCDS Recommendations
Modulation Index	FM: 50 kHz – 50 MHz deviation PM: 0.1 – 2.5 Radians BPSK: ±90 deg
Carrier Data Rate	100 bps – 1 Mbps
Subcarrier Frequency	5 kHz – 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	100 bps – 250 kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S

Notes:

1. IF Modulation
2. Modulation at baseband

Table 9-2. WS1 S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2300 MHz
G/T	29.6 dB/K (minimum at 5° elevation, clear sky)
Polarization	RHC or LHC
Antenna Beamwidth	0.5 deg
Antenna Gain	50 dBi
Carrier Modulation	PM, FM, BPSK, or QPSK/OQSPK
Modulation Index	PM: 0.2 – 2.8 Radians (peak)
Carrier Data Rate	100 bps – 20 Mbps (up to 40 Mbps for QPSK demodulation + Viterbi decoding, up to 10 Mbps in the case of Bi-phase decoding)
Carrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Subcarrier Frequency	5 kHz – 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	100 bps to 256 kbps (128 kbps max if Bi-Phase)
Subcarrier Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon (CCSDS Ver. 1 & 2)

9.2.3 WS1 Ka-band Telemetry

Table 9-3 identifies the Ka-band telemetry characteristics of the WS1.

Table 9-3. WS1 Ka-band Telemetry Characteristics

Characteristic	Value
Frequency	25.5 – 27 GHz
G/T	46.0 dB/K (data ch. At 10° elevation, clear sky)
Polarization	RHC or LHC
Antenna Beamwidth	0.04 deg
Antenna Gain	70.5 dBi
Demodulation	PSK, BPSK, QPSK, SQPSK, AQPSK, AUQPSK, AUSQPSK
Data Rate	1 GS/s Max sample rate 470 Mbps
Data Format	NRZ-L, M, S, DNRZ
Decoding	Reed-Solomon Viterbi decoding (½, ¼) 4D-TCM

9.2.4 WS1 Tracking Services

9.2.4.1 WS1 Doppler Tracking

The WS1 generates both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the WS1 S-band uplink signal with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 9-4.

Table 9-4. WS1 Doppler Tracking Characteristics

Characteristic	Value
Counter Resolution	0.001 cycles
Doppler Frequency Shift	≤ 0.25 MHz
Doppler Bias Frequency (fbias)	.240 MHz
Drift (Δf/f)	5×10^{-11} at 1 day
Accuracy	Function of CNR, IF Receiver PLL BW & Reference Clock Accuracy Typical: 0.0017 Hz @ 30 Hz PLL BW, 65 dB-Hz 0.0051 Hz @ 100 Hz PLL BW, 65 dB-Hz 0.046 Hz @ 300 Hz PLL BW, 65 dB-Hz
Output Equation	$(f_{transmit} \times [240/221] - f_{received}) + f_{bias}$
Auto Track Threshold	-87 dB

9.2.4.2 WS1 Antenna Autotracking Angle Data

The WS1 can record the angle of the ground antenna as it autotracks the user. This data is provided to the user as UTDF messages. (See Reference h in Section 1.3).

Acquisition data types supported by WS1 are Two Line Elements, Improved Inter-Range Vector, and Internet Product Version 2 (INPV2).

9.2.4.3 Range Tracking

Range tracking characteristics are shown in Table 9-5.

Table 9-5. WS1 Range Tracking Characteristics

Characteristic	Value
Modulation	PM, FM
Supported standards	ESA Standard, ESA Like Standard (includes USB) ESA Code Continuos Tone Standard
Major Tone	500 KHz 100 KHz (Tone Ranging) or 450 KHz (Code Ranging)
Minor Tones	Minor tones are each a programmable ratio of the major tone. Up to 6 minor tones for ESA standard or up To 8 minor tones for ESA like standard. ESA code and continuous tone standards do not use minor tones.
Modulation Index	0.1 – 2.5 Radians
Resolution	1 NS, ≈ 0.3 Meters

9.2.5 WS1 Baseband Data Interfaces

The WS1 sends and receives baseband data IP formats. Post-pass playbacks are via Secure Copy Protocol (SCP) or Secure File Transfer Protocol (SFTP).

9.3 VHF A/G Stations at WSC

The two VHF A/G Ground Stations at WSC are used only to support the International Space Station and Soyuz spacecraft. The VHF-1 and VHF-2 systems can transmit and receive voice only. The general characteristics of the two VHF A/G Ground Stations at WSC are as follows:

a. Location: 32° 30' N
106° 37'W

b. Quad Yagi antenna (VHF-1) and Quad Yagi (VHF-2) for simultaneously transmitting voice at VHF while receiving voice at VHF.

c. Manual scheduling, but only JSC-MCC is allowed to request support.

d. Tracking services: None.

e. Baseband interfaces: Dedicated NISN communications voice loops.

Sections 9.3.1 and 9.3.2 describe the VHF-1 and VHF-2 A/G characteristics, respectively. Section 9.4 describes the baseband interfaces.

9.3.1 VHF-1 A/G Ground Station

Tables 9-6 and 9-7 identify the A/G Full Duplex uplink and downlink characteristics of the WSC VHF-1 Ground Station, respectively.

Table 9-6. WSC VHF-1 A/G Uplink Characteristics

Characteristic	Value
Frequency	139.208 MHz
EIRP	43.4 dBWi
Polarization	RHC
Antenna Beamwidth	20 deg
Antenna Gain	18.0 dBi
Output Power	350 W
Carrier Modulation	FM
FM Deviation	± 10 kHz
Carrier Data Rate	N/A (Voice only on the uplink)

Table 9-7. WSC VHF-1 A/G Downlink Characteristics

Characteristic	Value
Frequency	143.625 MHz
G/T	N/A
Polarization	RHC
Antenna Beamwidth	20 deg
Antenna Gain	18.0 dBi
Carrier Modulation	FM
FM Deviation	± 10 kHz
Carrier Data Rate	N/A (Voice only on downlink)

9.3.2 VHF-2 A/G Voice Ground Station

Tables 9-8 and 9-9 identify the A/G Full Duplex voice uplink and downlink characteristics of the WSC VHF-2 Ground Station, respectively.

Table 9-8. WSC VHF-2 A/G Uplink Characteristics

Characteristic	Value
Frequency	130.167 MHz
EIRP	37.4 dBWi
Polarization	RHC
Antenna Beamwidth	20 deg
Antenna Gain	12.0 dBi
Output Power	350 W
Carrier Modulation	FM
FM Deviation	± 10 kHz
Carrier Data Rate	N/A (Voice only)

Table 9-9. WSC VHF-2 A/G Downlink Characteristics

Characteristic	Value
Frequency	121.750 MHz
G/T	N/A
Polarization	RHC
Antenna Beamwidth	20 deg
Antenna Gain	12.0 dBi
Carrier Modulation	FM
FM Deviation	± 10 kHz
Carrier Data Rate	N/A (Voice only)

9.4 Baseband Voice Interfaces

The WSC VHF-1 and VHF-2 ground stations can send and receive baseband voice from only the JSC-MCC via dedicated NISN communications voice loops.

Section 10. Santiago Satellite Station

10.1 General

This section describes the Santiago, Chile Satellite Station, fully owned and operated by SSC Chile S.A., a part of the SSC Group. The following URL can be used to link to further information regarding the Swedish Space Corporation's assets: http://www.sscspace.com/ssc-chile. Future developments may include the station at Punto Arenas, Chile.

10.2 AGO 9-meter

The general characteristics of the 9-m ground station at AGO are as follows:

a. Location: 33º 09′ 04″ S
70º 39 ′59″ W
733 meters above seas level (MASL)

b. One 9-m antenna for simultaneously transmitting at S-band while receiving at S-band. Figure 10-1 is a photograph of the 9-m antenna.

c. Routine supports are automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Real-time tracking services include: 1- & 2-way Doppler, Ranging, and antenna autotracking angles.

e. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets.

Sections 10.5 and 10.6 describe S-band performance characteristics. Sections 10.7.1 and 10.7.2 describe the tracking services and baseband data interfaces, respectively.

10.3 AGO 12-meter

The general characteristics of the 12-m ground station at AGO are as follows:

a. Location: 33º 09′ 05′ S
70º 40′ 05′ W
731 MASL

b. One 12-m antenna for simultaneously transmitting at S-band while receiving at S-band. Figure 10-2 is a photograph of the 12-m ground station. (New feed allowing uplink installed and being tested.)

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets.

Sections 10.5 and 10.6 describe S-band performance characteristics. Sections 10.7.1 and 10.7.2 describe the tracking services and baseband data interfaces, respectively.

Figure 10-1. AGO 9-m S-band Antenna

Figure 10-2. AGO 12-m S-band Antenna

10.4 AGO 13-meter

The general characteristics of the 13-m ground station at AGO are as follows:

a. Location: 33º 08′ 54′ S

70º 40′ 03″ W

732 MASL

b. One 13-m antenna for simultaneously transmitting at S-band while receiving at S-band. Figure 10-3 is a photograph of the 13-m antenna.

c. Routine supports are automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Real-time tracking services include 1- & 2-way Doppler, Ranging, and antenna autotracking angles.

e. Baseband data interfaces: IP, serial clock and data, 4800-bit blocks encapsulated in IP packets.

Optional X-band receiving upgrade and/or optional Ku-band transmit/receive upgrades are possible, while maintaining S-band capability.

Sections 10.5 and 10.6 describe S-band performance characteristics. Sections 10.7.1 and 10.7.2 describe the tracking services and baseband data interfaces, respectively.

Figure 10-3. AGO 13-m S-band Antenna

10.5 AGO S-band Command

Table 10-1 identifies the S-band command characteristics of the AGO 9-m antenna.

Table 10-2 identifies the S-band command characteristics of the AGO 12-m antenna.

Table 10-3 identifies the S-band command characteristics of the AGO 13-m antenna.

Table 10-1. AGO 9-m S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	75 dBW
Polarization	RHC or LHC
Antenna Beamwidth	1.12 deg
Antenna Gain	43.8 dBi
Output Power	2 kWatts
Carrier Modulation	FSK, BPSK, BPSK+AM, BPSK Square (Low BW) BPSK, Direct PCM (Intermediate & High BW)
Modulation Index	PM: 3.0 Radians (peak) BPSK
Carrier Data Rate	10 – 10,000 bps (Low BW) 100 bps – 1 Mbps (Intermediate & High BW)
Subcarrier Frequency	5 kHz – 2 MHz (Intermediate & High BW)
Subcarrier Modulation	PCM (Intermediate & High BW)
Subcarrier Data Rate	100 bps – 250 kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Note: The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

Table 10-2. AGO 12-m S-band Command Characteristics

Characteristic	Value
Frequency	2025-2120 MHz
EIRP	67.5 dBW
Polarization	RHCP or LHCP
Antenna Beamwidth	0.75 deg
Antenna Gain	46.5 dBi
Output Power	200 W
Carrier Modulation	FM, PM, BPSK, QPSK, OQPSK, AQPSK
Modulation Index	0 to 2.5 rad
Carrier Data Rate	100 bps to 1 Mbps
Subcarrier Frequency	5 kHz to 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	100 bps – 250 kbps
Data Format	NRZ-L, M, or S; or Bi□-L, M, or S

Note:

The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.

Table 10-3. AGO 13-m S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	70 dBW
Polarization	RHC or LHC
Antenna Beamwidth	0.75 deg
Antenna Gain	46 dBi
Output Power	400 W
Carrier Modulation	FSK, BPSK, BPSK+AM, BPSK Square (Low BW) BPSK, Direct PCM (Intermediate & High BW)
Modulation Index	PM: 2.5 Radians (peak) BPSK
Carrier Data Rate	10 bps – 10,000 bps (Low BW) 100 bps – 1 Mbps (Direct PCM on Carrier; Intermediate & High BW)
Subcarrier Frequency	5 kHz to 2 MHz (Intermediate & High BW)
Subcarrier Modulation	PCM (Intermediate & High BW)
Subcarrier Data Rate	100 bps to 250 kbps
Data Format	NRZ-L, M, or S; or Biϕ-L, M, or S
Note: The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

10.6 AGO S-band Telemetry

Table 10-4 identifies the S-band telemetry characteristics of the AGO 9-m antenna.

Table 10-5 identifies the S-band telemetry characteristics of the AGO 12-m antenna.

Table 10-6 identifies the S-band telemetry characteristics of the AGO 13-m antenna.

Table 10-4. AGO 9-m S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2300 MHz
G/T	23.6 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	1.0 deg
Antenna Gain	44.0 dBi
Carrier Modulation	BPSK, QPSK, OQPSK, PM/NRZ
Modulation Index	PM: 0.2 – 1.4 Radians (peak)
Carrier Data Rate	2 kbps – 10 Mbps (High BW Telemetry)
Carrier Data Format	NRZ-L, M, or S; Biϕ-L, M, or S; DM-M or S; M2M, RZ, and PN Randomized
Subcarrier Frequency	40 Hz – 128 kHz (Low BW) 5 kHz – 2 MHz (Intermediate & High BW)
Subcarrier Modulation	BPSK, PM/PCM
Subcarrier Data Rate	10 bps– 25 kbps, (NRZ) for 40 Hz-128 kHz 1 kbps – 250 Kbps for 5kHz – 2 MHz 1 kbps – 256 kbps (up to 128 kbps w/ Biϕ-L) for 5kHz – 2 MHz 1 kbps – 600 kbps (up to 300 kbps w/ Biϕ-L) for 5kHz – 2 MHz 1 kbps – 5 Mbps PM/PCM for 5kHz – 2 MHz
Subcarrier Data Format	NRZ-L, M, or S; Biϕ-L, M, or S; DM-M or S; M2M, RZ, and PN Randomized
Decoding	Viterbi and/or Reed-Solomon (CCSDS)

Note:

The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.

Table 10-5. AGO 12-m S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2300 MHz
G/T	25.7 dB/K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.75 deg
Antenna Gain	46.5 dBi
Carrier Modulation	BPSK, QPSK, OQPSK, PM/NRZ
Modulation Index	PM: 0.2 – 1.4 Radians (peak)
Carrier Data Rate	2 kbps – 10 Mbps (High BW Telemetry)
Carrier Data Format	NRZ-L, M, or S; Biϕ-L, M, or S; DM-M or S; M2M, RZ, and PN Randomized
Subcarrier Frequency	40 Hz – 128 kHz (Low BW) 5 kHz – 2 MHz (Intermediate & High BW)
Subcarrier Modulation	BPSK, PCM/PM
Subcarrier Data Rate	10 bps– 25 kbps, (NRZ) for 40 Hz-128 kHz 1 kbps – 250 Kbps for 5kHz – 2 MHz 1 kbps – 256 kbps (up to 128 kbps w/ Biϕ-L) for 5kHz – 2 MHz 1 kbps – 600 kbps (up to 300 kbps w/ Biϕ-L) for 5kHz – 2 MHz 1 kbps – 5 Mbps PM/PCM for 5kHz – 2 MHz
Subcarrier Data Format	NRZ-L, M, or S; Biϕ-L, M, or S; DM-M or S; M2M, RZ, and PN Randomized
Decoding	Viterbi and/or Reed-Solomon (CCSDS)

Note:

The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.

Table 10-6. AGO 13-m S-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2300 MHz
G/T	24.4 dB/deg K (clear sky & 5° elevation angle)
Polarization	RHC or LHC
Antenna Beamwidth	0.69 deg
Antenna Gain	47 dBi
Carrier Modulation	PCM/PM, BPSK, QPSK, OQPSK, SOQPSK, AQPSK, PCM/FM
Modulation Index	PM: 0.2 – 1.4 Radians (peak)
Carrier Data Rate	2 kbps – 10 Mbps (High BW Telemetry)
Carrier Data Format	NRZ-L, M, or S; Biϕ-L, M, or S; DM-M or S; R-NRZ
Subcarrier Frequency	10 bps – 25 kbps, (NRZ) for 40 Hz-128 kHz 1 kbps – 250 Kbps for 5kHz – 2 MHz 1 kbps – 256 kbps (up to 128 kbps w/ Biϕ-L) for 5kHz – 2 MHz 1 kbps – 600 kbps (up to 300 kbps w/ Biϕ-L) for 5kHz – 2 MHz 1 kbps – 5 Mbps PM/PCM for 5kHz – 2 MHz
Subcarrier Modulation	BPSK, PM/PCM
Subcarrier Data Rate	40 Hz – 128 kHz (Low BW) 5 kHz – 2 MHz (Intermediate & High BW)
Subcarrier Data Format	NRZ-L, M, or S; Biϕ-L, M, or S; DM-M or S, RZ
Decoding	Viterbi and/or Reed-Solomon (CCSDS)
Note: The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

10.7 Tracking Services

10.7.1 Doppler Tracking

The 9-m and 13-m ground stations generate both 1- and 2-way S-band Doppler tracking data. Two-way data is derived from a coherent downlink carrier, a turn-around of the 9-m and 13-m S-band uplink signals with a frequency ratio of 240/221. Doppler tracking characteristics are shown in Table 10-7.

10.7.2 Range Tracking

Range tracking characteristics are shown in Table 10-8.

Table 10-7. AGO 9-m and* 13-m *Doppler Tracking Characteristics

Characteristic	Value
Counter Resolution	0.001 cycles
Doppler Frequency Shift	≤ 0.25 MHz
Doppler Bias Frequency	0.24 MHz
Drift (Δf/f)	$4x10^{-11}$ at 0.1 sec
Accuracy	0.01 Hz
Output Equation	$1000 (f_{transmit} \times [240/221] – f_{received}) + f_{bias}$

Table 10-8. AGO 9-m and 13-m Range Tracking Characteristics

Characteristic	Value
Operating Modes	2-way coherent and non-coherent
Modulation Index	Carrier: 0.2 – 1.5 Radians (peak) Subcarrier (1.7 MHz): 0.3 – 1.2 Radians (peak)
Major Tone Frequencies	500 kHz, 100 kHz, and 20 kHz
Minor Tone Frequencies	100 kHz, 20 kHz, and 4 kHz on carrier or 1.7-MHz subcarrier. 800 Hz, 160 Hz, 40 Hz, and 10 Hz on 4-kHz tone
Received C/N	≥ 10 dB
Tone Power/N0	> 15 dB-Hz
Accuracy	1.0 m
Unambiguous Range	≤ 644,000 km

10.7.3 Antenna Autotracking Angle Data

The 9-m and 13-m ground stations can record the angle of the ground antenna as they autotrack the satellite. This data is provided to the FDF as UTDF messages.

10.7.4 Baseband Data Interfaces

The 9-m and 13-m ground stations can send and receive baseband data in any of the following formats: IP, serial clock and data, and 4800-bit blocks encapsulated in IP packets.

Section 11. Hartebeesthoek Satellite Station

For Information only. Check with GSFC 453/NEN for further support capabilities (or with GSFC 450.1/NIMO for future support possibilities). This station belongs to the SANSA. www.sansa.org.za/

HBK-2: S-(and Ext C)-**band antenna (HBKS)**

Slew rate: 10°/sec
Dish diameter: **12m**
Tracking mode: Program and Autotrack
Polarization: LCP and RCP

Transmit 2
Frequency range: **2.025 - 2.15 GHz**
Receive
Frequency range: **2.2 - 2.4 GHz**
G/T: **22.4 dB/K**
Acquisition Aid ant: 1.07m 2.2 - 2.3 GHz only
EIRP**: 69dBW**

HBK-5: S, X-band antenna (HB5S)
Slew rate: 10°/sec
Dish diameter: **10m**
Tracking mode: Program and Autotrack
Polarization: LCP and RCP

Receive
Frequency range:
Rx1: **2.2 - 2.4 GHz** [**G/T: 22.4 dB/K**]
Rx2: **8.0 - 8.5 GHz** [**G/T: 31.0 dB/K**]

Transmit
Frequency range: **2.025 - 2.10 GHz**
EIRP: **65dBW**

Section 12. Kiruna, Sweden, Esrange Station

12.1 General

This section describes the Esrange Satellite Station located near Kiruna, Sweden north of the Acrtic circle. Two 13-m antenna systems are described here. The Esrange Satellite Station includes six independent Telemetry Tracking & Command (TT&C) systems in S-Band (one with receive capability also in the UHF-Band), six multi-frequency receive antenna systems in S/X-Band and an operational building (manned 24x7) which houses reception system electronics and data processing equipment.

12.2 Kiruna, 13.0-m, KU3S

The general characteristics of the KU3S antenna are as follows:

a. Location: 67° 52′ 44.655″ N
   21° 02′ 16.800″ E

b. One 13.0-m 3-axis antenna for simultaneously transmitting at S-band while receiving at S- and X-bands.

c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.

d. Tracking services: Tone Ranging, Doppler and antenna autotracking angles.

e. Baseband data interfaces: Internet Protocol (IP), serial clock and data, 4800-bit blocks encapsulated in IP packets, and electronic file transfer and parcel shipping.

Sections 12.2.1 through 12.2.3 describe S-band and X-band performance characteristics.

12.2.1 KU3S S-band Command

Table 12-1 identifies the S-band command characteristics of the KU3S antenna.

12.2.2 KU3S S-band X-band Telemetry

Table 12-2 identifies the S-band and X-band telemetry characteristics of the KU3S antenna.

Table 12-1. KU3S S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 69.0 dBW
Polarization	RHC or LHC
Antenna 3dB beamwidth	0.8 deg typical
Antenna Gain	46.5 dBi

Transmit Modulation	PM,FM, BPSK, QPSK, OQPSK, AQPSK
Transmit Subcarrier	BPSK <= 2 MHz (up to 10 MHz with limitations) FSK tones < 100 Hz
Metric Tracking	Tone ranging, Doppler and Antenna angles
Note: The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

Table 12-2. KU3S S-band & X-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2300 MHz 7600 – 8500 MHz
G/T with radome	≥ 22.5 dB/K (S-band) ≥ 37.5 dB/K (X-band)
Polarization	RHC & LHC diversity (S) RHC & LHC simultaneously (X)
Antenna 3 dB Beamwidth	0.7 deg typical S-band 0.2 deg typical X-band
Receive Modulation	FM, PM, BPSK, QPSK, OQPSK, SOQPSK, GMSK, AQPSK (S-Band). BPSK, QPSK, UQPSK,SQPSK, 8-PSK, Double Polarization (X-Band)
Receive Subcarrier (S-band)	BPSK <= 2 MHz (up to 10 MHz with limitations)
Receive Data Rate	<= 20 Mb/s no subcarrier <= 600kbps with subcarrier (S-band) Mission Specific (X-band)
Receive Link Coding	Viterbi, Reed-Solomon, Descrambling, Turbo
Note: The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

12.3 Kiruna, 13.0-m, KU1S

The general characteristics of the KU1S antenna are as follows:

a. Location: 67° 53′ 22.410″ N
21° 03′ 56.357″ E

b. One 13.0-m Az-El antenna for simultaneously transmitting at S-band while receiving at S- and X-bands.
c. Automatically scheduled by NEN schedulers per 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling*.
d. Tracking services: Tone Ranging, Doppler and antenna autotracking angles.
e. Baseband data interfaces: Call to verify.

Sections 12.3.1 through 12.3.3 describe S-band and X-band performance characteristics.

12.3.1 KU1S S-band Command

Table 12-3 identifies the S-band command characteristics of the KU1S antenna.

12.3.2 KU1S S-band X-band Telemetry

Table 12-4 identifies the S-band and X-band telemetry characteristics of the KU1S antenna.

Table 12-3. KU1S S-band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 69.0 dBW
Polarization	RHC or LHC
Antenna 3dB beamwidth	0.8 deg typical
Antenna Gain	46.5 dBi
Transmit Modulation	PM,FM, BPSK, QPSK, OQPSK, AQPSK
Transmit Subcarrier	BPSK <= 2 MHz (up to 10 MHz with limitations) FSK tones < 100 Hz
Metric Tracking	Tone ranging, Doppler and Antenna angles
Note: The command modulator capabilities listed in the table (e.g., data rates, modulation schemes, data formats, coding schemes) represent all possible modulator capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

Table 12-4. KU1S S-band & X-band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2300 MHz 7600 – 8500 MHz
G/T with radome	≥ 22.5 dB/K (S-band) ≥ 37.5 dB/K (X-band)
Polarization	RHC & LHC diversity (S) RHC & LHC simultaneously (X)
Antenna 3 dB Beamwidth	0.7 deg typical S-band 0.2 deg typical X-band
Receive Modulation	FM, PM, BPSK, QPSK, OQPSK,SOQPSK, GMSK, AQPSK (S-Band). BPSK, QPSK, UQPSK,SQPSK, 8-PSK, Double Polarization (X-Band)
Receive Subcarrier (S-band)	BPSK <= 2 MHz (up to 10 MHz with limitations)
Receive Data Rate	<= 20 Mb/s no subcarrier <= 600kbps with subcarrier (S-band) Mission Specific (X-band)
Receive Link Coding	Viterbi, Reed-Solomon, Descrablling, Turbo
Note: The telemetry receiver capabilities listed in the table (e.g., data rates, modulation schemes, data formats, decoding schemes) represent all possible receiver capabilities, but may not reflect the actual ground station capabilities implemented by the NEN. Potential NEN users are encouraged to discuss the mission requirements and NEN capabilities with the NIMO to ensure that requirements and capabilities are fully understood and represented in the RFICD.	

Section 13. Scheduling

This section superseded by the standalone documents 453-UG-NEN Scheduling, *Users' Guide for Near Earth Network Scheduling* and 450-OIP-WSC/DSMC, *White Sands Complex (WSC)/Data Services Management Center (DSMC) Operations Interface Procedure (OIP)*.

Section 14. Baseband Data Interfaces and Storage

14.1 Introduction

This section describes the baseband data interface and storage equipment options at the NEN stations:

a. IONet Network.

b. Serial Clock and Data.

c. Parcel Shipment of Recorded Data.

d. Standard Autonomous File Server (SAFS).

e. NEN Gateway (Available only at the Wallops and Alaska Satellite Facility stations)

Table 14-1 summarizes the baseband data interfaces available at each station. An “X” means that capability is offered.

14.2 IONet Network

The IONet Network can be used by MOCs to send commands to and receive telemetry data from a NEN station.

14.2.1 Open and Closed Networks

The IONet Network uses open, restricted and closed NASA IP networks. “Open” and “Closed” are relative. The closed IONet is completely controlled while the open and restricted IONet has limited access. Although the closed network provides more security, the open network is still inaccessible to the public. A firewall (or “gateway”) is used when data crosses an open/closed boundary in either direction.

14.2.2 TCP/IP and UDP/IP

The IONet Network supports both TCP/IP and User Datagram Protocol/Internet Protocol (UDP/IP).

Figure 14-1 depicts the TCP/IP layer model. Each layer is encapsulated by the next lower level. “Encapsulation” is the addition of a control information header and/or trailer to a block of data. For example, in Figure 14-1, the IPDU packet encapsulates the Channel Access Data Unit (CADU) packet. For UDP/IP, the layering is identical to Figure 14-1, except the TCP layer is replaced by a UDP layer.

14.2.3 Packets and Layers

CADU and Command Link Transmission Unit (CLTU) packets are CCSDS-compliant telemetry and command data unit protocols, respectively. (See reference u in Section 1.3. for CLTU and reference n in Section 1.3 for CADU in Section 1.3.) For commands, the CADU layer in Figure 14-1 is replaced by a CLTU layer.

The Network Access Layer is a protocol format that provides physical access to NISN. For the NEN stations that support IP data transfer, the Network Access Layer is the Ethernet protocol that interfaces the NEN station to the Routers. The IP Layer allows data to traverse multiple networks between users and the NEN station. IP alone does not ensure that the data will be delivered, but when IP is used with TCP, all data is guaranteed to be delivered. TCP is a virtual connection protocol designed to work with IP. It provides reliable communication across a variety of both reliable and unreliable networks and internets.

Table 14-1. Baseband Data Interface Options

Station	NISN IP Network	Serial Clock and Data	Parcel Shipping	SAFS	Gateway
AGO	X			X	
ASF	X		X	X	X
SG1	X	X	X	X	
SG2	X	X	X	X	
SG3	X	X	X	X	
TR2	X				
WS1	X	X	X	X	
LEO-T – WFF	X	X		X	
WG1	X	X	X	X	X
MG1[1]	X		X	X	
USAK04	X	X	X	X	
USAK05	X	X	X	X	
USAK01	X		X	X	
USAK02	X		X	X	
USHI01	X		X	X	
USHI02	X		X	X	
AUWA01	X		X	X	
AUWA02	X		X	X	
SI1 (Singapore)	X			X	
PDL	No Service	No Service	No Service	No Service	
KUS	No service	No Service	No Service	No Service	
Note: An “X” indicates the capability is offered at the station. 1 – MG1 data delivery is not available by parcel shipping for ½ of the year. Contact the NEN for potential use of the MTRS.					

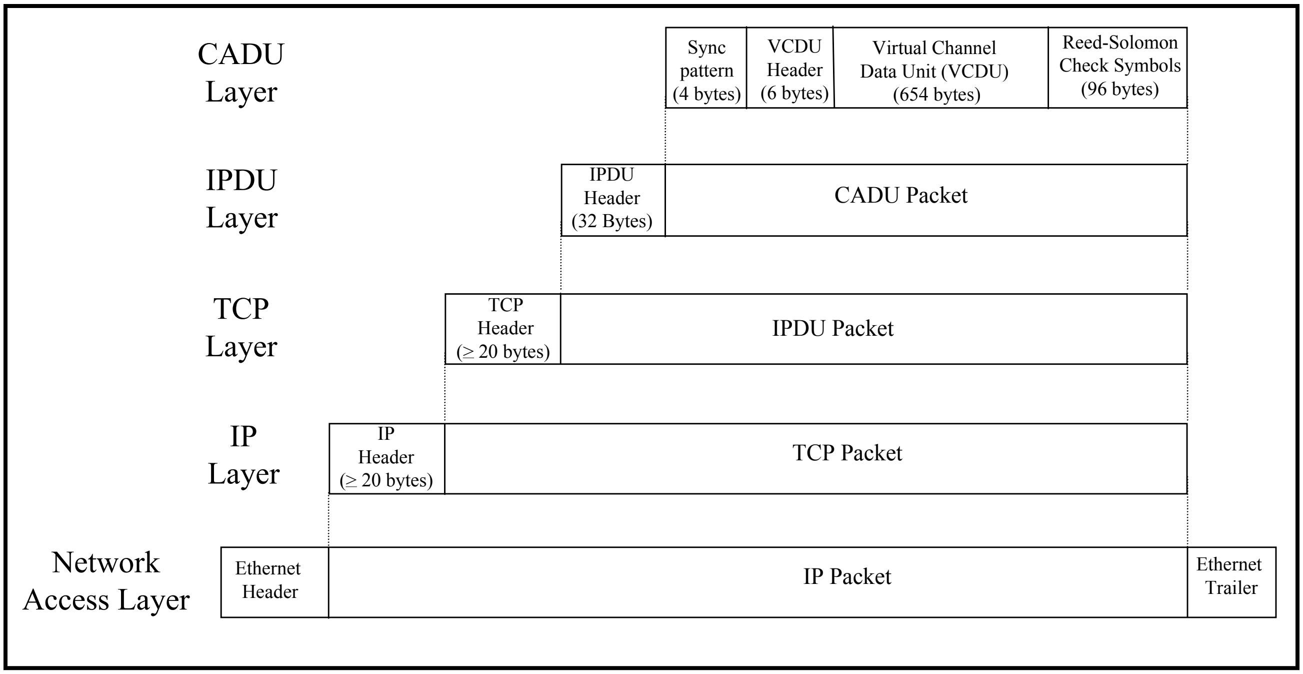


Figure 14-1. NISN IP Network Layers

Notes

1. TCP/IP layers are shown; UDP/IP is identical, except "TCP" is replaced by "UDP."
2. Telemetry packets are shown; command packets are identical, except "CADU" is replaced by "CLTU."

14.2.4 UDP

UDP is available to users who want faster data transfers than TCP provides. UDP is unreliable, however, because – unlike TCP – it doesn't provide the handshaking protocols that guarantee delivery in order without duplicate or missing packets.

14.2.5 PTP Encapsulation

All NEN stations that support IP use Programmable Telemetry Processors (PTP) to perform encapsulation and de-encapsulation. In addition to IPDU, the PTP supports several other packet formats for encapsulating CLTUs or CADUs prior to the TCP or UDP layers. PTPs offer the following packet format choices:

a. IPDU.
b. Advanced X-ray Astrophysics Facility (AXAF) Standard Formatted Data Unit (SFDU).
c. Deep Space-Terminal SFDU.
d. Advanced Composition Explorer (ACE) SFDU.
e. LEO-T Telemetry Frame Delivery Header.
f. LEO-T Command Delivery Header (CDH).

g. NASA Communications Real-time Transmission Protocol.

h. No extra encapsulation between the CADU or CLTU layer and the TCP or UDP layer.

Instead of a PTP, the LEO-T stations use a front-end processor that offers encapsulation and format choices that are a subset of the PTPs.

14.2.6 Command Data (Real-Time)

The MOC sends real-time command data to the NEN station via the IONet. Either TCP/IP or UDP/IP sockets may be used.

A few minutes prior to each command service (assuming TCP/IP data transfer), the MOC initiates two TCP/IP socket connections with the NEN station: one socket for command data, the other for command echoes. Individual station and project turn-around times can be found at the URL: http://esc.gsfc.nasa.gov/space-communications/NEN/NEN-Documents.html. If the user does not require command echo service, the MOC need not initiate the second socket.

14.2.7 S-band Telemetry Data

A few minutes prior to each S-band telemetry service (assuming TCP/IP data transfer), the MOC initiates two independent TCP/IP socket connections with the NEN station: one socket for telemetry data on the main carrier, the other for data on the subcarrier. Individual station and project turn-around times can be found at the URL: http://esc.gsfc.nasa.gov/space-communications/NEN/NEN-Documents.html. The MOC needs to initiate only one socket if the user vehicle transmits only one stream of telemetry data.

14.3 Serial Clock and Data

The serial clock and data option is the transmission and/or reception of raw digital data streams with associated clock signals.

14.4 Parcel Shipping of Recorded Data

When the telecommunication circuits at a NEN station cannot support the electronic transfer of high-rate science data (X-band or S-band), the NEN station will record the science data on non-volatile media such as a disk. The station will then parcel ship the recorded data to the user.

Operations agreements and support plans define the exact data-shipping criteria. Table 14-2 identifies the recording capabilities at each NEN station; an "X" means that capability is available.

Table 14-2. Digital Data Recording

Station	Solid State Recording
SG1	X
SG2	X
SG3	X
SI1	X
WG1	X
LEO-T – WFF	X
USAK04	X
USAK05	X
USAK01	X
USAK02	X
USHI01	X
USHI02	X
AUWA01	X
AUWA02	N/A
MG1	X
PDL	No Service
KUS	No Service
ASF	X
WS1	X

14.5 Standard Autonomous File Server

This section describes the Standard Autonomous File Server (SAFS). SAFS provides automated management of large data files without interfering with the assets involved in the acquisition of data. SAFS operates as a stand-alone solution, monitoring itself, and providing an automated level of fail-over processing to enhance reliability. By using an improved automated file transfer process, the SAFS system provides a quicker, more reliable file distribution for customers of near real-time data than has been realized by previous methods.

14.5.1 SAFS Architecture and Operation

Initially, the SAFS was installed at some NASA NEN sites for distributed acquisition of satellite data in support of QuikSCAT and ADEOS II missions. The SAFS have now been installed at the following NEN ground stations: ASF, MG1, SGS, WGS, and WS1. A SAFS also been installed at GSFC to provide for centralized customer data distribution. Figure 14-3 depicts the SAFS network architecture spanning the Closed, Restricted and Open IONets.

Note

> Due to IONet security protocols, data flows are restricted to transfers within the same network or from a higher security network to a lower security network (i.e. Closed to Restricted, Closed to Open, or Restricted to Open). No data is allowed to flow from Open to the Restricted or Closed.

The central SAFS provides a single point-of-contact for customers and isolates the NEN ground stations from customer interactions. At each ground station, the telemetry processors accept raw satellite data and process the data into files (format for later customer consumption) that are sent to the station SAFS via a standard network protocol.

The station SAFS uses FASTCopy to automatically push the files to the central SAFS via a standard network protocol where the files are made available to the mission customers. In addition, each SAFS has the ability to send data to multiple recipients and can provide automatic failover capabilities to send data to a secondary receiving server should the primary be unavailable. This failover capability is also extended to the Central SAFS (CSAFS) which consists of a primary and backup servers and Raids.

The ultimate factor as to whether the SAFS can send the data is network connectivity (where/what network are the recipients located), and the available transfer protocols; FTP, SFTP, SCP, or FastCopy (SFTP, SCP, or FastCopy are preferred). Depending upon the network connectivity of the data recipient, if all connectivity is outside of NASA's Closed or Restricted IONets then all data would be transferred from the CSAFS, however, if a recipient is located on the Closed or Restricted IONets, the data could be sent directly from a station SAFS. Table 14-3 shows the data distribution capabilities of each SAFS.

Table 14-3. SAFS Network Distributions using FastCopy, SFTP, SCP, or FTP

Station	Closed Push	Closed Pull	Restricted Push	Restricted Pull	Open Push	Open Pull	Other Push	Other Pull
AGO	X	X	O	X	X	X	X	X
ASF	X	X	X	X	O	X	X	X
MG1	O	X	X	X	X	X	X	X
SG1 (SGS)	O	X	X	X	X	X	X	X
WGS	O	X	X	X	X	X	X	X
WS1	X	X	O	X	X	X	X	X
Commercial	X	X	X	X	O	X	X	X
CSAFS	X	X	X	X	O	O	O	O

Notes:
- ALL station data flows to CSAFS at GSFC.
- AGO includes the SA1 and SA2 antennas.
- ASF includes the AS1, AS2, and AS3 antennas.
- WGS includes the WG1 (11 meter) and WG2 (LEOT) antennas.
- Commercial includes USN antennas and KSAT antennas (SG2, SG3, SI1, & TR2).

Customers can "pull" their data files from the CSAFS system once they receive a data ready notification (DRN) of its availability, however due to email restrictions on the Closed IONet this function is not available from a station SAFS. Or, if the customer chooses, they may have the SAFS system automatically "push" their data files to them which would eliminate the delay inherent in the notification and reaction processes required for "pull" customers. Due to the added functionality, FastCopy is the preferred transfer method from any SAFS, but FTP, SFTP, and SCP are also available transfer protocols, with FTP being the least desirable.

14.5.2 SAFS Hardware and Software

The SAFS system hardware is installed in a standard 19" rack and includes the following:

a. Redundant Array of Independent Disks (RAID) storage system

b. Windows servers

c. Rack mounted keyboard, monitor, with touch pad

The SAFS software includes the following:

a. COTS RepliWeb Managed File Transfer

b. Custom scripts for job control and monitoring

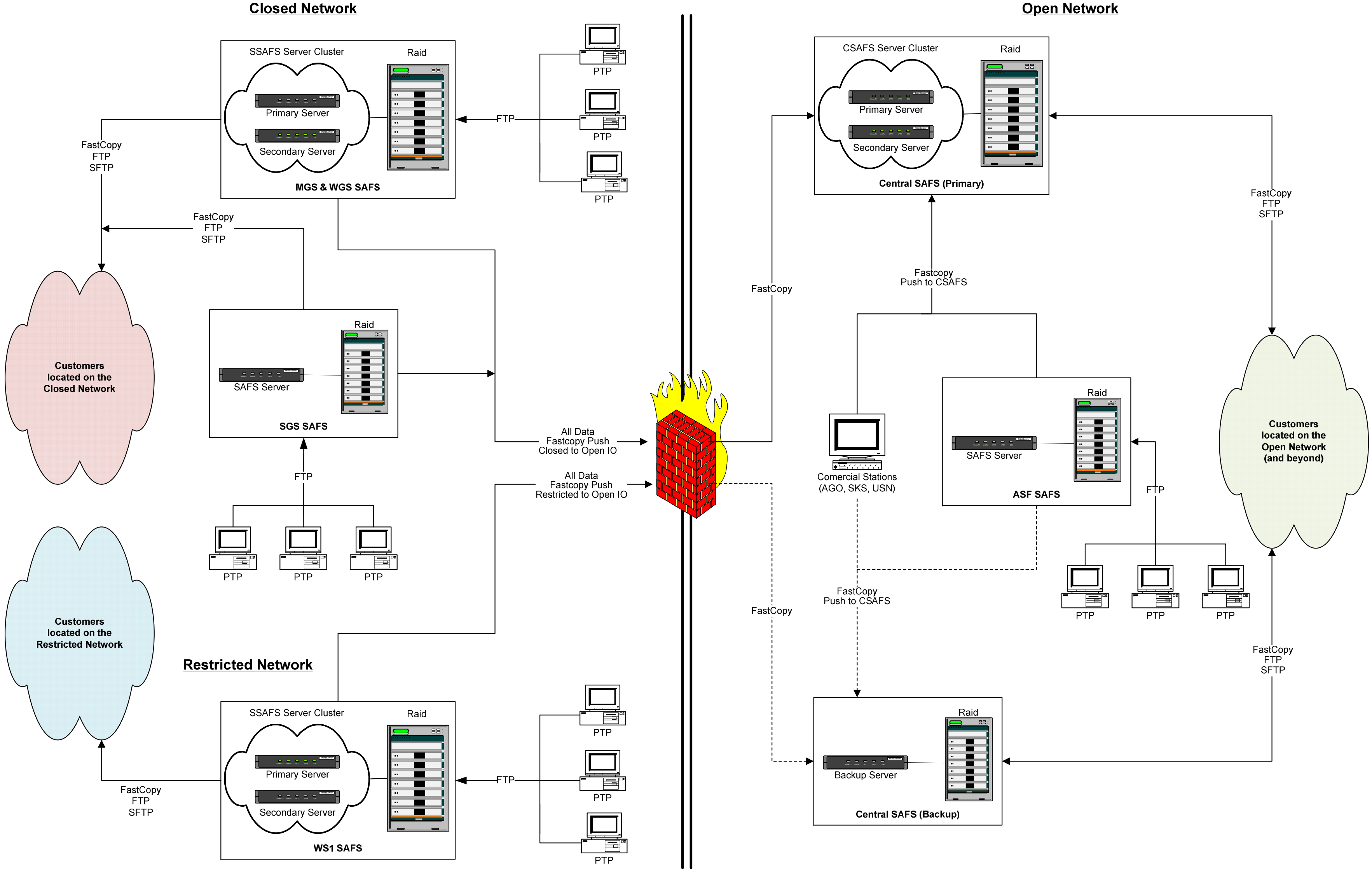


Figure 14-2. SAFS Architecture

14.5.3 SAFS Distribution Methods

There are four defined types of interactions possible between the TM Processors, Station SAFS (SSAFS), CSAFS, and customers. These types are dependent on the project and station SAFS used.

Note

> Direct distribution from a Station SAFS (Type 3 or Type 4) can only be done if the customer MOC is located on the same network as the Station SAFS, and is only available as a push transfer.

Type 1: Uses SAFS file naming convention, with distribution from the CSAFS:

a. TM Processor pushes file to SSAFS using ***safsFileName***.

b. SSAFS pushes file to CSAFS using ***safsFileName***.

c. CSAFS transfers file to customer using ***safsFileName*** **(**this can be CSAFS pushes to the customer or the customer pulls from CSAFS).

d. Events logged using ***safsFileName,*** and files archived using ***safsFileName***.

Type 2: Uses Project file naming convention, with distribution from the CSAFS:

a. TM Processor pushes file to SSAFS using ***projectFileName.***

b. SSAFS pushes file to CSAFS using ***projectFileName.***

c. CSAFS transfers file to customer using ***projectFileName*** **(**this can be CSAFS pushes to the customer or the customer pulls from CSAFS).

d. Events logged using ***projectFileName***, and files archived using ***projectFileName***.

Type 3: Uses SAFS file naming convention, with distribution from the SSAFS:

a. TM Processor pushes file to SSAFS using ***safsFileName***.

b. SSAFS pushes file to CSAFS using ***safsFileName***. (This is to provided added availability/contingency and archive for the customer to pull data if needed.)

c. SSAFS transfers file to customer using ***safsFileName*** **(**this is a push function only).

d. Events logged using ***safsFileName,*** and files archived using ***safsFileName***.

Type 4: Uses Project file naming convention, with distribution from the SSAFS:

a. TM Processor pushes file to SSAFS using ***projectFileName***.

b. SSAFS pushes file to CSAFS using ***projectFileName***. (This is to provided added availability/contingency and archive for the customer to pull data if needed.)

c. SSAFS transfers file to customer using ***projectFileName*** **(P**ush function only).

d. Events logged using ***projectFileName,*** and files archived using ***projectFileName***.

14.5.4 SAFS Project Parameters (Current Mission Set)

Project	SAFS Id*	SAFS Type	SAFS GS	Data File(s)		SAFS Name	Meta Data	File Trans	Archive (Default 7)
AIM	aim	1	ASF SG1 SKS# USN# WGS	Housekeeping1 Housekeeping2 Real Time Science	hk1 hk2 rt sci	Y	Y	FC Push CSAFS	7 Days
COSMIC	cos	1	ASF MG1	VC 00 VC 01 VC 02	vc0 vc1 vc2	Y	N	FTP Pull CSAFS	15 Days
EO1	eo1	1	MG1 SG1 USN# WGS	VC 00 VC 01 VC 02 VC 03 VC 04 VC 06 VC 07 VC 08 VC 09 VC 11 VC 12 VC 14	c00 c01 c02 c03 c04 c06 c07 c08 c09 c11 c12 c14	Y	Y	FTP Pull CSAFS	7 Days
GRACE	gr1	1	ASF MG1 WGS SG1 SKS#	VC 07	vc7	Y	N	FTP Pull CSAFS	7 Days
	gr2	1	ASF MG1 WGS SG1 SKS#	VC 07	vc7	Y	N	FTP Pull CSAFS	7 Days
RHESSI	hes	1	AGO# WGS WS1	VC 00 VC 01 VC 02 VC 03	vc0 vc1 vc2 vc3	Y	N	FTP Pull CSAFS	7 Days
ICESAT-2	ice2	1	ASF SG1 SG2 WGS	VC 00 VC 01 VC 02 VC 05	vc0 vc1 vc2 vc5	Y	N	SFTP Push CSAFS	7 Days
CYGNUS	orb	1	WGS	VC ALL	vca	Y	N	SFTP Pull CSAFS	7 Days
CPOD	pons	1	ASF MG1 WGS	VC ALL	vca	Y	N	SFTP Pull CSAFS	7 Days

Project	SAFS Id*	SAFS Type	SAFS GS	Data File(s)		SAFS Name	Meta Data	File Trans	Archive (Default 7)
QUIKSCAT	qst	1	ASF SG1 SKS# USN# MG1 WGS	Housekeeping1 Housekeeping2 Science	hk1 hk2 sci	Y	Y	FC Push CSAFS	7 Days
SCAN (Testbed)	sca	1	WGS	VC ALL	vca	Y	N	SFTP Pull CSAFS	7 Days
SCISAT-1	sci	1	ASF	RAW	raw	Y	N	SFTP Push CSAFS	14 Days
SMAP	smp	1	ASF MG1 SG1 SG2 TR2 WGS	VC 00 VC 01	vc0 vc1	Y	N	SFTP Pull CSAFS	14 Days
SOLAR-B	sol		MG1 WGS	RAW	raw	Y	N	FTP Pull CSAFS	7 Days
SORCE	sor	1	AGO# WGS	HRT PBK SCI	hrt pbk sci	Y	N	FC Push CSAFS	7 Days
SWIFT	swi	2	AGO# WGS USN#	VC 00 VC 01 VC 02 VC 03 VC 04 VC 06 VC 07	vc0 vc1 vc2 vc3 vc4 vc6 vc7	N	N	FTP Push SSAFS	7 Days
THEMIS	thm	1	AGO# WGS WS1 USN#	VC 00 VC 01 VC 02 VC 03 VC 04 VC 06	vc0 vc1 vc2 vc3 vc4 vc6	Y	N	FTP Pull CSAFS	30 Days

* Defined by NEN Scheduling
# Utilizes a SAFS like interface to send data to CSAFS

14.5.5 SAFS File Naming Convention

The SAFS file naming convention is defined as follows:

ProjectID YYYYMMDDHHMMSS TMprocessorID Type . Ext

Pass Recording Start Time

Where:

ProjectID	3 character project Identifier as defined by NEN Scheduling. (Example: qst, cos, eo1, etc…)
Pass Recording Start Time	YYYYMMDDHHMMSS
YYYY	Year
MM	Month
DD	Day of Month
HH	Hour (24 hour clock)
MM	Minutes
SS	Seconds
TMprocessorID	P [PTP sequence – 2 digit number]
	D [Data stripper sequence – 2 digit number]
Type	Data type (Example: for QuikSCAT: sci/hk1/hk2)
Ext	Extension (3 characters)
	dat (data)
	mta (metadata)
	flg (flag file – see section IV below)

Example 1:

SAFS file name for QuikSCAT:	qst20121125132245p01sci.dat
ProjectID	qst
Pass Recording StartTime:	
Year	2012
Month	11
Day of Month	25
Hour (24 hour clock)	13
Minutes	22
Seconds	45
TMprocessorID	p01
Type	sci
Ext	dat

Example 2:

SAFS file name for ADEOS II:	sol20121201081532p01raw.dat
ProjectID	sol
Pass Recording StartTime:	
Year	2012
Month	12
Day of Month	01
Hour (24 hour clock)	08
Minutes	15
Seconds	32
TMprocessorID	p01
Type	raw
Ext	dat

14.5.6 Telemetry Processor to SAFS Interface Requirements

The requirements for the interface between the Standard Autonomous File Server (SAFS) and the Telemetry Processor (TMP) are as follows:

1. The TMP will transfer files to specific SAFS directories by project and file types, using project parameters from section II above. The SAFS file destination path structure will be:
/raid1/safs/**ProjectID** with one or more data type subdirectories as needed.

Example 3: /raid1/safs/qst/sci/
/raid1/safs/cosmic/vcdat/

2. If a metadata file is associated with a data file, it will be sent to the same directory as its corresponding data file.

Example 4: The QuikSCAT files qst20121201081532p02hk2.dat and qst20121201081532p02hk2.mta would both be sent to the SAFS directory /raid1/safs/qst/hk2.

3. If the TMP is **not** using FASTCopy to transfer files to the SAFS, then **after** the data and metadata files are transferred to a SAFS directory, a flag file must be sent to the same SAFS directory to indicate completion of the data/metadata transfers. The flag file will have the same file name, but with an extension of **.flg**. This flag file will contain the names of the data and metadata files.

Example 5: After the QuikSCAT files **qst20120213134522p01sci.dat** and **qst20120213134522p01sci.mta** are sent to the SAFS, the file **qst20120213134522p01sci.flg** will be sent as the flag file for the pair and will contain the following:

qst20120213134522p01sci.dat
qst20120213134522p01sci.mta

Example 6: After the SOLARB file **sol20121022011657p01raw.dat** is sent to the SAFS, the file **sol20121022011657p01raw.flg** will be sent as the flag file and will contain the following: sol20121022011657p01raw.dat

NOTE

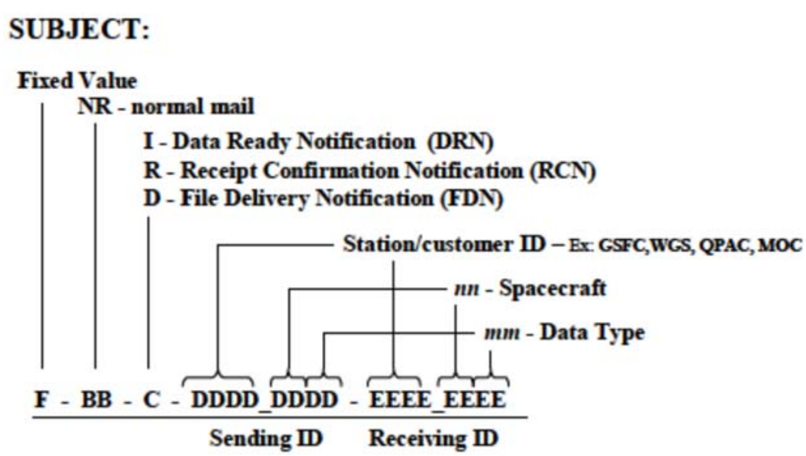
If the TMP is using FASTCopy to transfer files to the SAFS, flag files are not required, but may be used.

14.5.6.1 SAFS Data Exchange and Email Formats

TYPE	DIRECTION	PROTOCOL	DESCRIPTION
DRN	Customer “pulls”	E-mail	Server sends an E-mail message to inform “pull” customers that data is ready at server for transfer.
RCN	All Customers	E-mail	All customers send an E-mail message to inform the server when data is received, and the status of the transfer.
FDN	Server “pushes”	E-mail	Server sends an E-mail message to inform “push” customers that their data has been delivered, and the status of the transfer.

The E-mail message consists of a subject and message area.

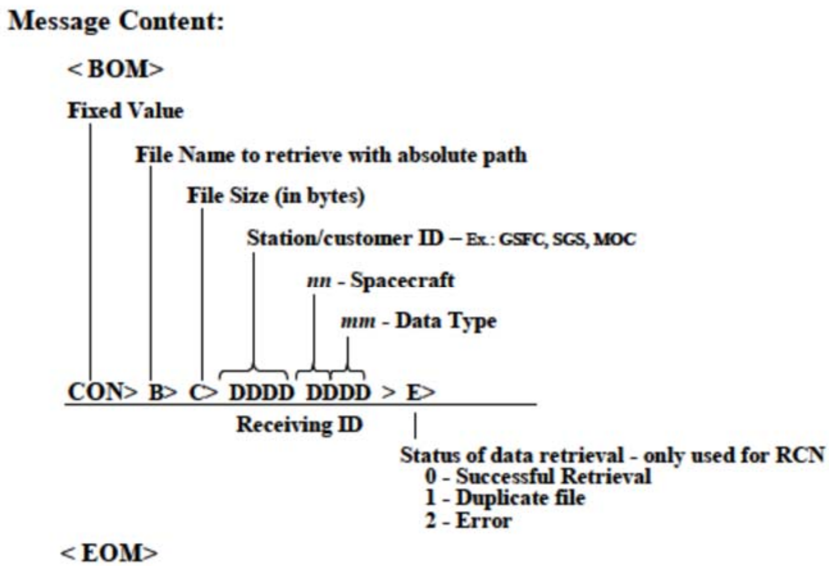
a) The subject area has the same format for all message types:



Example data message subject lines:

DRN: F-NR-I-ASF_1021-GSFC_1021
FDN: F-NR-D-ASF_1021-GSFC_1021
RCN: F-NR-R-ASF_1021-GSFC_1021

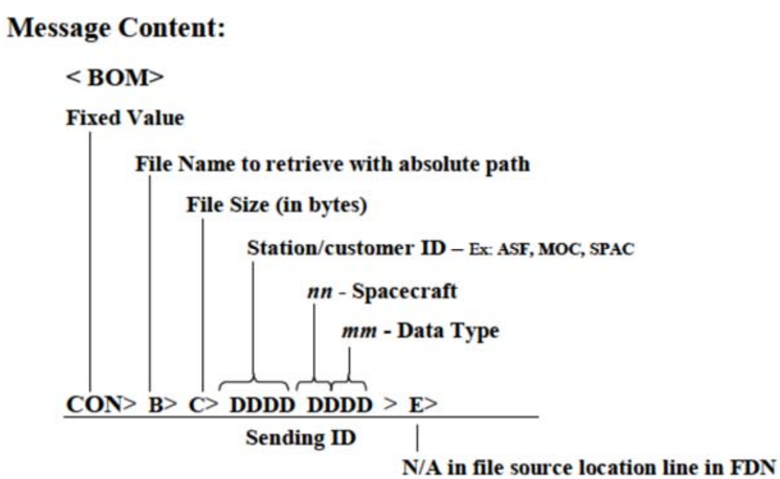
b) The message area for DRN and RCN (Receipt Confirmation Notice) message types is as follows, and has a single content line:

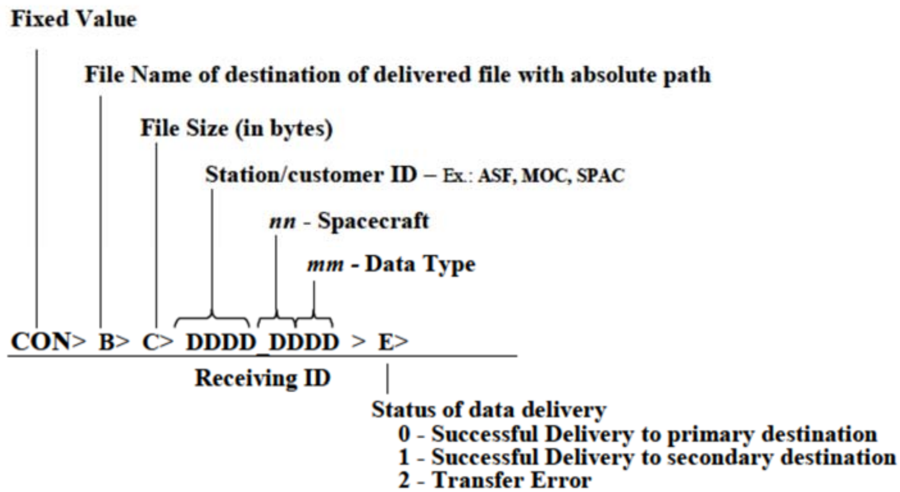


Example DRN message content:

<BOM>
CON>/raid1/safsarchive/sam/12185173627_vc0>866636>SAMPEX_7784>
>
<EOM>

c) the message area for the FDN (File Delivered Notification) message type is as follows, and has two content lines:





Example FDN message content:

<BOM>
CON>/raid1/safsarchive/qst/qst20120703170202p62hk1.dat>7803936>ASF_1021>>
CON>/raid1/safs/qst/hk1/qst20120703170202p62hk1.dat>7803936>GSFC_1021>0>
<EOM>

14.5.7 SAFS Transfer Protocols

DATA DIRECTION	PROTOCOL	PROCEDURES
Customer "pulls"	FTP, SFTP, SCP or COTS *(CSAFS only)*	1) Server sends DRN to customer before transfer. 2) Customer "pulls" file and sends RCN to server after transfer.
Server "pushes"	FTP, SFTP, SCP or COTS *(FDN and Failover COTS only)*	1) Server sends FDN to customer after file transfer: a) If transfer not successful to customer's primary destination after *n* tries, then • Server sends FDN to customer's primary destination with failure status. • File is transferred to customer's secondary destination b) If transfer not successful to customer's secondary destination after *n* tries, then • Server sends FDN to customer's secondary destination with failure status. • Server sends FDN to customer's tertiary destination with failure status and info for customer "pull" of file. 2) Customer sends RCN to server after transfer.

14.5.8 SAFS Data Archive

Upon being processed by the SAFS (Station and Central) data files are archived for a configurable period of time (NASA requires a minimum of 3 days) to allow for customer retrieval or station resend on a contingency basis. By default the archive period is typically 7 days, but can be shorter or longer depending upon storage requirements and customer needs.

14.6 NEN Gateway

The NEN Gateway (NENG) separates X-band Virtual Channel data, packages it into manageable sized files and delivers them to the project. The NENG uses standard Transmission Control Protocol/Internet Protocol (TCP/IP) and file-based transmission protocols. The NENG is a computer system connected to the NEN station Cortex XXL, X-band receiver that handles file construction from an incoming Consultative Committee for Space Data Standards (CCSDS) Advanced Orbiting Systems (AOS) stream. Presently, the NENG is located at the WGS and the ASF and only supports downlink data processing for the IRIS mission. NENG service to other customers can be implemented.

14.6.1 Operational Description

The NEN station Cortex HDR XXL – High Data Rate Receiver performs demodulation, decoding and frame synchronization on the customer X-band data stream. Each virtual channel in the AOS frame that is received by the station X-band receiving system will be written into separate files. Files are separated into small one-minute file sizes for a single VCID that allow for faster turn-around time on the data and smaller transmission cycles in case of NENG to user transfer problems. The NENG stores the file-based data in a 7-day temporary circular buffer used for retransmissions and failure recovery when necessary. At the end of a pass the NENG will perform an automatic file transfer protocol (ftp)/secure file transfer protocol (sftp)/secure copy protocol (scp) push to the customer. If the customer wants to "replay" a data set they may use the self-service ftp/sftp/scp interface on the system to pull their data to their site. Alternatively, the customer may choose to manually retrieve files and not select automatic file transfer. The NENG will store customer data sets for at least 7 days, allowing for delayed retrieval.

Figure 14-3 shows the data flow from the NEN station antenna to the NEN Gateway and then, the customer interface.

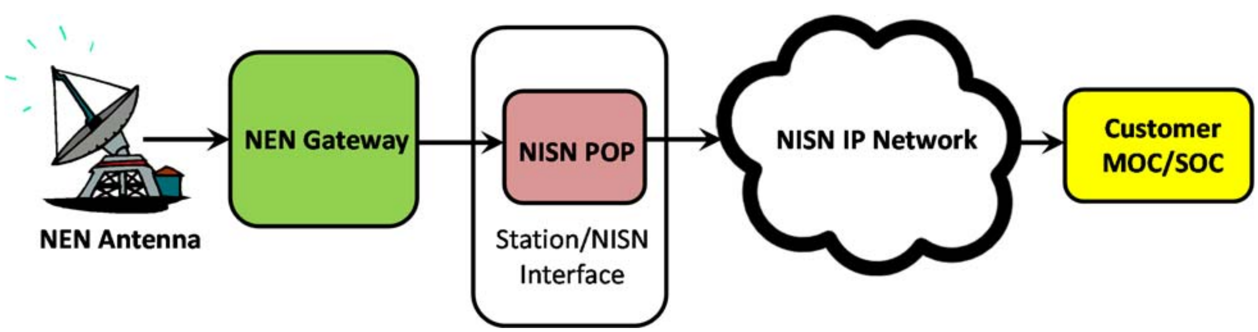


Figure 14-3. NEN Antenna to NEN Gateway to Customer Data flow

14.6.2 Gateway Design

The NEN Gateway storage system is a single fault tolerant RAID disk system, with a capacity of about 10 terabytes. The software and hardware traces its legacy to the SDO, LRO and WS1 implementations. The NEN Gateway uses Commercial off the Shelf (COTS) hardware exclusively. NEN customers schedule services via the NEN and receive return data packetized for transport via an Open Systems Interface (OSI) Level 4 (L4) protocol. Multiple missions and/or science centers can schedule services from the NEN Gateway, to the extent resources permit.

Section 15. Frequency Management

15.1 Introduction

This section provides information to assist a flight project in determining its frequency spectrum requirements. It also describes the procedures for obtaining authorization for the required spectrum.

15.2 Determining Frequency Spectrum Requirements

15.2.1 International Frequency Spectrum Allocations

International frequency spectrum allocations are prepared by World Radio Communication Conferences convened under the auspices of the International Telecommunications Union (ITU). These allocations become part of the ITU-R International Radio Regulations, a treaty that requires ratification by the United States (US). In most cases, these allocations also become part of the National Allocation Table. Refer Table 15-1.

Management of the radio frequency spectrum within the US is divided between government and non-government uses: the National Telecommunications and Information Administration (NTIA) administers government allocations (including NASA), and the Federal Communications Commission manages non-government allocations.

NASA is a member of the NTIA's Interdepartment Radio Advisory Committee, which coordinates US spectrum allocation issues. US allocations relevant to the NEN are consistent with the international allocations.

Table 15-2 identifies the bands in which the space science services are "primary" or "secondary" with respect to other services. Within these bands, operations with a primary status are protected from unacceptable interference from other services, but NEN operations with a secondary status shall be operated on a non-interference basis.

It is important to note that all spacecraft communication links with the NEN and other ground networks must be coordinated, licensed and internationally registered prior to operation.

Table 15-1. United States and ITU-R Table of Frequency Allocations

International Table			United States Table	
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table
2025-2110 SPACE OPERATION (Earth-to-space) (space-to-space) EARTH EXPLORATION-SATELLITE (Earth-to-space) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (Earth-to-space) (space-to-space) 5.392			2025-2110 SPACE OPERATION (Earth-to-space) (space-to-space) EARTH EXPLORATION-SATELLITE (Earth-to-space) (space-to-space) SPACE RESEARCH (Earth-to-space) (space-to-space) 5.391 5.392 US90 US222 US346 US347 US393	2025-2110 FIXED NG118 MOBILE 5.391 5.392 US90 US222 US346 US347 US393
2110-2120 FIXED MOBILE 5.388A 5.388B SPACE RESEARCH (deep space) (Earth-to-space) 5.388			2110-2120 US252	2110-2120 FIXED MOBILE US252

International Table			United States Table	
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table
2200-2290 SPACE OPERATION (space-to-Earth) (space-to-space) EARTH EXPLORATION-SATELLITE (space-to-Earth) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (space-to-Earth) (space-to-space) 5.392			2200-2290 SPACE OPERATION (space-to-Earth) (space-to-space) EARTH EXPLORATION-SATELLITE (space-to-Earth) (space-to-space) FIXED (line-of-sight only) MOBILE (line-of-sight only including aeronautical telemetry, but excluding flight testing of manned aircraft) 5.391 SPACE RESEARCH (space-to-Earth) (space-to-space) 5.392 US303	2200-2290 US303
2290-2300 FIXED MOBILE except aeronautical mobile SPACE RESEARCH (deep space) (space-to-Earth)			2290-2300 FIXED MOBILE except aeronautical mobile SPACE RESEARCH (deep space) (space-to-Earth)	2290-2300 SPACE RESEARCH (deep space) (space-to-Earth)

Table 15-1. United States and ITU-R Table of Frequency Allocations (cont)

International Table			United States Table	
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table
8025-8175 EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 5.463 5.462A			8025-8175 EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) Mobile-satellite (Earth-to-space) (no airborne transmissions) US258 G117	8025-8400
8175-8215 EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) MOBILE 5.463 5.462A			8175-8215 EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Mobile-satellite (Earth-to-space) (no airborne transmissions) US258 G104 G117	
8215-8400 EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 5.463 5.462A			8215-8400 EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) Mobile-satellite (Earth-to-space) (no airborne transmissions) US258 G117	US258
8400-8500 FIXED MOBILE except aeronautical mobile SPACE RESEARCH (space-to-Earth) 5.465 5.466			8400-8450 FIXED SPACE RESEARCH (space-to-Earth) (deep space only)	8400-8450 Space research (space-to-Earth) (deep space only)
			8450-8500 FIXED SPACE RESEARCH (space-to-Earth)	8450-8500 SPACE RESEARCH (space-to-Earth)

Table 15-1. United States and ITU-R Table of Frequency Allocations (cont)

International Table			United States Table	
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table
13.25-13.4 EARTH EXPLORATION-SATELLITE (active) AERONAUTICAL RADIONAVIGATION 5.497 SPACE RESEARCH (active) 5.498A 5.499			13.25-13.4 EARTH EXPLORATION-SATELLITE (active) AERONAUTICAL RADIONAVIGATION 5.497 SPACE RESEARCH (active) 5.498A	13.25-13.4 AERONAUTICAL RADIONAVIGATION 5.497 Earth exploration-satellite (active) Space research (active)
13.4-13.75 EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION SPACE RESEARCH 5.501A Standard frequency and time signal-satellite (Earth-to-space) 5.499 5.500 5.501 5.501B			13.4-13.75 EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION G59 SPACE RESEARCH 5.501A Standard frequency and time signal-satellite (Earth-to-space) 5.501B	13.4-13.75 Earth exploration-satellite (active) Radiolocation Space research Standard frequency and time signal-satellite (Earth-to-space)
13.75-14 FIXED-SATELLITE (Earth-to-space) 5.484A RADIOLOCATION Earth exploration-satellite Standard frequency and time signal-satellite (Earth-to-space) Space research 5.499 5.500 5.501 5.502 5.503			13.75-14 RADIOLOCATION G59 Standard frequency and time signal-satellite (Earth-to-space) Space research US337 US356 US357	13.75-14 FIXED-SATELLITE (Earth-to-space) US337 Radiolocation Standard frequency and time signal-satellite (Earth-to-space) Space research US356 US357
14-14.25 FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B 5.484A 5.506 5.506B RADIONAVIGATION 5.504 Mobile-satellite (Earth-to-space) 5.504C 5.506A Space research 5.504A 5.505			14-14.2 Space research	14-14.2 FIXED-SATELLITE (Earth-to-space) NG183 Mobile-satellite (Earth-to-space) Space research

Table 15-1. United States and ITU-R Table of Frequency Allocations (cont)

International Table			United States Table	
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table
14.5-14.8 FIXED FIXED-SATELLITE (Earth-to-space) 5.510 MOBILE Space research			14.5-14.7145 FIXED Mobile Space research	14.5-14.8
			14.7145-14.8 MOBILE Fixed Space research	
14.8-15.35 FIXED MOBILE Space research			14.8-15.1365 MOBILE SPACE RESEARCH Fixed US310	14.8-15.1365 US310
5.339			15.1365-15.35 FIXED SPACE RESEARCH Mobile 5.339 US211	15.1365-15.35 5.339 US211

International Table			United States Table	
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table
25.5-27 EARTH EXPLORATION-SATELLITE (space-to-Earth) 5.536B FIXED INTER-SATELLITE 5.536 MOBILE SPACE RESEARCH (space-to-Earth) 5.536C Standard frequency and time signal-satellite (Earth-to-space) 5.536A			25.5-27 EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED INTER-SATELLITE 5.536 MOBILE SPACE RESEARCH (space-to-Earth) Standard frequency and time signal-satellite (Earth-to-space) 5.536A US258	25.5-27 Inter-satellite 5.536 Standard frequency and time signal-satellite (Earth-to-space) 5.536A US258

Table 15-2. NEN Primary Frequency Allocations

Band	Frequency	Link	Allocated Services
S-band	2025-2110 MHz	Uplink	Primary: Space Operation, Earth Exploration-Satellite, Space Research
	2110-2120 MHz	Uplink	Primary: Space Research (deep space only)
	2200-2290 MHz	Downlink	Primary: Space Operation, Earth Exploration-Satellite, Space Research
	2290-2300 MHz	Downlink:	Primary: Space Research (deep space only)
X-band	8025-8400 MHz	Downlink	Primary: Earth Exploration-Satellite
	8400-8450 MHz	Downlink	Primary: Space Research (deep space only)
	8450-8500 MHz	Downlink	Primary: Space Research
Ku-band	13.4-14.2 GHz	Downlink	Secondary: Space Research (Note)
	14.5-15.35 GHz	Uplink	Secondary: Space Research
Ka-band	25.5-27.0 GHz	Downlink	Primary: Earth Exploration-Satellite, Space Research
Note: In the band 13.75 –14.0 GHz, geostationary space stations in the space research service, for which information for advance publication has been received by the Internal Frequency Registration Board prior to 31 January 1992, shall operate on an equal basis with stations in the fixed satellite service. New geostationary space stations in the space research service advanced published after that date will operate on a secondary basis.			

15.2.2 DSN Protection

As stated above, the Deep Space Network (DSN) has primary allocations in the 2290 – 2300 MHz, and 8400 – 8450 MHz bands. Each of these bands is adjacent to a NEN allocation. NEN sites are responsible for protecting DSN stations from unacceptable interference.

The ITU-R recommended interference protection criteria in the DSN band for interference from non-DSN transmitters are summarized in Table 13-3.

Table 15-3. Interference Protection Criteria for DSN

Frequency (MHz)	Protection Criteria for DSN Earth Stations(dBW/Hz)
2290 – 2300	-222.0
8400 – 8450	-221.0

S-band links operating in the upper portion of the 2200 – 2290 MHz band have the potential to cause unacceptable interference to deep space missions operating in the 2290 – 2300 MHz band. Recommendation ITU-R SA.1157 defines protection criteria for deep space operations in the 2 GHz band. This recommendation indicates that the protection criterion for deep space Earth stations operating near 2 GHz is that the interference at the input to the deep space earth station receiver should not exceed -222 dBW/Hz and current NASA policy is that this criterion must be met 100% of the time. This protection criterion is measured at the deep space Earth station after accounting for the receiving antenna gain.

Platforms operating in the upper portion of the 2200 – 2290 MHz band need very stringent filtering to meet the deep space protection criteria. For example, a platform using a 2287.5 MHz return/down link with a necessary bandwidth of 5 MHz or higher coule easily violate the deep space protection criteria when it transmits within the view of a DSN ground antenna.

Mitigation techniques such as filtering out sideband emissions have been very successful to meet the deep space protection criterion. In particular, the "NASA/GSFC Recommended Filtering Referenced to the Output of the Power Amplifier" minimizes the interference in the DSN band with a reasonable implementation loss. Figure 15-1 shows the output spectral plot of the "NASA/GSFC Recommended Filtering Referenced to the Output of the Power Amplifier". Figure 13-2 shows an example of the spectral output of an unfiltered BPSK signal vs. a signal filtered by the "NASA/GSFC Recommended Filtering Referenced to the Output of the Power Amplifier" and compares them to the DSN protection criterion. . Such a filter could reduce or eliminate the need for operational coordination of down/return links.

X-band links operating in the upper portion of the 8025-8400 MHz and the 8450-8500 MHz bands also have the potential to cause unacceptable interference to deep space missions operating in the 8400-8450 MHz band, and current NASA policy is that this criterion must be met 100% of the time, so appropriate mitigation techniques must be employed to ensure that ITU-R SA.1157 protection criteria are met above 8400 MHz.

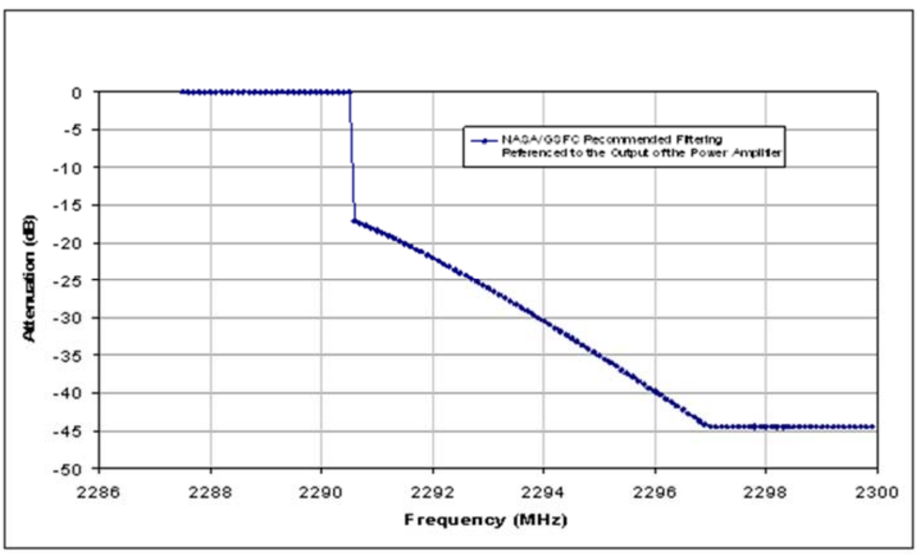


Figure 15-1. Spectral Output for NASA/GSFC Recommended S-band Filtering Referenced to the Output of the Power Amplifier

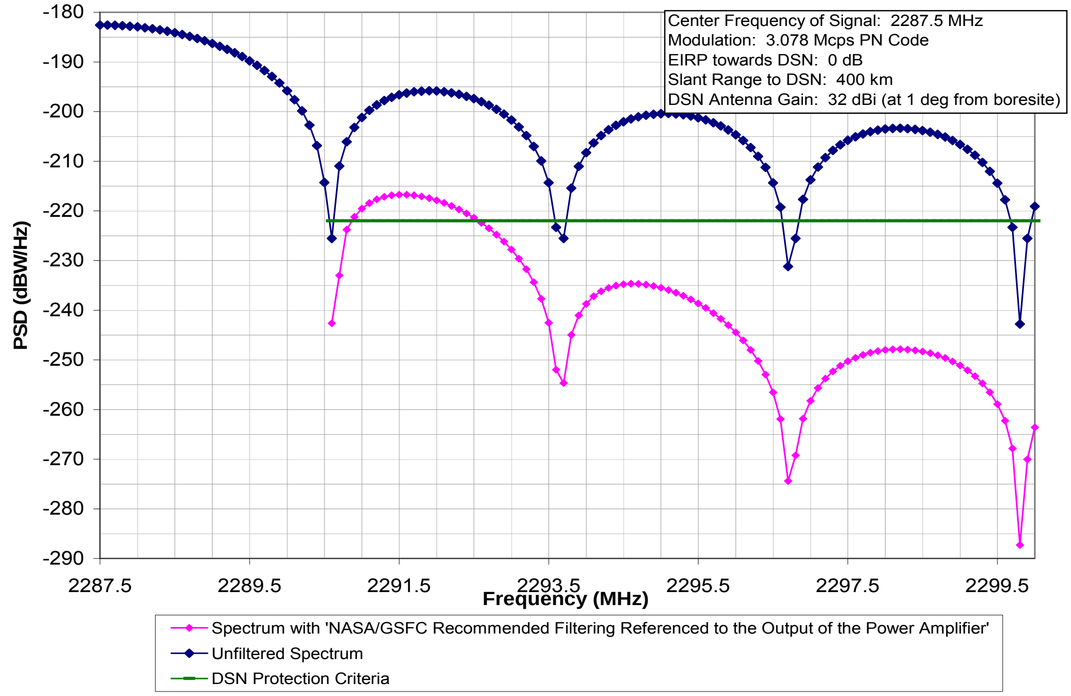


Figure 15-2. Example of Unfiltered and Filtered 3 Mcps Code with DSN Protection Criteria for S-band

15.2.1 Protection of Terrestrial Operations and Ground Receivers

NEN users share most of their receive bands with terrestrial services. Terrestrial services are protected by limiting the spacecraft power-flux density at the surface of the earth from space-based transmitters. Power Flux Density limits are imposed on missions by both the NTIA and the ITU-R. Those limit values can be found in the ITU-R Radio Regulations Article 21, Table 21-4. Although largely similar, there are a few differences between the ITU-R and the NTIA National Power Flux Density limits also imposed upon US missions. In some cases the NTIA limits may be more constraining or there may be NTIA limitations for spectrum where there are no ITU-R limitations. Additional limitations apply for EESS operation in the 8025-8400 MHz spectrum.

The Power Flux Density (PFD) limit is defined at the Earth's surface as a function of the angle of arrival above the local horizontal plane θ, for all conditions and for all methods of modulation. The limits relate to the PFD that would be obtained under assumed free-space propagation conditions.

Table 15-4. PFD Limits Applicable to TypicalNEN Bands

Frequency (MHz)	Power-Flux Density Limit for Angles of Arrival (θ) Above the Horizontal Plane (dBW/m^2)			Reference Bandwidth
	$0^\circ \leq \theta \leq 5^\circ$	$5^\circ < \theta < 25^\circ$	$25^\circ \leq \theta \leq 90^\circ$	
460 – 470	-152	-152	-152	4 kHz
2200 – 2290	-154 -130	-154 + 0.5 (θ - 5) -130 + 0.5 (θ - 5)	-144 -120	4 kHz
8025 – 8500	-150	-150 + 0.5 (θ - 5)	-140	4 kHz
25500 – 27000	-115	-115 + 0.5 (θ - 5)	-105	1 MHz

15.2.1 ITU-R and SFCG Limits on PFD in X-band for EESS Downlinks

SFCG Recommendation 14-3R9 and ITU-R Recommendation SA.1810 provide system design guidelines for Earth-exploration satellites operating in the band 8025-8400 MHz and they define the following specific PFD limit for EESS transmissions in the 8025-8400 MHz band. This limit is more constraining than the normal ITU-R (and NTIA) limitation.

15.3 Obtaining Frequency Spectrum Authorization

15.3.1 Regulations, Policies, and Instructions

NASA missions must comply with all US and international frequency spectrum requirements. Reference 'g' in Section 1.3 states these requirements and other legal obligations mandated by NTIA. Reference 'i' in Section 1.3 provides detailed instructions for obtaining frequency spectrum authorization in compliance with reference 'g' in Section 1.3.

15.3.2 GSFC Spectrum Management Office

The GSFC Spectrum Management Office is responsible for all spectrum-related activities associated with the NEN. The Office is part of the ESC Projects Division, Code 450. The responsibilities of the Spectrum Management Office include:

a. Coordinate RF spectrum requirements pertaining to GSFC and NEN resources, in accordance with Chapters 2 and 3 of reference 'i' in Section 1.3.

b. Ensure interference-free operations between user vehicles and the NEN, in accordance with Chapter 4 of reference 'i' in Section 1.3.

c. Assist the flight project in determining frequency requirements, including performing interference analyses and specifying the frequencies to be used after obtaining all required domestic and international coordination agreements..

d. Provide guidance in providing the information required to complete the Frequency Authorization Request to be sent to the NTIA. Chapter 10 of reference 'j' in Section 1.3 provides instructions for information required for filing the requests.

e. Coordinate with the NTIA's Spectrum Planning Subcommittee and Space Systems Subcommittee, which conduct the frequency spectrum allocation review, and the review of international spectrum paperwork. Appendix F of reference 'j' in Section 1.3 describes the four-stage review process for the national process.

15.3.3 Flight Project Responsibilities

Flight projects must contact the GSFC Spectrum Management Office to begin the allocation request process prior to any contractual decisions that would commit the project to a specific design (see Section 13.3.2). Each project must designate a point-of-contact for working with the Spectrum Management Office as given in Reference NPD 2570.1, *NASA Radio Frequency (RF) Spectrum Management Manual*.

15.4 Bandwidth Requirements

In order to more efficiently utilize the limited spectrum allocated for space-to-Earth data transmissions, the SFCG and NTIA have recommendations for bandwidth utilization in S-and X-bands as discussed below. NEN bands not listed do not have such restrictions.

15.4.1 BW Requirements in the 2200-2290 MHz Band

Considering that most space-to-Earth systems and space-to-space systems currently operating in the band use bandwidths no more than 6 MHz, and that larger bandwidths than the above do not promote homogeneity and tend to increase future congestion in the band, the SFCG recommends that systems using this band be designed to minimize their bandwidths to reduce the potential interference to other systems in the band.

NTIA requires the following limits in Section 8.2.41 of the NTIA manual for all US licensed operations:

In the band 2200-2290 MHz, space-to-Earth and space-to-space operations should make use of transmissions that have necessary bandwidths constrained to no more than 5 MHz. For transmissions that require necessary bandwidths of greater than 5 MHz, the requesting agency shall submit justification on why a bandwidth exceeding 5 MHz is necessary; furthermore agencies are to explain why the radio communications requirement cannot be satisfied through use of transmissions using less bandwidth, (i.e., 5 MHz or less), (e.g., through use of more spectrally efficient modulation). Spread spectrum missions (e.g., space-to-Tracking and Data Relay Satellite communications, lunar downlinks, and lunar data relay satellite communications) that enable multiple users on the same channel and require a necessary bandwidth of approximately 6.16 MHz are exempt from this policy.

15.4.2 BW Requirements in the 8450-8500 MHz Band

SFCG Recommendation SFCG 05-1R5 recommends that the 8450 – 8500 MHz band is used for Category A (near-Earth) missions requiring an occupied bandwidth of up to 10 MHz per mission and having technical requirements that are best satisfied in the band.

15.5 Unwanted Emission Masks

Figure 15-3 shows the unwanted emission mask given in Section 5.6 of the NTIA Manual. This emission mask is applicable for all US authorized Earth and space stations operating above 470

MHz. The NTIA emission mask applies to the continuous spectrum and all discrete spectral lines, including spurious outputs and harmonics.

The NTIA mask is interpreted as follows:

a. dBsd is dB attenuation in a 4 kHz bandwidth, relative to the maximum power in any 4 kHz band within the necessary bandwidth.

b. For frequencies offset from the assigned frequency less than the 50% of the necessary bandwidth (B_n), no attenuation is required.

c. At a frequency offset equal to 50% of the necessary bandwidth, an attenuation of at least 8 dB is required.

d. Frequencies offset more than 50% of the necessary bandwidth should be attenuated by the following mask:

$$40 \cdot \log\left(\frac{2 \cdot |f_d|}{B_n}\right) + 8 \quad \text{(dBsd)}$$

where f_d is the frequency displaced from the center of the emission bandwidth.

a. For cases of very narrow-band emissions where the necessary bandwidth is less than the minimum bandwidth (B_L) given in Figure 15-3, B_L shall be used in place of B_n.

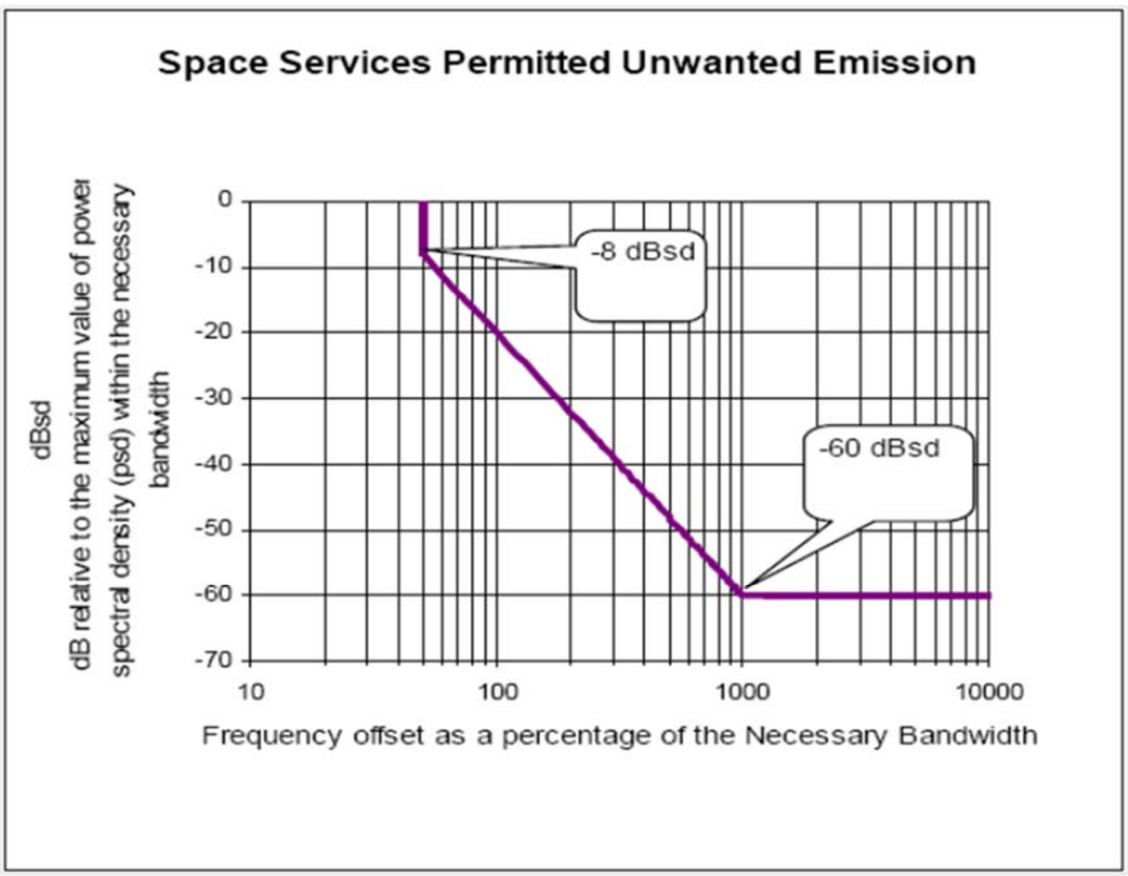


Figure 15-3. NTIA OOB Emission Mask for Earth and Space Stations

15.5.1 SFCG Emission Mask

Figure 15-4 shows the unwanted emission mask specified by SFCG Recommendation SFCG 21-2R4. That Recommendation contains the following recommendations for all operations:

1) that space agencies use the most bandwidth efficient modulation schemes practicable for their missions;
2) that, PCM/PM/Bi-phase or PCM/PM/NRZ modulation only be used when a carrier component is technically necessary and for symbol rates below 2 Ms/s;
3) that the emitted spectrum[3,4] for all Space Science Services projects that will utilize space-to-Earth link frequency assignments in the bands 2200–2290 MHz, 8025–8400 MHz and 8450–8500 MHz, adhere to the low rate spectral emission mask of Figure 15-4 for symbol rates below 2 Ms/s and to the high rate spectral emission mask of Figure 15-4 for symbol rates equal or above 2 Ms/s;
4) that the emitted spectrum[3] for all Space Science Services projects designed for launch after 2020 that will utilize space-to-Earth link frequency assignments in the 25.5-27.0 GHz band and for channel symbol rates[5] equal or above 10 Ms/s, adhere to the high rate spectral emission mask of Figure 15-4;
5) that transmissions that include a ranging signal be exempt from the spectrum masks in Fig 1;
6) that PCM/PSK/PM transmissions in accordance with REC SFCG 21-3 be exempt from the spectrum masks in Fig 15-4.

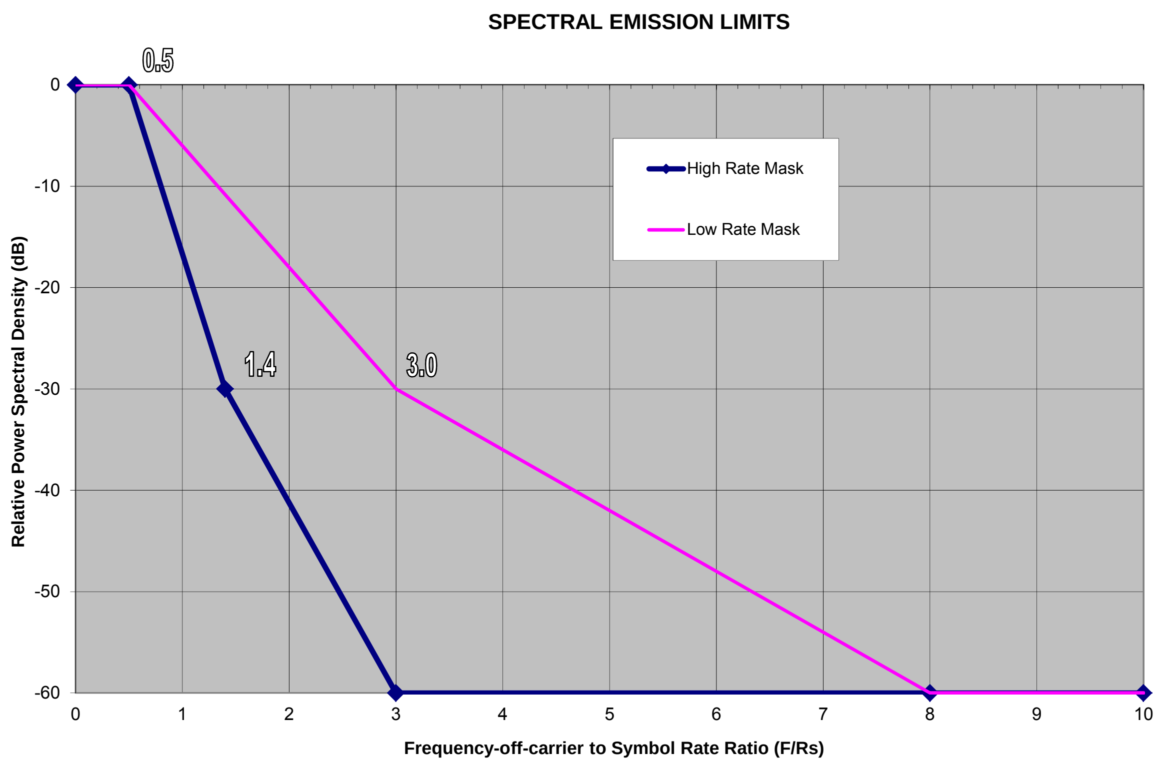


Figure 15-4. SFCG OOB Emission Mask for Space Stations in S/X/Ka-Bands

Refer to Recommendation SFCG 21-2R4for full details on the requirements as the document is subject to revisions and updates and the information included her is just a summary.

Section 16. Link Budget Parameters

16.1 General

This section provides S-band and X-band link parameters that will assist flight projects with link budget calculations. The link budget parameters provided in this section are estimated values for example purposes only. For specific link budget calculations, contact the ESC Projects Division Program Office. This section provides the following information:

a. S-band atmospheric and rain attenuation constants.

b. X-band atmospheric and rain attenuation constants.

c. Ka-band atmospheric and rain attenuation constants.

d. Example user spacecraft constraint losses and ground terminal losses for telemetry links.

e. X-band G/T measurement data.

f. Ground station line-of-sight coverage for spacecraft altitudes between 500 km and 1000 km.

16.2 S-band Atmospheric and Rain Attenuation Constants

Atmospheric and rain attenuation constants were developed for S-band (2200 MHz – 2400 MHz) NEN stations based on ITU recommendation ITU-R P.618-10. Table 16-1 lists the S-band rain attenuation constants for the NEN stations that have S-band capabilities. There are other propagation effects such as scintillation, cloud, site diversity etc. Refer to the Code 450 CLASS Group for further detail analysis.

16.3 X-band Atmospheric and Rain Attenuation Constants

Atmospheric and rain attenuation constants were developed for the X-band (8000 MHz – 8500 MHz) NEN based on ITU recommendation ITU-R P.618-10. Table 16-2 lists the X-band rain attenuation constants for the NEN stations that have X-band capabilities. There are other propagation effects such as scintillation, cloud, site diversity etc. Refer to the Code 450 CLASS Group for further detail analysis.

16.4 Ka-band Atmospheric and Rain Attenuation Constants

Atmospheric and rain attenuation constants were developed for the Ka-band (25500 MHz – 27000 MHz) NEN based on ITU recommendation ITU-R P.618-10. For Table 16-3 lists the Ka-band rain attenuation constants for the NEN stations that have Ka-band capabilities. There are other propagation effects such as scintillation, cloud, site diversity etc. Refer to the Code 450 CLASS Group for further detail analysis.

Table 16-1. S-band Rain Attenuation Constants (5° Elevation Angle) [2.3 GHz]

Ground Station	Rain Attenuation (dB)		
	99% Availability	99% Availability	99% Availability
SGS (Norway)	0.0	0.0	0.02
WGS (WFF)	0.01	0.04	0.16
MG1 (Antarctica)	0.0	0.0	0.0
ASF (Alaska)	0.0	0.01	0.06
PDL (Florida)	0.02	0.12	0.40
WS1 (White Sands, New Mexico))	0.00	0.03	0.12
USHI (USN South Point, Hawaii)	0.02	0.15	0.48
AUWA (USN Dongara, Australia)	0.0	0.03	0.13
HBK (Hartebeesthoek, South Africa)	0.01	0.07	0.25
KIR (Kiruna, Sweden)	0.0	0.01	0.05
AGO (Santiago, Chile)	0.0	0.02	0.06
WAL (Weilheim, Germany)	0.0	0.03	0.12

Table 16-2. X-band Rain Attenuation Constants (5° and 10° Elevation Angle) [8.5 GHz]

Ground Station	Elevation Angle	Rain Attenuation (dB)	
		99% Availability	99.9% Availability
SGS (Norway)	5°	0.12	0.62
	10°	0.06	0.32
WGS (WFF)	5°	1.04	4.30
	10°	0.60	2.60
MG1 (Antarctica)	5°	0.01	0.05
	10°	0.0	0.02
ASF (Alaska)	5°	0.36	1.63
	10°	0.20	0.95
USHI (USN South Point, Hawaii)	5°	2.74	13.71
	10°	1.46	8.87
AUWA (USN Dongara, Australia)	5°	0.77	4.28
	10°	0.40	2.66
HBK (Hartebeesthoek, South Africa)	5°	1.53	8.02
	10°	0.80	5.03

Table 16-3. Ka-band Rain Attenuation Constants (5° and 10° Elevation Angle) [27 GHz]

Ground Station	Elevation Angle	Rain Attenuation (dB)			
		90% Availability	95% Availability	99% Availability	99.9% Availability
WS1 (White Sands)	5°	1.84	3.08	8.98	40.15
	10°	1.07	1.82	5.47	28.94

16.5 Implementation Losses, Constraint Losses, and Ground Terminal Losses

Constraint loss is the link degradation due to linear and non-linear spacecraft transmitter distortions. Ground terminal loss is the link degradation due to ground terminal receive system distortions. The sum of the constraint loss and the ground terminal loss is typically stated as the implementation loss in NEN link budgets.

Constraint losses and ground terminal losses vary with spacecraft and ground station design, and are usually analyzed on a case-by-case basis. There is no fixed constraint loss value for all spacecraft and no fixed ground terminal loss value for all NEN stations. Variations in a spacecraft's transmitter signal characteristics from mission to mission can significantly impact the amount of constraint loss. Likewise, variations in the ground terminal's receive performance characteristics and operational data rate can significantly impact the amount of ground terminal loss. The ESC Projects Division Program Office typically performs analytical modeling and simulation as required for specific flight project communications hardware and NEN receivers to estimate the overall implementation loss for a mission link budget.

Sections 16.5.1 and 16.5.2 provide example implementation losses, constraint losses, ground terminal losses, and distortion characteristics for X-band and S-band links, respectively.

The loss values and parameters discussed below in Sections 16.5.1 and 16.5.2 are intended to only provide the user an example of the expected link performances under specific scenarios. As previously stated, implementation loss for NEN links should be analyzed on a case-by-case basis. The implementation loss assessment will determine the additional user spacecraft Effective Isotropic Radiated Power (EIRP) required to provide acceptable performance throughout the lifetime of the mission.

In addition to the distortion characteristics stated in Sections 16.5.1 and 16.5.2, the CCSDS and SFCG provide recommended X-band and S-band spacecraft characteristics and distortion limits for space-to-Earth data transmissions. This information can be found in CCSDS 732.0-B-2 and CCSDS 131.0-B-1.

16.5.1 X-band Implementation Loss Examples

Table 16-4 lists the signal characteristics specified for the Ice Cloud, and Land Elevation Satellite (ICESat) X-band transmitter. Simulation for the ICESat project resulted in an estimated constraint loss of 3.0 dB. The constraint loss is greatly dependent on the shape of the transmitter signal magnitude and phase response over the 3 dB bandwidth. Because the actual (measured) response was not available for the simulation, a response shape was assumed for the simulation. As test data becomes available for the flight hardware, the simulations can be repeated using measured distortion values to improve the accuracy of the constraint loss estimate.

Table 16-4. ICESat X-band Transmitter Characteristics

Parameter	Value
Frequency	8100 MHz
Data Format	NRZ-M
Data Rate (I/Q Bit Rate)	20 Mbps on each channel (40 Mbps total)
Data Modulation	Staggered QPSK
Data Asymmetry (1)	≤ 3 percent
Data Rise Time (1)	≤ 2.5 nsec
Data Bit Jitter (1)	≤ 1 percent
I/Q Power Ratio	1:1
I/Q Data Skew (1)	0.5 ± 0.1 symbol period
QPSK Gain Imbalance	≤ 1.2 dB peak to peak
QPSK Phase Imbalance	≤ 5.0 deg
AM/AM	≤ 1.0 dB/dB
AM/PM	≤ 10.0 deg/dB
3 dB Bandwidth	60.0 MHz
Roll-off	0.62 dB/MHz
Gain Flatness	≤ 2.0 dB peak to peak
Gain Slope	≤ 0.4 dB/MHz
Phase Nonlinearity	≤ 5.0 dB peak to peak
Phase Noise (1) 100 Hz – 40 MHz offset from carrier	≤ 2.0 deg RMS
Spurious Phase Modulation (1)	≤ 2.0 deg RMS
Out-of-Band Spurious Output (1)	≤ -40 dBc
Incidental AM (1)	≤ 5 percent
Note: (1) Parameter not simulated for ICESat constraint loss estimate	

The ground terminal loss for ICESat was estimated by performing characterization tests at the Wallops Ground Station using similar equipment to that implemented for ICESat. The test results indicated an estimated ground terminal loss of 2.0 dB. Thus, the resulting X-band implementation loss for the ICESat link budget was estimated at 5.0 dB.

Similar analyses for the Aqua mission resulted in an estimated spacecraft constraint loss of 1.9 dB and a ground terminal loss of 2.5 dB for a total implementation loss of 4.4 dB. The difference in implementation loss between Aqua and ICESat can be attributed to a number of factors including required Bit Error Rate (BER) (10E-3 for Aqua versus 10E-5 for ICESat), the use of measured transmitter gain flatness and phase non-linearity values rather than specified values, and differences in other signal parameters such as data rate, phase noise, and Amplitude Modulation/Phase Modulation (AM/PM) distortion.

16.5.2 S-band Implementation Loss Examples

Table 16-5 lists the signal characteristics for a typical LEO spacecraft's S-band transmitter for the following two scenarios:

a. Suppressed carrier modulation, but no convolutional coding.

b. PM with a residual carrier, but no convolution coding.

Table 16-6 lists the signal characteristics for a typical LEO spacecraft's S-band transmitter for the following two scenarios:

a. Suppressed carrier modulation with rate ½ convolutional coding.

b. PM with a residual carrier with rate ½ convolution coding.

Simulations were conducted to determine the implementation loss for S-band using suppressed carrier modulation schemes and PM with a residual carrier. The simulations were conducted with and without ½ rate convolution. Ground station characteristics were included in the simulations. The ground station characteristics were assumed, but the fidelity scenarios assumed were a conservative representation for existing (or future) NEN ground terminals.

Simulations using the Table 16-5 and Table 16-6 characteristics yielded the implementation losses listed in Table 16-7.

As an example of implementation loss for S-band links with subcarriers, reference n in Section 1.3 states an implementation loss for the ICESat S-band subcarrier telemetry link (PCM, BPSK, PM) as 2.0 dB.

Table 16-5. USAT S-band Transmitter Characteristics (Uncoded)

Parameter	Value
Frequency	2200-2400 MHz
Data Format	NRZ-L
Data Rate (I/Q Bit Rate)	4 Mbps (BPSK), 8 Mbps (QPSK)
Data Modulation	BPSK, QPSK
Data Asymmetry	3 percent
Data Rise Time	5 percent
Data Bit Jitter (1)	≤ 0.1 percent
I/Q Power Ratio	1:1
I/Q Data Skew	2.5 percent
Gain Imbalance	0.25 dB
Phase Imbalance	3.0 deg
AM/AM	0 dB/dB (full saturation)
AM/PM	12 deg/dB
3 dB Bandwidth	8.0 MHz
Roll-off	25 dB/MHz
Gain Flatness (peak-to-peak)	0.3 dB over ± 3.5 MHz
Gain Slope	0.1 dB/MHz
Phase Nonlinearity (peak-to-peak)	3.0 degrees over ± 3.5 MHz
Phase Noise (1)	1 Hz – 10 Hz: ≤ 50.0 degrees RMS 10 Hz – 100 Hz: ≤ 6.0 degrees RMS 100 Hz – 1 kHz: ≤ 2.5 degrees RMS 1 kHz – 6 MHz: ≤ 2.5 degrees RMS
Spurious Phase Modulation	2 degrees RMS @ 15.63 kHz (BPSK) 1 degree RMS @ 15.63 kHz (QPSK)
Spurious Outputs	-23 dBc @ 47.0 kHz -15 dBc @ 12.0 MHz
Incidental AM	5 percent @ 7.48 kHz
Note: (1) Parameter not simulated, but impact on implementation loss determined via analysis techniques.	

Table 16-6. USAT S-band Transmitter Characteristics (Rate ½ Convolutional Coding)

Parameter	Value
Frequency	2200 – 2400 MHz
Data Format	NRZ-L
Data Rate (I/Q Bit Rate)	2 Mbps (BPSK), 4 Mbps (QPSK)
Data Modulation	BPSK, QPSK
Data Asymmetry	3 percent
Data Rise Time	5 percent
Data Bit Jitter(1)	0.1 percent
I/Q Power Ratio	1:1
I/Q Data Skew	2.5 percent
Gain Imbalance	1.0 dB (BPSK); 0.5 dB (QPSK)
Phase Imbalance	9.0 deg (BPSK); 5.0 deg (QPSK)
AM/AM	0 dB/dB (full saturation)
AM/PM	15 deg/dB
3 dB Bandwidth	8.0 MHz
Roll-off	25 dB/MHz (BPSK), 50 dB/MHz (QPSK)
Gain Flatness (peak-to-peak)	0.4 dB over ± 3.5 MHz
Gain Slope	0.1 dB/MHz
Phase Nonlinearity (peak-to-peak)	4.0 degrees over ± 3.5 MHz
Phase Noise (1)	1 Hz – 10 Hz: ≤ 50.0 degrees RMS 10 Hz – 100 Hz: ≤ 6.0 degrees RMS 100 Hz – 1 kHz: ≤ 2.5 degrees RMS 1 kHz – 6 MHz: ≤ 2.5 degrees RMS
Spurious Phase Modulation	2 deg RMS @15.6 kHz (BPSK) 1 deg RMS @ 15.6 kHz (QPSK)
Spurious Outputs	-23 dBc @ 23.5 kHz -15 dBc @ 12.0 MHz
Incidental AM	5 percent @ 3.74 kHz
Note: (1) Parameter not simulated, but impact on implementation loss determined via analysis	

Table 16-7. S-band Implementation Losses

Modulation Scheme	Implementation Loss
PM, Residual Carrier	1.7 dB
BPSK	1.7 dB
QPSK	4.2 dB
PM, Residual Carrier (rate ½ coding)	1.9 dB
BPSK (rate ½ coding)	1.9 dB
QPSK (rate ½ coding)	2.3 dB

16.6 Ground Station Line-Of-Sight Coverage

Figures 16-1 through 16-12 depict each ground station's line-of-sight coverage for spacecraft altitudes of 500 km, 750 km, and 1000 km (red, green and blue respectively). All line-of-sight coverages are based on the local terrain. Line-of-sight coverage analyses for specific mission orbit parameters can be performed by the ESC Projects Division Program Office.

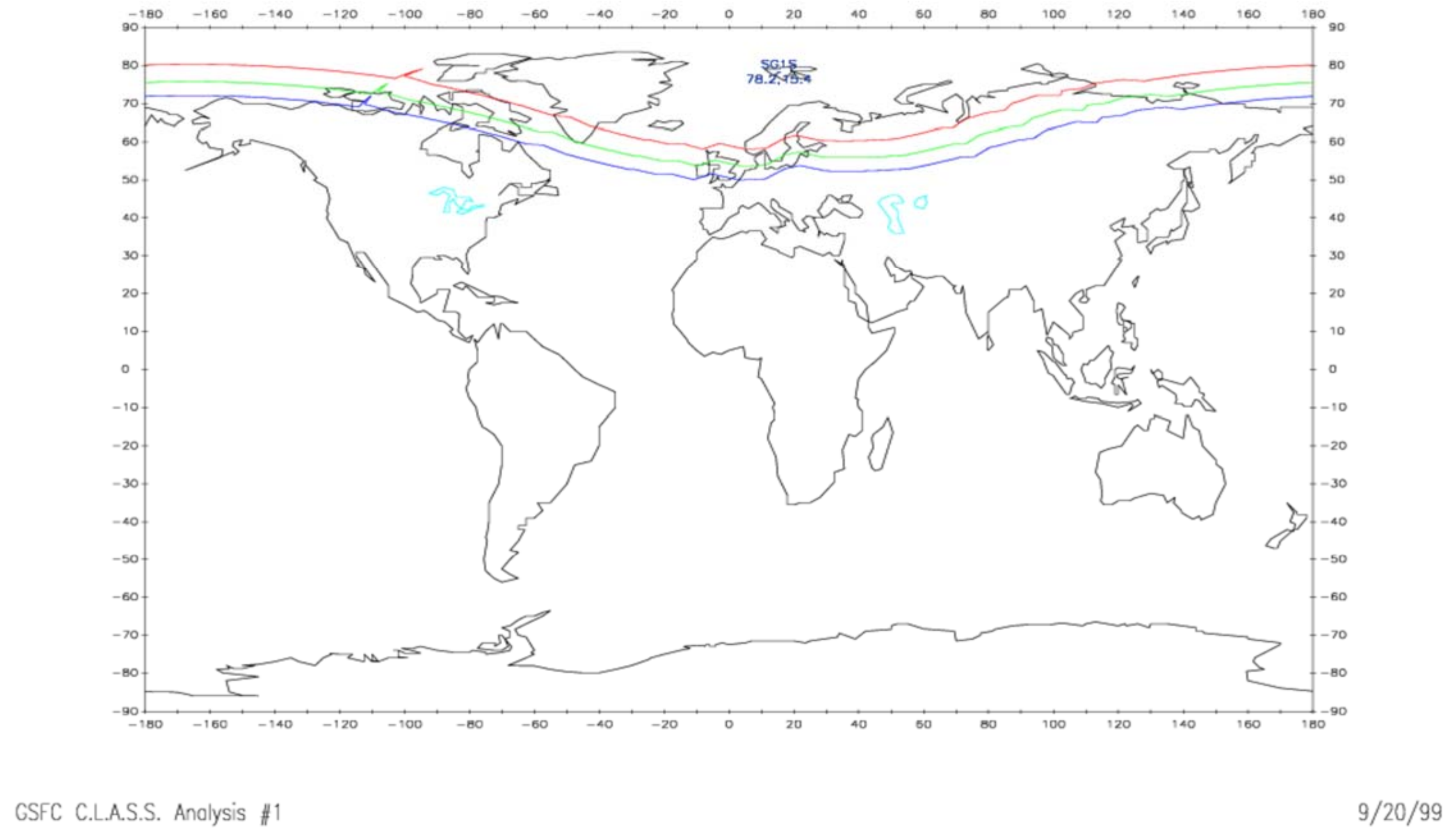


Figure 16-1. Norway Line-of-Sight Coverage

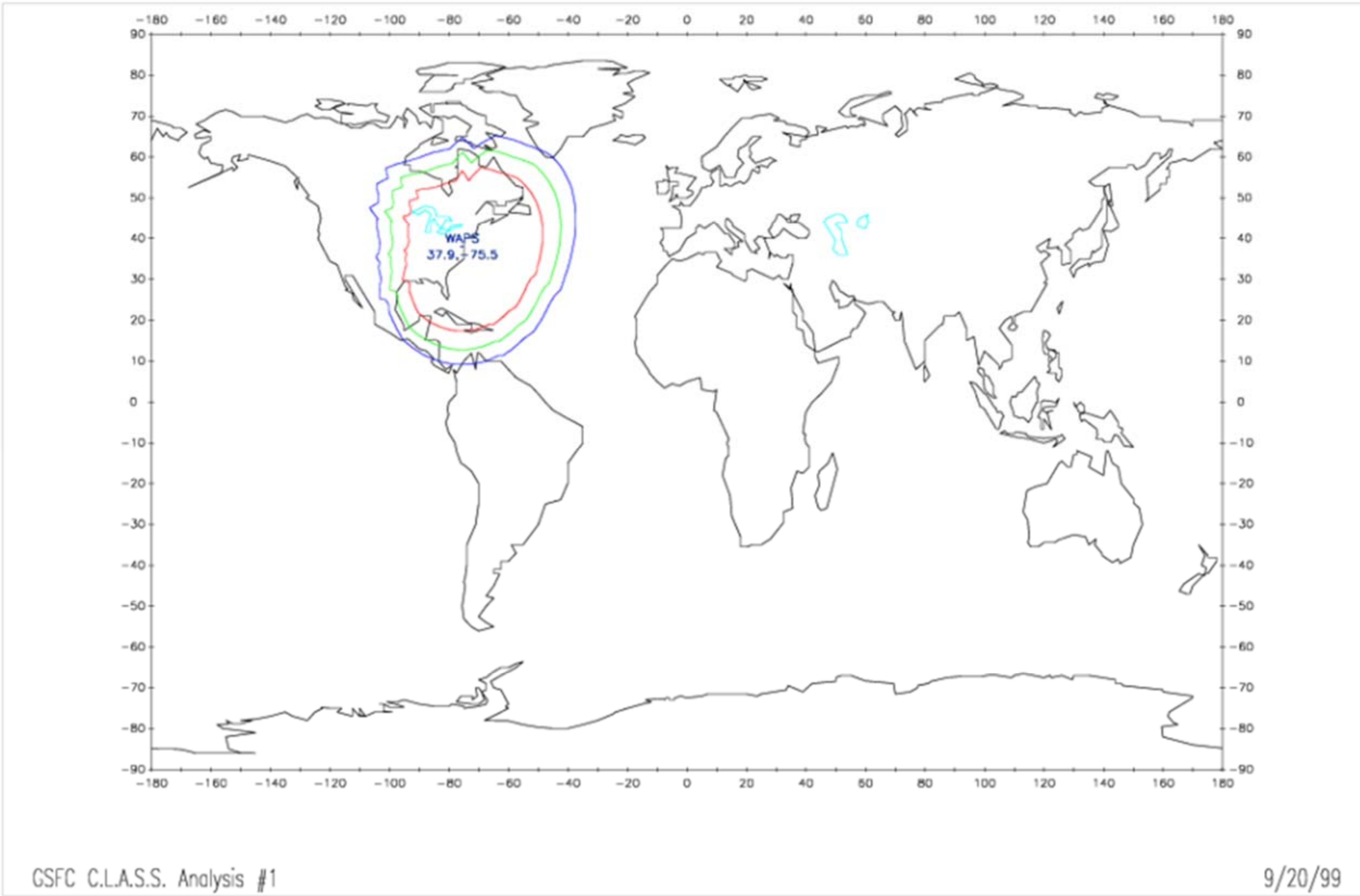


Figure 16-2. Wallops Line-of-Sight Coverage

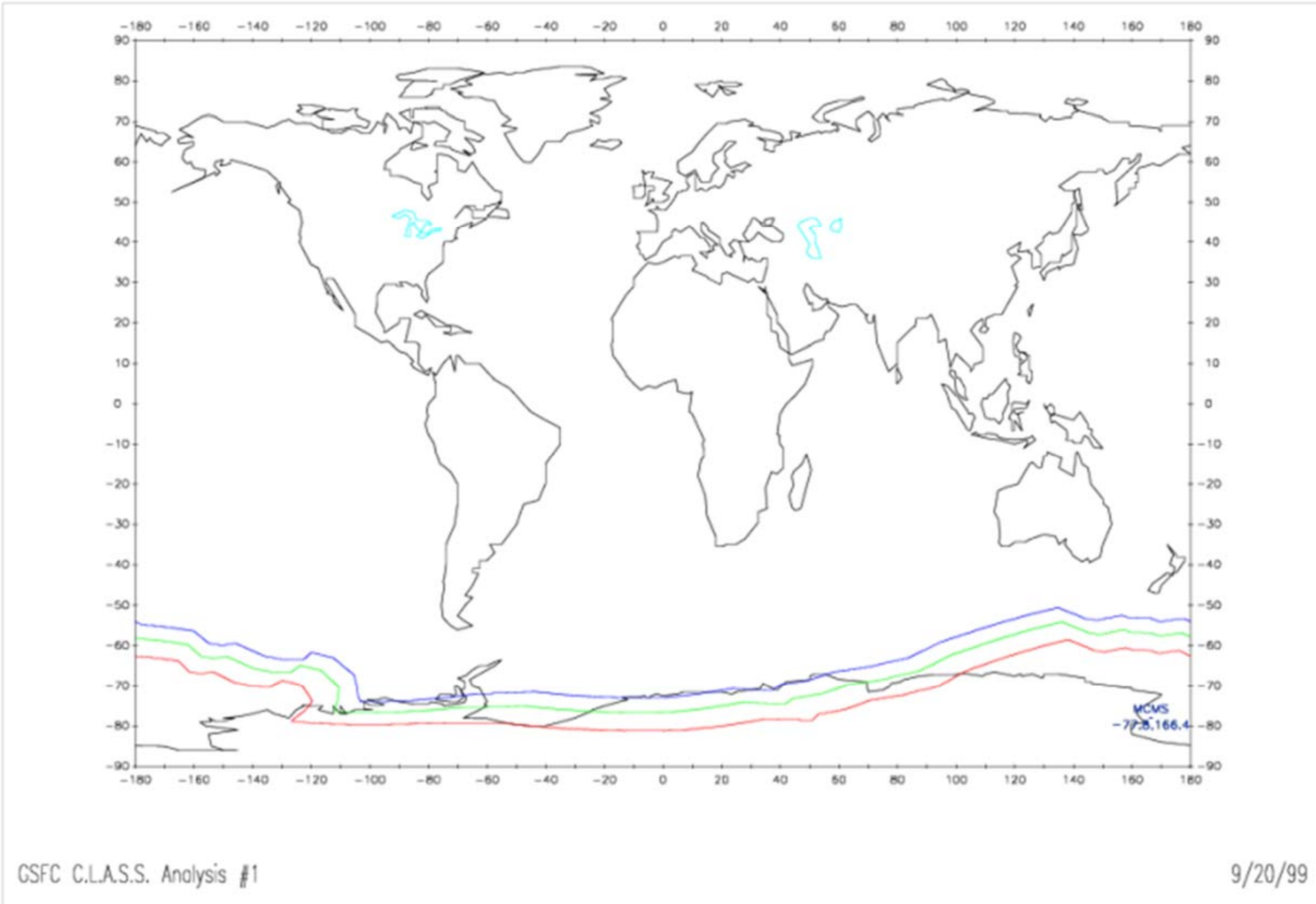


Figure 16-3. McMurdo Line-of-Sight Coverage

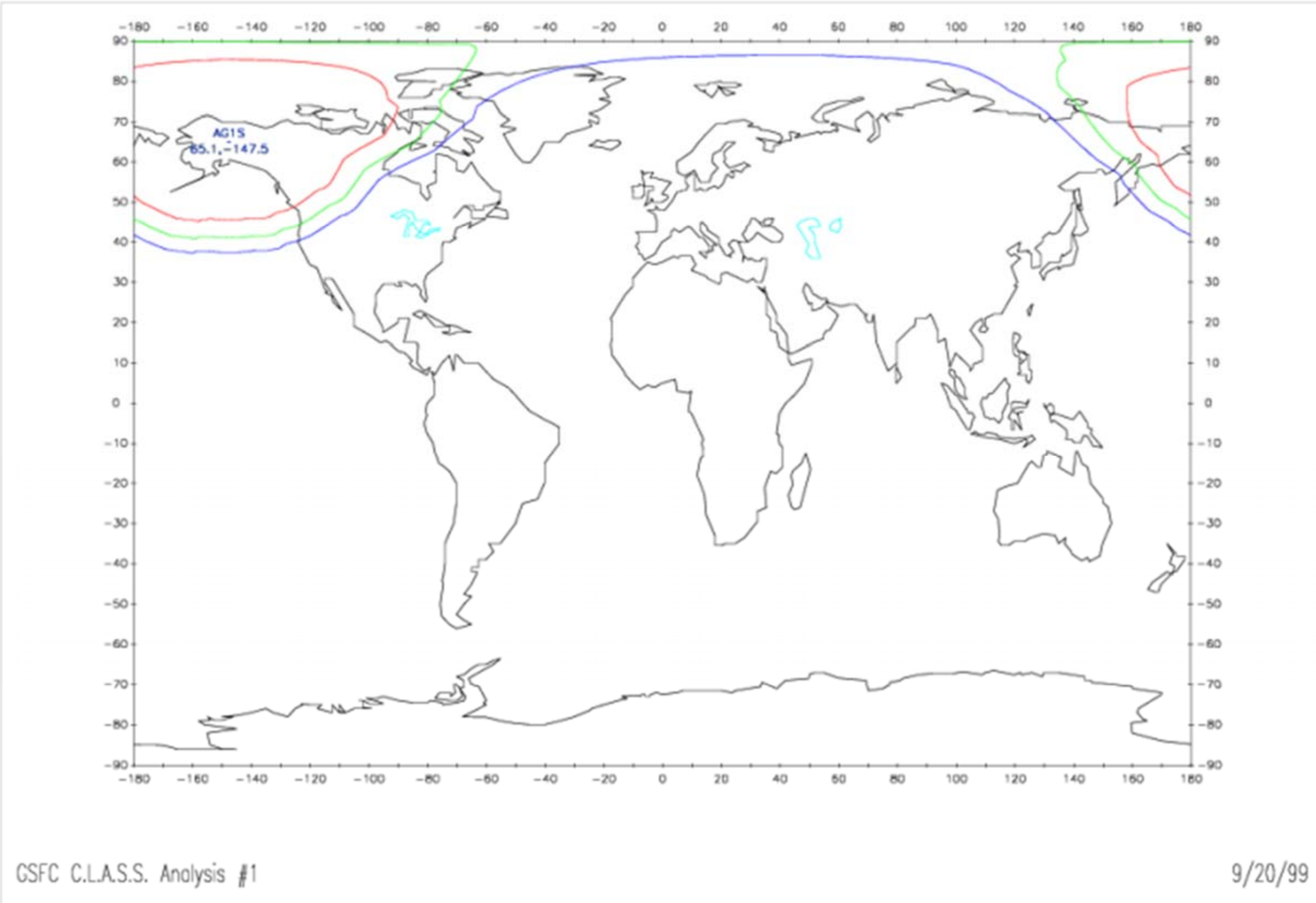


Figure 16-4. North Pole/ASF Line-of-Sight Coverage

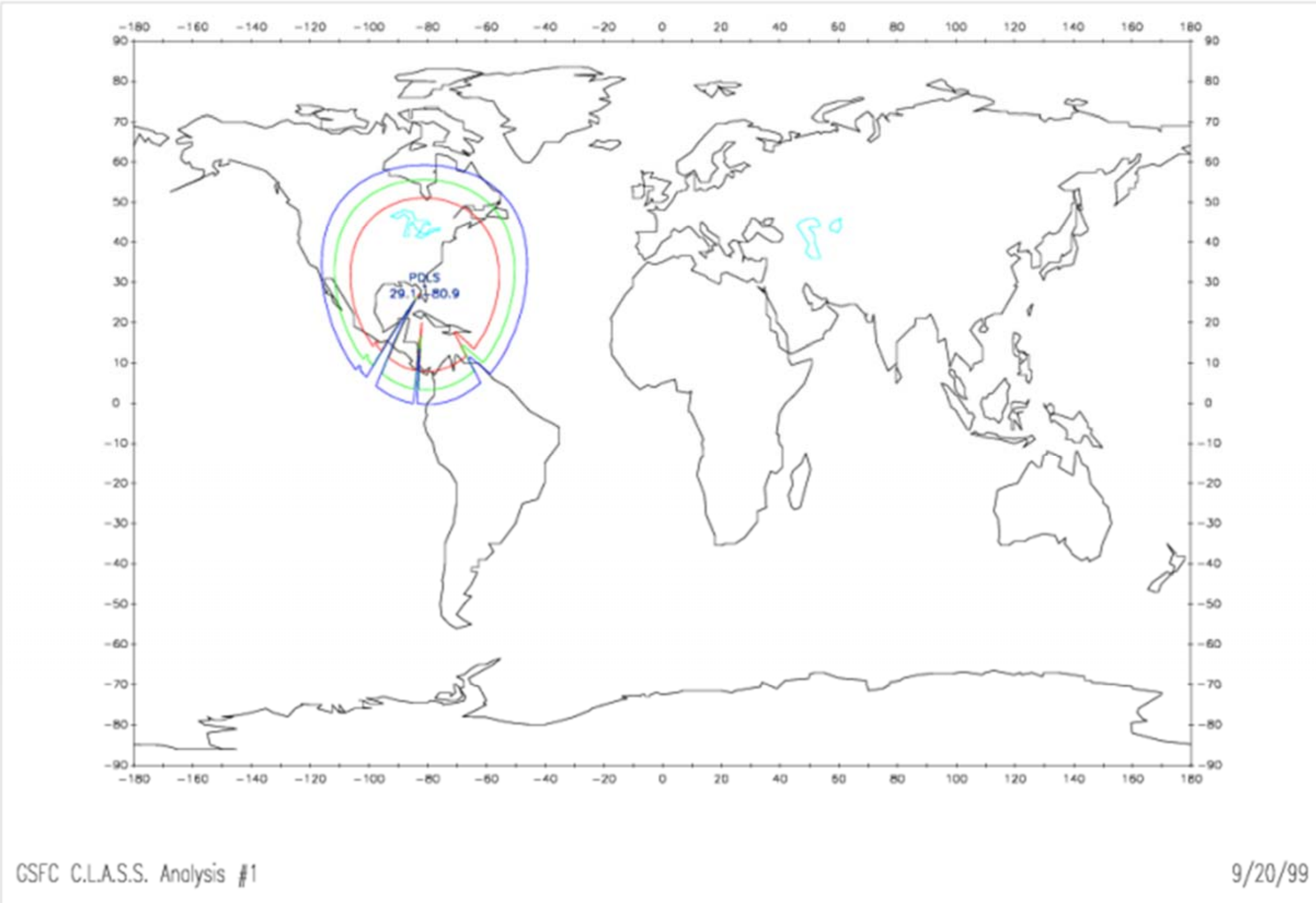


Figure 16-5. PDL Line-of-Sight Coverage

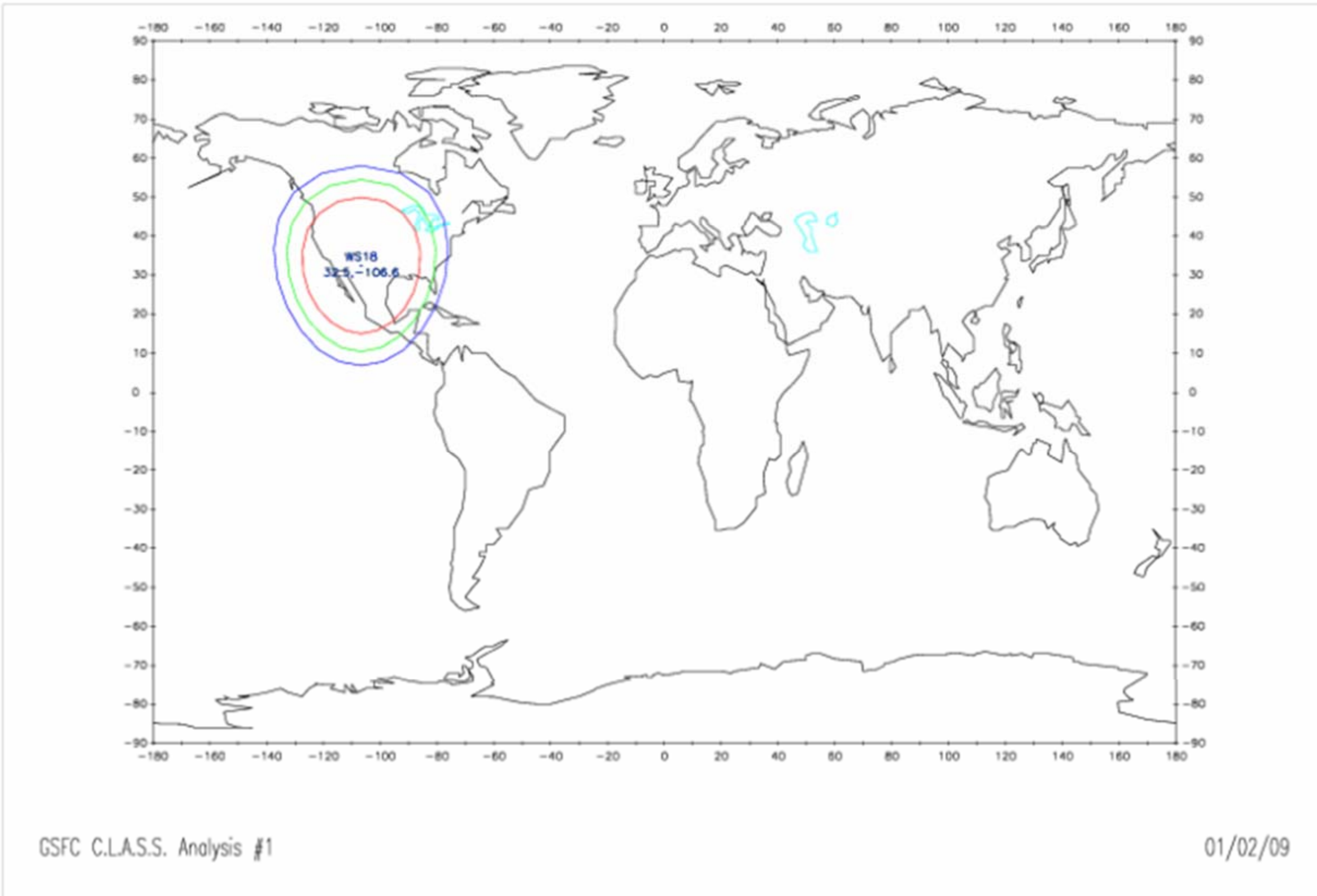


Figure 16-6. WS1 Line-of-Sight Coverage

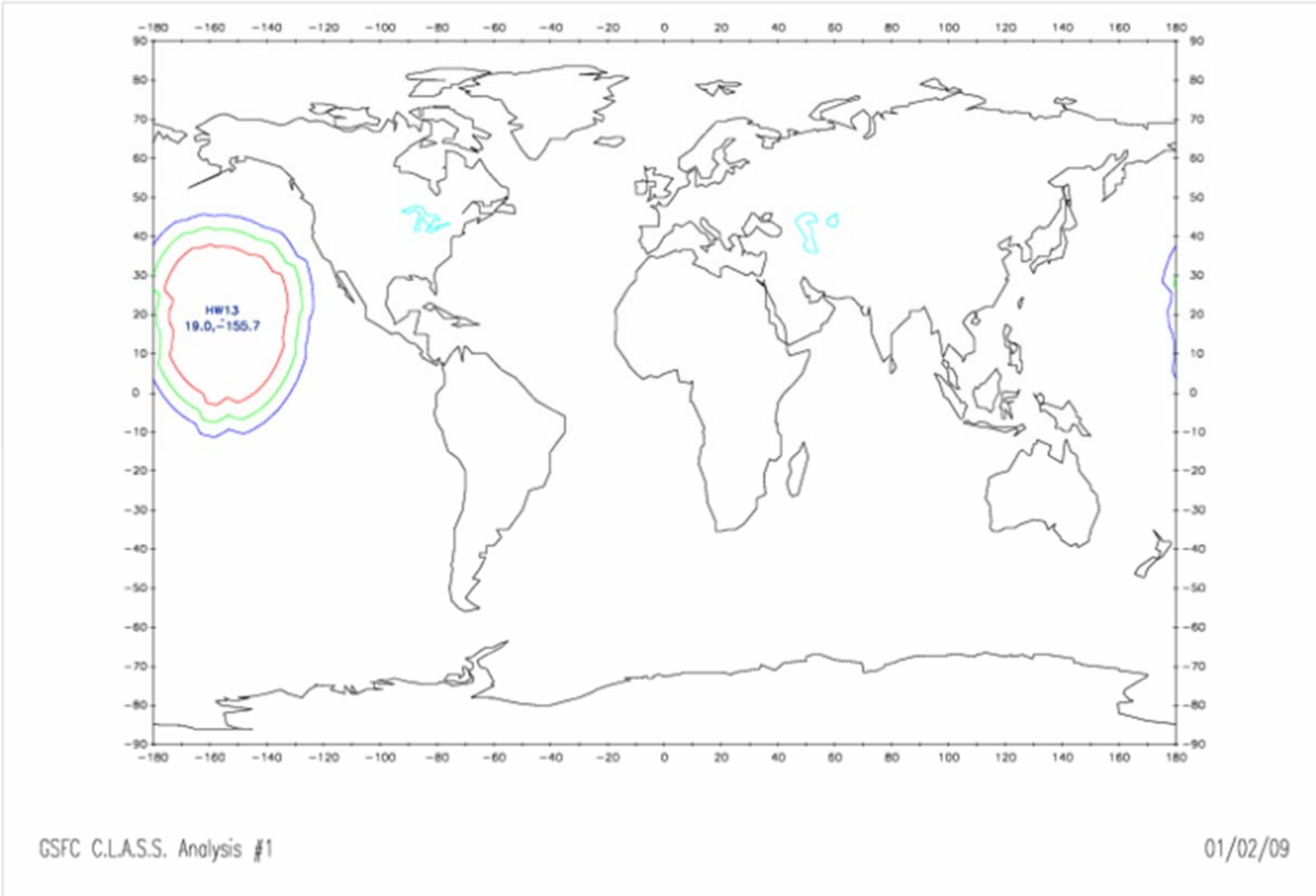


Figure 16-7. USN South Point Hawaii Line-of-Sight Coverage

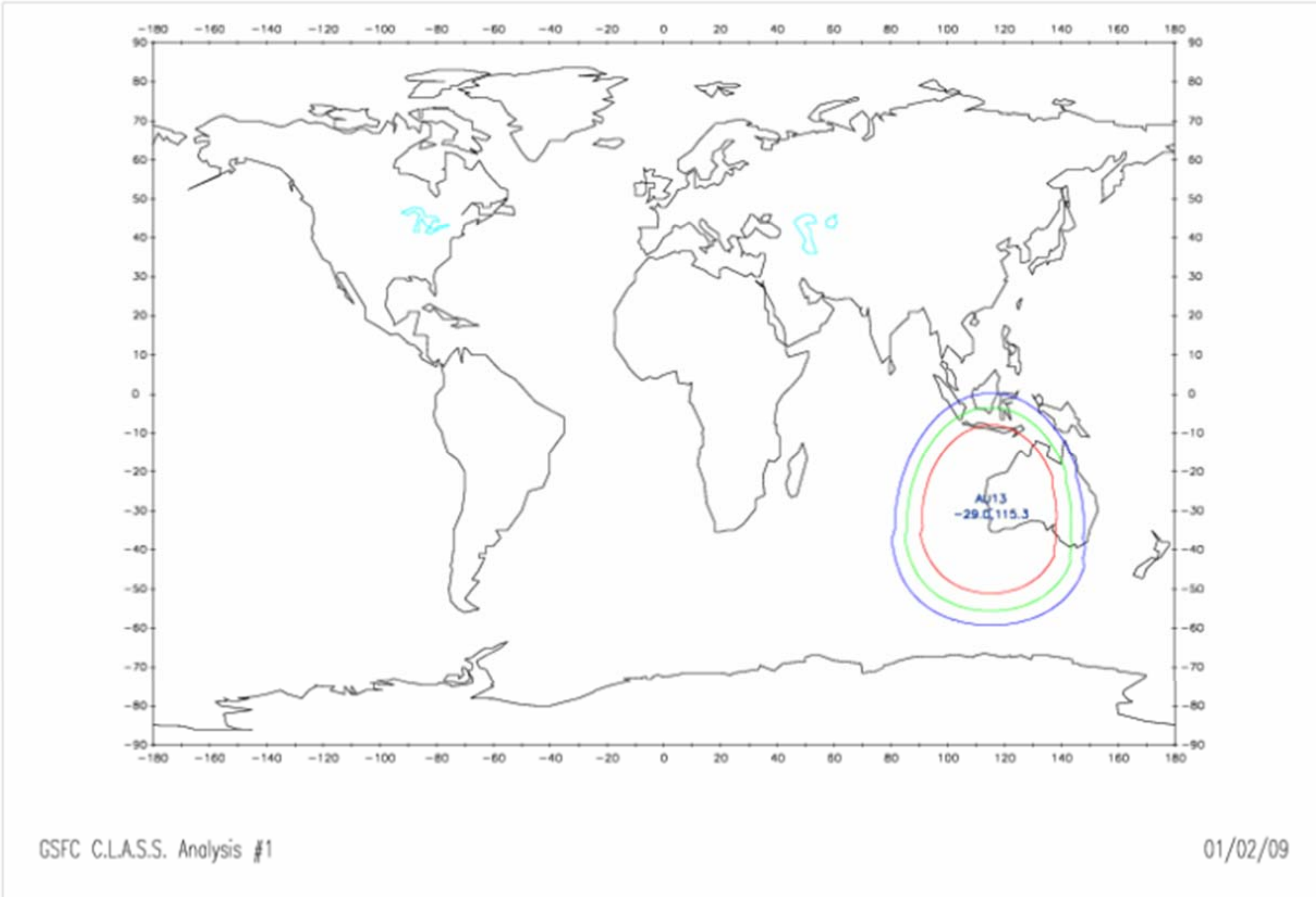


Figure 16-8. USN Dongara Western Australia Line-of-Sight Coverage

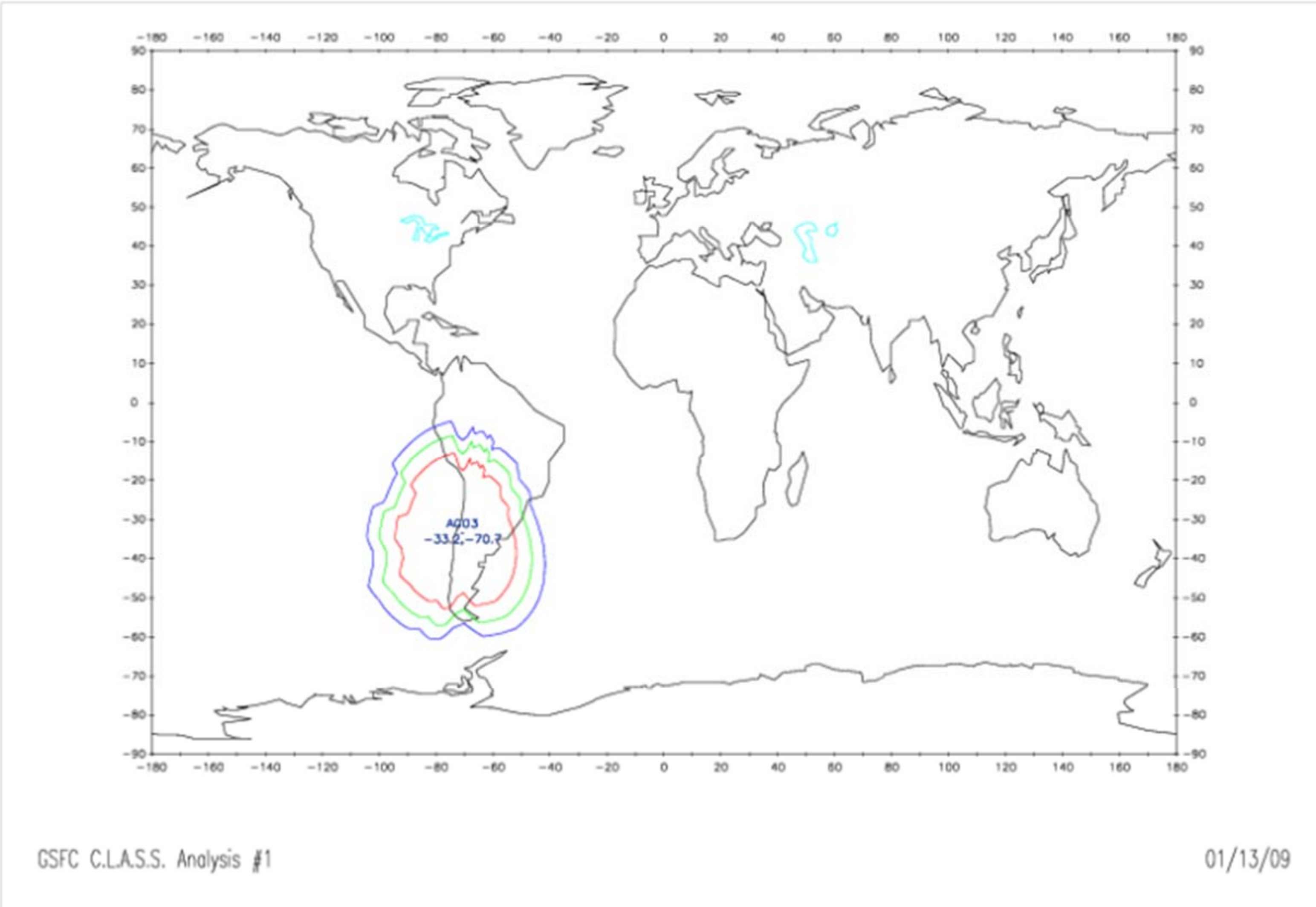


Figure 16-9. AGO Line-of-Sight Coverage

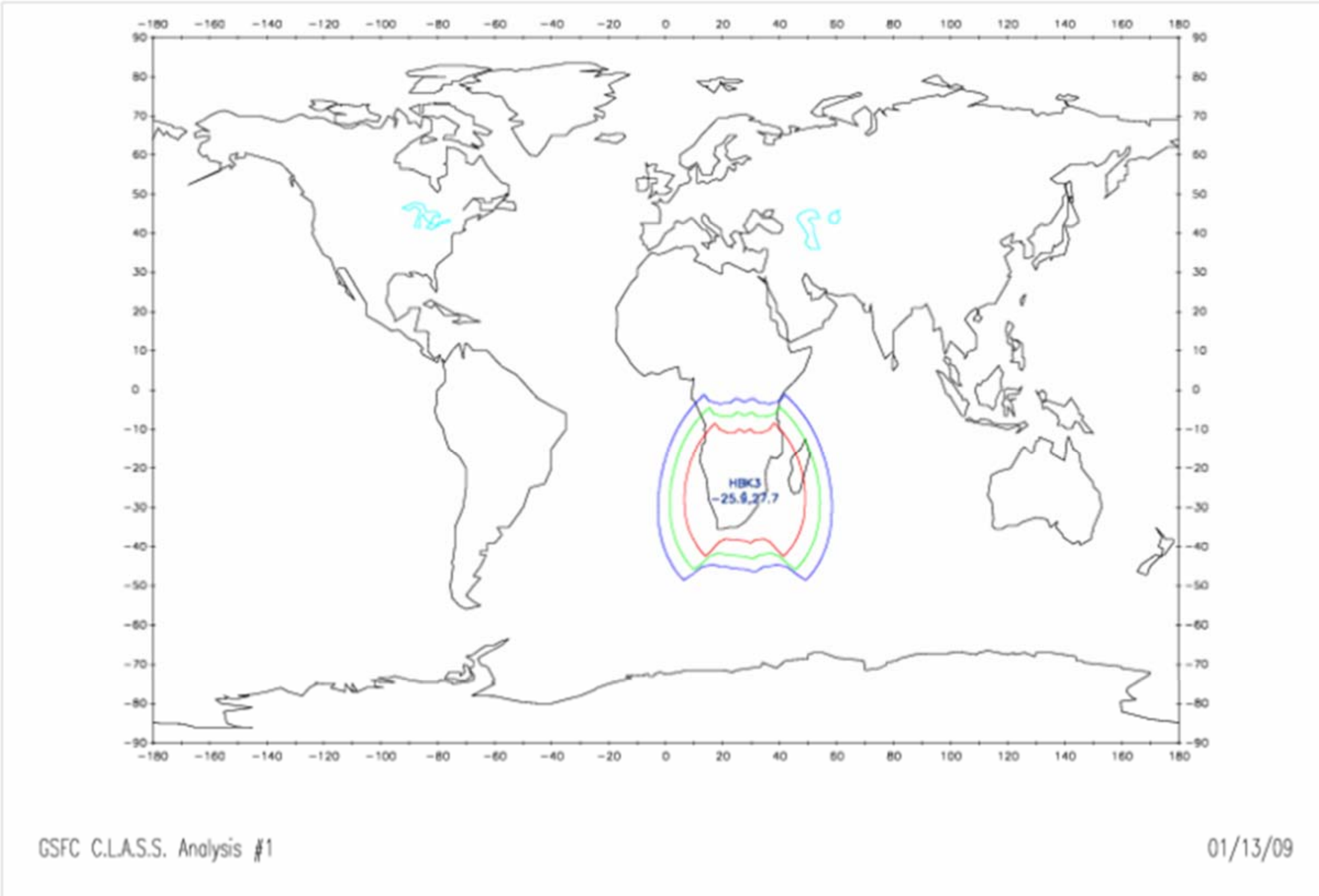


Figure 16-10. Hartebeesthoek Line-of-Sight Coverage

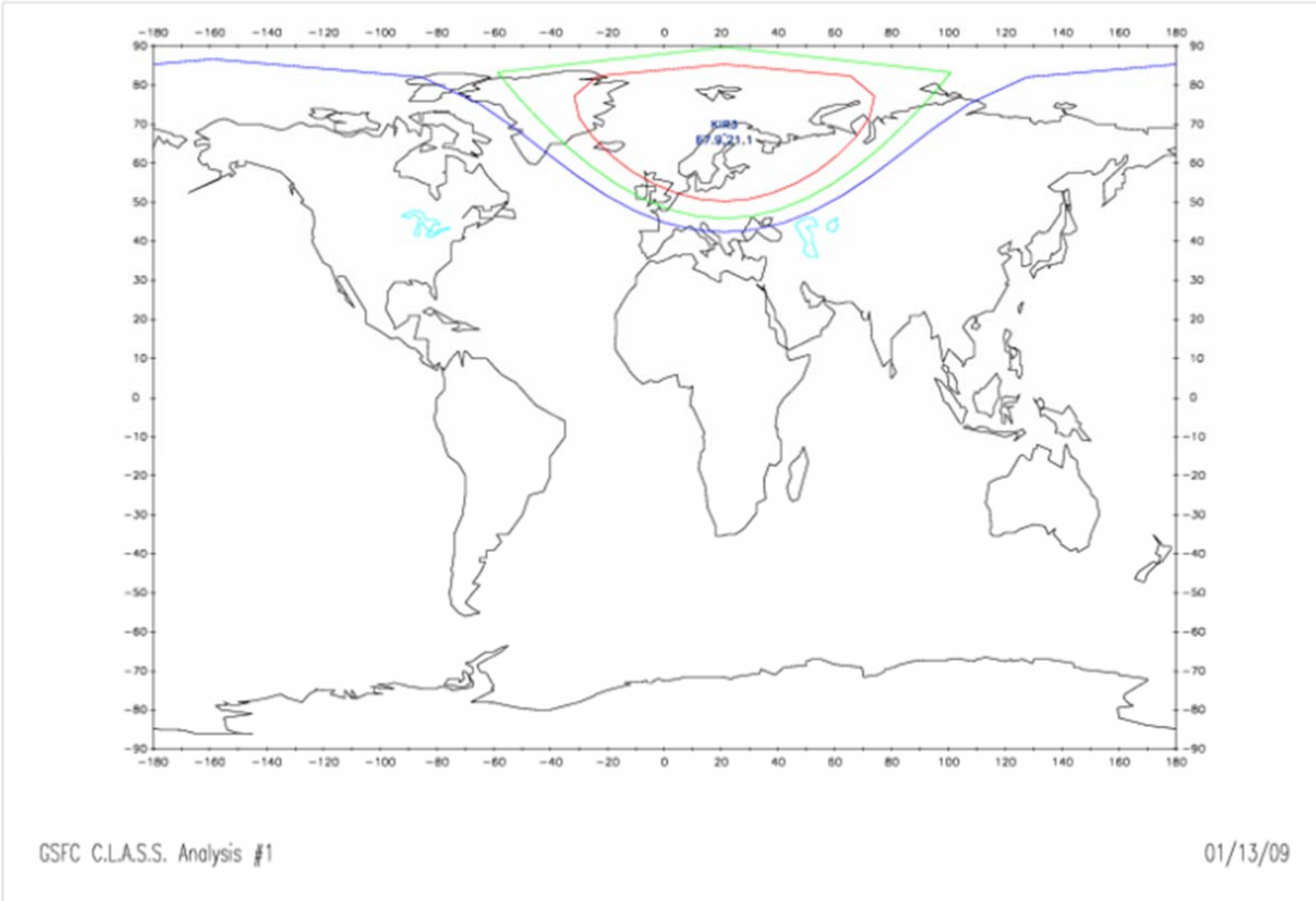


Figure 16-11. Kiruna Line-of-Sight Coverage

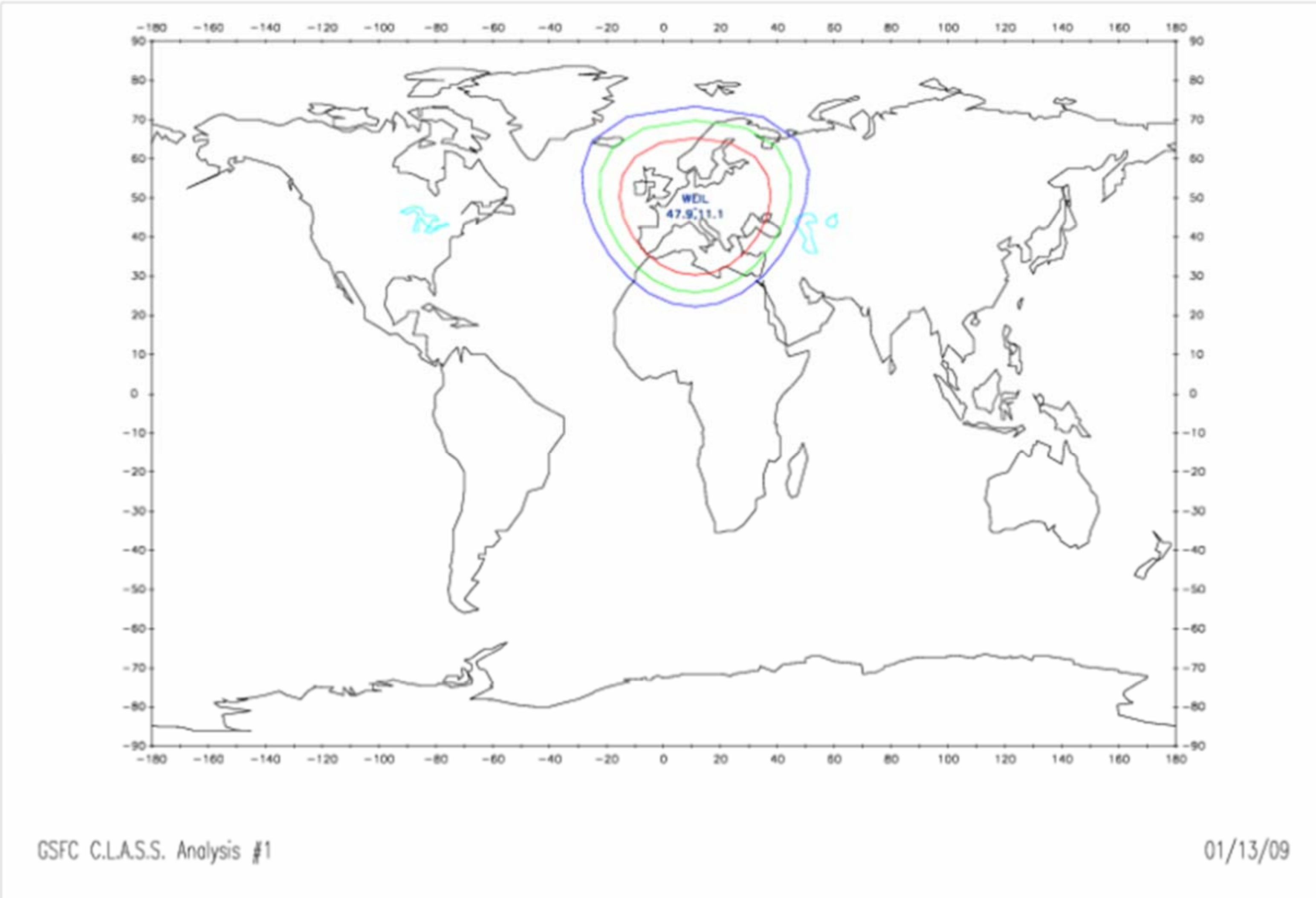


Figure 16-12. Weilheim Line-of-Sight Coverage

Appendix A. Units of Measurement

This appendix contains abbreviations and symbols for commonly used units of measurement. As a general rule, these short forms should be used only in tables or charts, or in text when used with numerals.

A	atto- (prefix 10^{-18})	dBm	decibel referred to 1 milliwatt
A	ampere	dBV	decibel referred to 1 volt
Å	Angstrom	dBW	decibel referred to 1 watt
ata	atmosphere absolute	deg	degree
b/b	bit per block	deg/sec	degree per second
b/f	bit per frame	dg	decigram
b/in.	bit per inch	dr	dram
bps	bit per second	eV	electron volt
Btu	British thermal unit	f	femto- (prefix 10^{-15})
c	centi- (prefix 10^{-2})	F	farad
^{o}C	degree Celsius	F_o	frequency of resonance (center frequency)
C	coulomb	^{o}F	degree Fahrenheit
cal	calorie	frm/sec	frame per second
cc	cubit centimeter	ft	foot
cg	centigram	ft/min	foot per minute
cgs	centimeter-gram-second	ft/sec	foot per second
cm	centimeter	G	gauss; giga- (prefix 10^{9})
d	deci- (prefix 10^{-1})	g	unit of gravitational force; gram
da	deka- (prefix 10^{1})	gal	gallon
dB	decibel	gal/min	gallon per minute
dBi	decibel referred to an isotropic radiation source	gal/sec	gallon per second
GHz	gigahertz (1000 MHz)	lb	pound

h	2ector- (prefix 102)
h:m:s	hours:minutes:seconds
hp	horsepower
hr	hour
Hz	hertz (cycles per second)
in.	inch
in.-lb	inch-pound
in./sec	inch per second
k	kilo- (prefix 103)
kΩ	kilohm
K	kelvin
kb	kilobit
kbps	kilobit per second
keV	kiloelectron volt
kg	kilogram
kHz	kilohertz
km	kilometer
km/hr	kilometer per hour
kp/sec	kilopulse per second
kV	kilovolt
kVA	kilovoltampere
kW	kilowatt
kWh	kilowatthour
kw	kiloword
kw/sec	kiloword per second
kyd	kiloyard
kyd/sec	kiloyard per second
mV	millivolt
MW	megawatt
mW	milliwatt
lb/sq in.	pound per square inch
lin ft	linear foot
lm	lumen
M	mega- (prefix 106)
m	meter; milli- (prefix 10^{-3})
mA	milliampere
mb	millibar
Mbps	megabit per second
mG	milligauss
mg	milligram
mi/hr	mile per hour
MHz	megahertz
μ	micro- (prefix 10^{-6})
μA	microampere (microamp)
μsec	microsecond
μV	microvolt
μW	microwatt
mi	statute mile
min	minute
ml	milliliter
mm	millimeter
mm/sec	millimeter per second
mμ	millimicron
mo	month
MΩ	megohm
msec	Millisecond
MV	megavolt
T	tera- (prefix 1012)
V	volt
VA	voltampere

n	nano- (prefix 10^{-9})
nm	nanometer
nmi	nautical mile
nsec	nanosecond
Ω	ohm
oz	ounce
p	pico- (prefix 10^{-12})
pF	picofarad
p/min	pulse per minute
psec	picosecond
p/sec	pulse per second
q	dynamic pressure
rad	radian
Re	earth radius
rev	revolution
rev/min	revolution per minute
rev/sec	revolution per second
rms	root mean square
sec	second
smp	sample
smp/sec	sample per second
Sq	square
Vac	volt, alternating current
Vdc	volt, direct current
V/mil	volt per mil
Vpp	volt peak to peak
Vrms	volt root mean square
W	watt
w/frm	word per frame
w/min	word per minute
w/sec	word per second
wk	week
yd	yard
yr	year

Abbreviations and Acronyms

Acronym	Definition
ACE	Advanced Composition Explorer
A/G	Air-to-Ground
AGO	Santiago Satellite Station, Santiago, Chile (SSC)
AM	Amplitude Modulation
AOS	Advanced Orbiting Systems
AQPSK	Asynchronous Quadrature Phase Shift Keying
ASF	Alaska Satellite Facility, Fairbanks, AK
AXAF	Chandra Advanced X-ray Astrophysics Facility
BER	Bit Error Rate
Biϕ	Bi-phase
BP	Bi-phase
BPSK	Biphase Shift Keyed
BW	Bandwidth
CADU	Channel Access Data Unit
CCB	Configuration Control Board
CCSDS	Consultative Committee for Space Data Systems
CDH	Command Delivery Header
CLASS	Communications Link Analysis and Simulation System (tool)
CLTU	Command Link Transmission Unit
CNR	Carrier to Noise Ratio
COTS	Commercial-off-the-Shelf
CSAFS	Central SAFS
CSO	Communications Service Office
DBP	Differential B-Phase
DLM	Depot Level Maintenance
DM	Delta Modulation

Acronym	Definition
DRN	Data Ready Notification
DSMC	Data Services Management Center
DSN	Deep Space Network
EIRP	Effective Isotropic Radiated Power
EOM	End of Mission
EOS	Earth Observing System
ESA	European Space Agency
ESC	Exploration and Space Communications Projects Division, GSFC
FDF	Flight Dynamics Facility, GSFC
FDN	File Delivered Notification
FM	Frequency Modulation
FSK	Frequency Shift Keyed
ftp	File Transfer Protocol
GEO	Geosynchronous
GN	Ground Network
GNSTAT	Ground Network Status Message
GSFC	Goddard Space Flight Center, Greenbelt, MD
G/T	Gain to Noise (antenna gain/noise temp in deg Kelvin)
HBK	Hartebeesthoek Tracking Station, Hartebeesthoek, South Africa
HPA	High Power Amplifier
ICD	Interface Control Document
ICESat	Ice Cloud, and Land Elevation Satellite
ID	Identification
IF	Intermediate Frequency
INP	Internet Predicts
INPv2	INP version 2
IONet	Internet Protocol Operational Network
I	In-phase Data Channel
IP	Internet Protocol

Acronym	**Definition**
IPDU	Internet Protocol Data Unit
ISDN	Integrated Services Digital Network
ITU-R	International Telecommunications Union – Radiocommunication Sector
JSC	Johnson Space Center, Houston, TX
KIR	Kiruna Satellite Station, Kiruna, Sweden (SSC)
KSAT	Kongsberg Satellite Services, Svalbard, Norway
LEO	Low Earth Orbit
LEO-T	Low Earth Orbiter-Terminal
LHC	Left Hand Circular (polarization)
LRO	Lunar Reconnaissance Orbiter
MASL	Meters Above Sea Level
MCC	Mission Control Center (JSC)
Mcps	Mega cycles per second
MGS	McMurdo Ground Station, McMurdo, Antarctica
MG1	McMurdo 10-m Antenna system, Antarctica
MOC	Mission Operations Center
MPLS	Multiprotocol Label Switching
MTRS	McMurdo TDRS Relay System
N/A	Not Applicable
NAM	Network Advisory Message
NASA	National Aeronautics and Space Administration
NEN	Near Earth Network
NENUG	Near Earth Network Users' Guide
NGIN	Next Generation Integrated Network
NIMO	Networks Integration Management Office, GSFC
NISN	NASA Integrated Services Network
NMC	Network Management Center, USN
NPD	NASA Policy Directive
NRZ	Non Return to Zero; level (-L), Mark (-M), Space (-S)
NTIA	National Telecommunications and Information Agency

Acronym	Definition
OOB	Out-of-Band
OQPSK	Offset Quadriphase Shift Keyed
OS	Operations Supervisor
PCM	Pulse Code Modulation
PDL	Ponce De Leon, NEN station, New Smyrna Beach, FL
PFD	Power Flux Density
PLL	Phase Locked Loop
PM	Phase Modulation
PN	Pseudorandom Noise
PTP	Programmable Telemetry Processor
Q	Quadrature Phase Data Channel
QPSK	Quadriphase Shift Keyed
RAID	Redundant Array of Independent Discs
RCCA	Root Cause/Corrective Action
RCN	Receipt Confirmation Notice
RF	Radio Frequency
RFICD	Radio Frequency Interface Control Document
RHC	Right Hand Circular (polarization)
RMS	Root Mean Square
RNRZ	Randomized Non-Return-to-Zero
RNRZ-L	Randomized Non-Return-to-Zero-Level
RSS	Remote Status Server
SAFS	Standard Autonomous File Server
SANSA	South African National Space Agency
S/C	spacecraft
SCaN	NASA Space Communications and Navigation (Program)
SCP	Space Communications Processor; secure copy protocol
SFCG	Space Frequency Coordination Group
SFDU	Standard Formatted Data Unit
sftp	secure file transport protocol
SGS	Svalbard Ground Station, Svalbard, Norway
SLE	Space Link Extension

Acronym	**Definition**
SN	Space Network
SQPSK	Staggered QPSK
SSAFS	Station SAFS
SSC	Swedish Space Corporation
SSPA	Solid State Power Amplifier
TBD	To Be Determined
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TDM	Time Division Multiplexed
TDRS	Tracking and Data Relay Satellite
TM	Telemetry
TMP	Telemetry Processor
TR2	TrollSat Antenna No.2, KSAT, TrollSat, Antarctica
UDP	User Datagram Protocol
UG	Users' Guide
UPS	Uninterruptible Power Source
UQPSK	Unbalanced Quadriphase Shift Keyed
URL	Universal Resource Location (Internet)
US	United States
USB	Universal Serial Bus
USN	Universal Space Network
UTDF	Universal Tracking Data Format
VC	Virtual Channel
VHF	Very High Frequency
VPN	Virtual Private Network
WAL	Weilheim Tracking Station, Weilheim, Germany
WFF	Wallops Flight Facility
WGS	Wallops Ground Station, Wallops, VA
WS1	White Sands One Ground Station
WSC	White Sands Complex, White Sands, NM
Z	Zulu