Appendix IV

FORMOSAT-3/COSMIC Ground Network Interface Control Document for NOAA Ground Stations

Table of Contents

1 Introduction

1.1 Purpose

The purpose of this document is to define the interfaces between the Remote Terminal Stations (RTS and RTS-R) and the following two facilities:

National Space Organization (NSPO) Satellite Operation Control Center (SOCC) in Hsin-Chu, Taiwan

University Corporations for Atmospheric Research (UCAR) COSMIC Data Analysis and Archive Center (CDAAC) in Boulder, Colorado

These interfaces support the FORMOSAT-3/Constellation Observing System for Meteorology, Ionosphere, and Climate (FORMOSAT-3/COSMIC) mission.

1.2 Scope

This ICD documents all interfaces among the SOCC, the CDAAC, and RTS/RTS-R on the FORMOSAT-3/COSMIC Mission. These interfaces include the real-time telecommanding, real-time telemetry monitoring, and real-time RTS/RTS-R status monitoring interfaces used during the spacecraft contacts. This document also documents the non real-time interfaces to the SOCC and CDAAC. These interfaces include the Mission Planning interfaces for Scheduling, Ephemeris Updates, and Data Transfer.

2 Related Documents

2.1 Applicable Documents

1.RS3-PLAN-018	FORMOSAT-3/COSMIC Mission Support Plan for NOAA Ground Station
2. RS3-ICD-0004	FORMOSAT-3/COSMIC NOAA to SOCC IT Configuration Document
3.	FORMOSAT-3/COSMIC NOAA Link Budget

2.2 Reference Documents

1. CCSDS 101.0-B-5, June 2001, Blue Book, Telemetry Channel Coding

2. CCSDS 102.0-B-5, November 2000, Blue Book, Packet Telemetry

3. CCSDS 103.0-B-2, June 2001, Blue Book, Packet Telemetry Service Specification

IN-SNEC, Command, Ranging and Telemetry Unit - CORTEX Series TCP/IP Ethernet Interface, STI 100013_TTC (Issue: 1 Revision 2 dated January 8, 2002)

IN-SNEC, Command, Ranging and Telemetry Unit - CORTEX Series TCP/IP Ethernet Interface, STI 100013 (Issue: 3 Revision 2, dated January 8, 2002)

3 List of Terms

SOCC: In this document, SOCC is the satellite operations control center of NSPO located in Taiwan.

NOAA RTS/RTS-R: RTS is the ground stations of NOAA supporting FORMOSAT-3/COSMIC mission with uplink (commanding) and downlink capability, while RTS-R is a receive only RTS with S-band downlink service and post pass file transfer service.

FORMOSAT-3/COSMIC: Reference to the spacecraft bus (FORMOSAT-3) and payload (COSMIC). This is also referred to at times as simply COSMIC in this document.

VPN: A VPN is one or more WAN links over a shared public network, typically over the Internet or an IP backbone from a Network Service Provider (NSP) that simulates the behavior of dedicated WAN links over leased lines.

4 System Overview

4.1 Mission Overview

The FORMOSAT-3/COSMIC mission (also referred to as COSMIC) features six small spacecraft developed by Orbital Sciences Corporation (Orbital) launched together on a Minotaur rocket and deployed into separate complementary orbit planes. NOAA RTS and RTS-R sites selected to support this mission are Fairbanks of Alaska (FCDAS) and KSAT Tromso, Norway as primary, and Wallops CDA (WCDAS) as backup. Contacts are planned, on average, every half hour out of each RTS/RTS-R for continuous operations. Communications to the spacecraft are provided at S-band for uplink and downlink. Uplink telecommanding will only be provided by the FCDAS station in Alaska and the WCDAS at Wallops for backup purpose. For RTS/RTS-R sites, S-band downlink with data rates of 2Mbit or 32 kbps are provided.

The command link to each spacecraft is at 2039.5000 MHz with a data rate of 32 kbps. The BPSK/ NRZ-M modulation formatted data stream consists of High-level Data Link Control (HDLC) transfer frames separated by a continuous idle.

The downlink from each spacecraft is at 2215.0 MHz at either a “high rate”, 2 Mbps stream or a “low rate”, 32 kbps stream. The data rate may autonomously change in mid-pass which requires the RTS/ RTS-R CORTEX to automatically switch data rates. COSMIC downlink consists of Consultative Committee for Space Data Systems (CCSDS) transfer frames containing real-time spacecraft state-of-health (SOH), playback spacecraft SOH, payload science and SOH, and fill data. Transfer frames of each type are assigned a unique virtual channel identifier (VCID). The CCSDS transfer frames contain a header, data and Reed-Solomon encoding for error correction. The downlink is BPSK/ NRZ-M modulation formatted. Only non-payload data is downlinked at the low rate. The RTS/RTS-R's are configured to support high or low rate downlinks at all times. The spacecraft uses HDLC data format for command and CCSDS standard data format telemetry data interfaces. The following CCSDS standards are referenced in the spacecraft design.

-> CCSDS 101.0-B-5, June 2001, Blue Book, Telemetry Channel Coding

-> CCSDS 102.0-B-5, November 2000, Blue Book, Packet Telemetry

-> CCSDS 103.0-B-2, June 2001, Blue Book, Packet Telemetry Service Spec.

4.2 Ground Network Services Overview

There are three major external interfaces for the RTS/RTS-R on the FORMOSAT-3/COSMIC program including:

RTS/RTS-R to FORMOSAT-3/COSMIC Spacecraft Interface

RTS/RTS-R to SOCC Interface

RTS/RTS-R to CDAAC Interface

Figure 4.2-1 provides a high level NOAA RTS/RTS-R interface description.

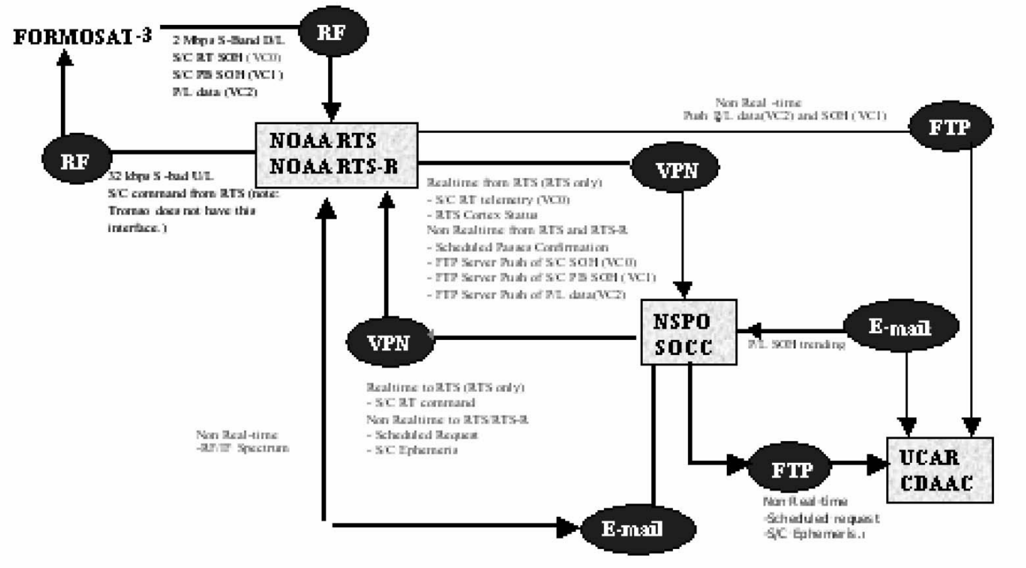


Figure 4.2-1 NOAA RTS/RTS-R External Interfaces

The spacecraft will transmit real-time telemetry, stored SOH, and stored science data to the ground station during a RTS/RTS-R pass. During a pass the RTS will send real-time telemetry and RTS cortex status to SOCC for monitoring. The RTS also uplinks real-time commands relayed from the SOCC to the satellite. At the end of a pass, the RTS/RTS-R will first push SOH data (VC0 and VC1) to the SOCC. After the SOH data have been transmitted to the SOCC, the VC2 science data are sent to CDAAC, and then the VC1 SOH data are sent to CDAAC, followed by the VC2 science data to SOCC. The data transfer between the RTS/RTS-Rand the SOCC is through a VPN, transfers to CDAAC are through the open internet to a firewall protected FTP server.

For off-line operations, SOCC will provide request for pass scheduling files and will update the ephemeris so that RTS/RTS-R can pull these files from the ftp site.

Fairbanks is a primary ground station for uplink and downlink. Wallops is a backup commanding station for the Fairbanks station, and it can also be a backup to Tromso if necessary. Tromso, is a primary ground station for receiving telemetry, but has no capability to do commanding, and does not provide real-time telemetry / status to the SOCC it is called RTS-R (Receive only). Svalbard, as the backup station of Tromso, has uplink and downlink capability, this site is expected to be available only until June 2008. FORMOSAT-3 can use it to do the uplink when there is an emergency.

Table 4.2-1 provides a summary of the data sent between the external interfaces and identifies the applicable ICD section that describes the message formats.

Table 4.2-1 NOAA RTS/RTS-R to CDDAC/SOCC Interface List

RTS/RTS-R to SOCC INTERFACE	ICD Message Formats Section
Real-Time Cortex Telemetry (RTS only)	5.2.1 CORTEX Telemetry Messages
Real-Time Cortex Telecommand Uplink (RTS only)	5.2.2 CORTEX Telecommand Messages

Real-Time Cortex Monitoring (RTS only)	5.2.3 CORTEX Monitoring Messages
Non Real-Time Contact Scheduling	5.4.1 Contact Schedule Requests
Non Real-Time Spacecraft Ephemeris	5.4.4 Satellite Ephemeris Update
Non Real-Time Data Push	5.3.1 Post-Contact Telemetry Data File Format
RTS/RTS-R to CDAAC INTERFACE	
Non Real-Time Data Push	5.3.1 Post-Contact Telemetry Data File Format

4.3 Role and Responsibility of Each Ground Stations

Table 4.3-1 Role and Responsibility of Each Ground Stations

Station	Uplink capability	Receive capability	Routine operations	Backup	Spacecraft emergency
Fairbanks	Y	Y	Y	N/A	Y
Tromso	N	Y	Y	N/A	N
Wallops	Y	Y	N	Backup to Fairbanks and Tromso	Y
Svalbard	Y	Y	N	Interim Backup (June 2008)	Y
Taiwan (Chungli/ Tainan)	Y	Y	N	Backup to Fairbanks and Tromso	Y

The interface specification defined in the following sections shall refer to the capability required for FORMOSAT-3/COSMIC operations in Table 4.3-1.

5 Interface Specifications

5.1 Network Connectivity

The network communications infrastructure connecting the SOCC to the RTS and RTS-R is comprised of two components: a real-time service and a non-real-time service. The real-time network communications is provided through a virtual private network (VPN) that links the SOCC to the NOAA RTS. The SOCC receives non real-time post-contact telemetry files delivery via a VPN interface to the RTS/RTS-R.

The network communications infrastructure connecting the CDAAC to the RTS/RTS-R is comprised of non-real-time service only. The non-real-time post-contact telemetry file delivery to the CDAAC site is performed over the Open Internet.

5.1.1 Communication Services

The NOAA RTS/RTS-R shall use VPN services via Open Internet to interface to the SOCC facility. The SOCC Facility shall provide the required VPN networking equipment to interface to the RTS/ RTS-R site.

The SOCC is responsible for the SOCC facility Internet Service Provider used for the VPN interface. The SOCC Internet Service Provider must provide a minimum of 512Kbps bandwidth to meet the real-time latency requirements specified for the COSMIC mission.

The RTS/RTS-R has standardized on Cisco products. The SOCC to RTS/RTS-R link shall be implemented with the IPSEC protocol with AES encryption for VPN tunneling.

5.1.2 Real-Time Networking Interfaces

The following sections specify the general requirements on the RTS for the real-time network communications interface between the SOCC and RTS sites.

NOTE: There are no real-time connections to the RTS-R or CDAAC sites.

5.1.2.1 Real-Time Connection Interface

All SOCC to RTS real-time connections are made to a Data Router system running at the NOAA RTS site. The Data Router is configured to route individual socket ip/port connections between the SOCC and the RTS site (CORTEX device). The Data Router is non-intrusive for all socket connections that are allowed. The Data Router permits the list of SOCC socket port connections defined in Table 5.1-1 for each RTS site.

The RTS shall be the Server and the SOCC the Client for all real-time TCP/IP socket port connections. The RTS Server shall continuously "listen" for external client connections to the RTS. The SOCC shall control when these socket ip/ports are connected or disconnected.

5.1.2.2 Real-Time Networking Protocols

The RTS and SOCC real-time systems shall use TCP/IP socket protocols to provide end-to-end, reliable transport of data over the communications services.

5.1.2.3 Real-Time Socket Connections

The RTS shall provide three TCP/IP socket connection ports to the SOCC for each RTS site. The RTS may have multiple CORTEX devices. The RTS is responsible for routing the SOCC connection to the current "active" device at each RTS site. The following TCP/IP socket port connections are available to the SOCC for each RTS site:

Table 5.1-1 Real-Time SOCC Socket Port Connections

	Socket Port	Description	Remarks
1	Real-time CORTEX Satellite Tele-commanding Messages	Interface to CORTEX Satellite Tele-command Data (TC Port) (ICD Section 5.2.2)	This interface is not applicable to RTS-R TG5
2	Real-time CORTEX Telemetry Data Messages	Interface to CORTEX Telemetry Data (TM Port) (ICD Section 5.2.1)	This interface is not applicable to RTS-R TG5
3	Real-time CORTEX Monitoring Data Messages	Interface to CORTEX Monitoring Data Port (MON Port) (ICD Section 5.2.3)	This interface is not applicable to RTS-R TG5

NOAA RTS sites shall define a set of dedicated COSMIC SOCC socket ip/port number assignments for each socket connection to the RTS. Each RTS site shall have a set of four unique, dedicated ip/port numbers reserved for the COSMIC mission. The list of IP addresses, socket port numbers assignments and other network information shall be documented in the FORMOSAT-3/COSMIC NOAA to SOCC IT Configuration Document

5.1.2.4 Real-Time Networking Performance

In order to assure reliable satellite operations, especially during commanding, minimum command and telemetry latency requirements are needed. These latency requirements are a shared responsibility between the NSPO SOCC and the RTS. However portions of the latency are controlled by network resources that are outside of the SOCC and RTS control, therefore both agencies have a shared responsibility to ensure that these requirements are met.

The RTS-to-SOCC networking shall support the latency requirements for real-time data as defined in Table 5.1-2 under nominal ISP operations.

Table 5.1-2 Real-Time Latency Requirements under normal operating internet service

Data Interface	Latency Requirement
Real-time Spacecraft Telecommanding	1 to 5 seconds from output of SOCC VPN router to modulation of uplink 1 to 5 seconds from CORTEX generated telecommanding socket response message to SOCC VPN router
Real-time Spacecraft Telemetry	1 to 5 seconds from receipt of downlink signal at RTS to receipt of packet at SOCC VPN router
Real-time NOAA RTS Status Messages	1 to 5 seconds from device generated status to receipt of status at SOCC VPN router

The SOCC site VPN shall provide a minimum of 512 Kbps of network bandwidth for the real-time interfaces to the RTS.

The RTS site VPN shall provide a minimum of 512 Kbps of network bandwidth for the real-time interfaces to the SOCC.

5.1.2.5 Real-Time Data Security

The SOCC and NOAA RTS shall support end-to-end data security when using the communications services. Security implementation shall include IP address authentication, confidentiality of socket port numbers, and physical access control to the mission systems. Authorized IP addresses and socket port numbers for FORMOSAT-3/COSMIC shall be specified in the FORMOSAT-3/COSMIC NOAA To SOCC IT Configuration Document

5.1.3 Non Real-Time Networking Interface

The following paragraphs specify the general requirements on the RTS/RTS-R for the non real-time communications interface that supports both SOCC and CDAAC connections.

5.1.3.1 Non Real-Time Connection Interfaces

The RTS/RTS-R needs to control the FTP push functionality in order to avoid overloading available bandwidth and to avoid conflict with ongoing operations and transmission of files with time critical requirements. To ensure that network bandwidth limitations are not exceeded all non-realtime transfers to and from the RTS are initiated by the RTS/RTS-R.

The CDAAC shall provide a firewall protected FTP server interface available via the Open Internet for the RTS/RTS-R to automatically FTP push compressed mission data files. This interface will also be used to manually re-transmit requested archived mission telemetry files to the CDAAC

The SOCC shall provide a FTP server interface available via the SOCC-to-RTS/RTS-R VPN for the RTS/RTS-R to FTP push compressed VC0, VC1, and VC2 data files. This interface will also be used to manually re-transmit requested archived mission telemetry files to the SOCC. The RTS and RTS-R shall push payload and SOH data (VC2 and VC1) through FTP from the remote RTS/RTS-R to the CDAAC FTP server at the completion of the contact. The RTS/RTS-R shall also push compressed VC0, VC1, and VC2 data to the SOCC FTP server after completion of a pass. The priority of these operations is discussed in paragraph 5.1.3.3.

The SOCC shall also provide a FTP interface via the VPN that includes separate directories containing schedule request files and Two Line Element files for the RTS/RTS-R. A directory shall also be provided to receive schedule confirmation files from the RTS/RTS-R.

Unique FTP accounts are setup for the SOCC and CDAAC sites.

The FTP connectivity information for RTS/RTS-R, SOCC, and CDAAC facilities (username, password, directories and IP address) shall be documented in the FORMOSAT-3/COSMIC NOAA To SOCC IT Configuration Document

5.1.3.2 Non Real-Time Networking Protocols

The NOAA RTS/RTS-R, SOCC and CDAAC shall support the FTP protocol for transferring archived files over the non real-time interfaces.

5.1.3.3 Non Real-Time Latency Requirements

The RTS/RTS-R site shall start the push of the compressed, VC0 and VC1 files to SOCC within 3 minutes after the end of a pass. (see paragraph 5.3.5 for non-real-time file delivery sequence)

Each RTS/RTS-R site VPN network shall have sufficient networking capacity to transfer data files at a minimum rate of 512Kbps.

5.1.3.4 Non Real-Time Data Security

The SOCC, CDAAC and NOAA RTS/RTS-R shall support end-to-end data security for the communications services used to support the FORMOSAT-3/COSMIC mission. Security implementation shall include NOAA FTP server ID/password protection, IP address authentication, confidentiality of pertinent information, IP Access Lists for FTP Server Access, and physical access control to mission systems as documented in the FORMOSAT-3/COSMIC NOAA To SOCC IT Configuration Document

5.2 Real-Time Interface Data Formats

As SOCC connects with the command port, the RTS shall be capable of detecting it and then automatically trigger an uplink sequence, which is to bring the carrier up, wait 15 seconds, and then turn the modulation As SOCC disconnects with the command port, the RTS shall be capable of detecting it and then automatically trigger a sequence to bring the carrier down.

This section defines the detailed formats for the Ethernet messages sent on the real-time TCP/IP interfaces between the SOCC and the RTS. There are three types of messages sent between the SOCC and each RTS site (note: the RTS-R does not support this interface):

Real-Time CORTEX Telemetry Messages

Real-Time CORTEX Monitoring Message

Real-Time CORTEX TeleCommanding Messages

The SOCC is essentially connecting directly to the CORTEX device at the RTS sites. The format of the messages for the SOCC to RTS CORTEX interfaces are defined in the CORTEX manuals identified in Table 5.2-1. The SOCC connects to a Data Router at the RTS. The non-intrusive Data Router routes the connection to the active CORTEX at the RTS site.

The RTS has complete responsibility for the Cortex Control Data interfaces. The CORTEX Control interface is used by the RTS to set the CORTEX Configurations

The default CORTEX Data Time-Tag configuration is Time Tag Code 2 for the COSMIC mission. The current active Time Tag code setting value can be found in the Cortex Monitoring Message.

Table 5.2-1 CORTEX Messages Formats Reference Manuals

Reference Document	Description
IN-SNEC, Command, Ranging and Telemetry Unit - CORTEX Series TCP/IP Ethernet Interface, STI 100013_TTC	This manual provides a detailed description for all message formats on the Telemetry Message, Monitoring Data, and Satellite Tele-command real-time interfaces used on the COSMIC Mission.
IN-SNEC, Command, Ranging and Telemetry Unit - CORTEX Series TCP/IP Ethernet Interface, STI 100013	This manual provides a detailed description of the TCP/IP message headers, post-ambles, responses and requests used for all messages defined in the STI_100013_TTC manual.

5.2.1 CORTEX Telemetry Messages

The “Telemetry Data” section in reference document IN-SNEC, Command, Ranging and Telemetry Unit - CORTEX Series TCP/IP Ethernet Interface, STI 100013_TTC provides information on the message formats for the Real-Time CORTEX Telemetry Message interface.

The SOCC shall connect to this interface to issue the required CORTEX Telemetry Request message to initiate the flow of real-time telemetry. The SOCC shall configure the CORTEX to send VC0 Spacecraft Real-time SOH telemetry information on the Telemetry Monitoring socket. Table 5.22 provides the definition of the fields in the CORTEX 64-byte Telemetry Request Message. This message is sent once to initiate the permanent real-time telemetry data flow.

Table 5.2-2 CORTEX TM -Telemetry Request Message Format

OFFSET	TYPE	VALUE	DESCRIPTION	COSMIC VALUE
0	Integer	1234567890	Start of message	1234567890
1	Integer	×	Size of message in bytes (including header and postamble)	64
2	Integer	User Configurable	Flow identification	0

3	Integer	0: Telemetry channel A 1: Telemetry channel B 2: Telemetry channel C 3: Telemetry channel D 4: Telemetry channel E 5: Telemetry channel F	Telemetry channel	1
4	Integer	0 to 1024	Number of buffered TM blocks or frames (0 = Real time telemetry)	0
5	Integer	0: Permanent flow 1: Single block/frame transmission 2: Permanent flow + dummy TM Other values: Reserved	Data flow	0
6	Integer	Frame mask (MSB)	Frame Mask set to mask the 3-bit Virtual Channel Field in the Transfer Frame header	0x000E0000
7	Integer	Frame mask (LSB)	Frame Mask set to mask the 3-bit Virtual Channel Field in the Transfer Frame header	0x00000000
8	Integer	Expected value (MSB)	Expected value in the Frame Mask offset 6-7 is a 3-bit "000" for the Virtual Channel Zero	0x00000000
9	Integer	Expected value (LSB)	Expected value in the Frame Mask offset 6-7 is a 3-bit "000" for the Virtual Channel Zero	0x00000000
10 to 14		Unused	Not checked	0
15	Integer	-1234567890	Standard TCP/IP postamble	-1234567890

The Telemetry Message TCP-IP Message Header "Flow Identification" value is set to 0 for COSMIC.

Table 5.3-1 provides the definition of the fields in the 1348 Byte CORTEX Telemetry Message reply. This message includes a 64 byte CORTEX header + 1279 byte COSMIC Telemetry Frame data + 1-byte zero-fill for 32-bit alignment + 4 Byte CORTEX postamble. NOTE: CORTEX Telemetry frames are 32-bit aligned (LSBs of the last word are zero-filled if the frame or block length, in bytes, is not a multiple of 4. This is the source for the 1-byte zero fill).

5.2.1.1 Telemetry Frame Data Format

The Telemetry Frame data field in the CORTEX Telemetry Message shall contain the Telemetry CCSDS Transfer Frame data. This transfer frame data begins with the 4-byte frame sync pattern and ends with the 160 byte Reed Solomon check symbols. A complete description of all Transfer Frame fields shall be defined in Figure 5.2-1 and Figure 5.2-2.

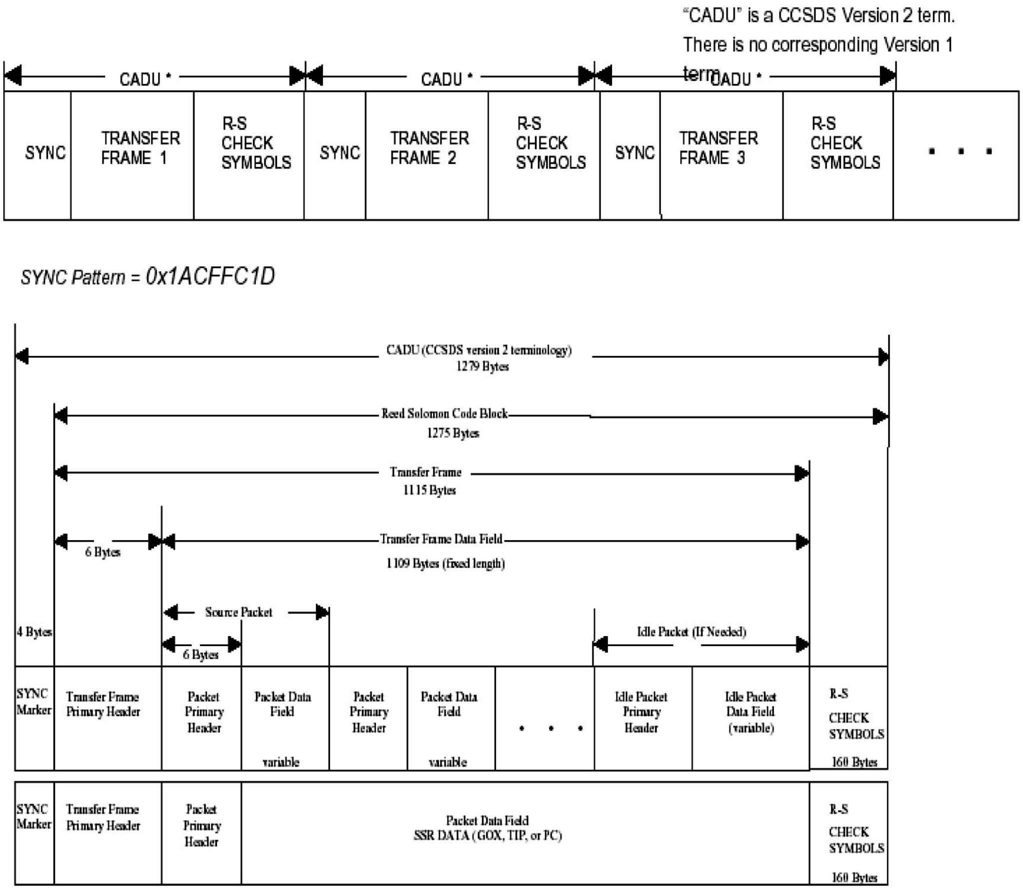


Figure 5.2-1 FORMOSAT-3 CCSDS Version 1 Spacecraft Downlink Format

ROCSAT-3 Transfer Frame Primary Header

Transfer Frame Ver.	S/C ID	Virtual Channel ID	Oper. Ctrl Flag	Master Channel Frame Count	Virtual Channel Frame Count	Transfer Frame Data Field Status				
						Trans. Frame Sec. Hdr. Flag	Sync Flag	Pkt Order Flag	Seg. Len ID	First Hdr. Ptr
2	10	3	1	8	8	1	1	1	2	11

TRANSFER FRAME PRIMARY HEADER

Version – b'00'

Spacecraft ID – 0x3F1 … 0x3F6

Virtual Channel ID

- 0x0 - Spacecraft realtime SOH
- 0x1 - Spacecraft bus stored
- 0x2 - Payload Science/SOH
- 0x7 - Fill frame

Operational Control Field Flag - 0

Master Channel Frame Count – 0x00 (Fixed)

Virtual Channel Frame Count - Incrementing count.

Secondary Header Flag – b'0'

Sync Flag – b'0'

Packet Order Flag – b'0'

Segment Length ID – b'11'

First Header Pointer - 0x000

PACKET PRIMARY HEADER

Version – b'000'

Type – b'0'

Packet Secondary Header Flag – b'1' or b'0' ***

Application Process Identifier (APID)

- 0x000-0x2FF - Spacecraft SOH TM
- 0x300 – Payload Data - GOX A
- 0x301 – Payload Data - GOX B
- 0x302 – Payload Data - TIP
- 0x303 – Payload Data - Attitude
- 0x304 – Payload Data - Reserved
- 0x7FF – Idle

Grouping Flags – b'11'

Source Sequence Count - Incrementing

Packet Length - Variable

*** Packet Secondary Header Flag
= b'1' Spacecraft SOH TM
= b'0' for Science Data

ROCSAT-3 Packet Primary Header

Version No.	Type	Packet Secondary Header Flag	Application Process ID	Grouping Flags	Source Sequence Count	Packet Data Length
3	1	1	11	2	14	16

Spacecraft SOH Packet Secondary Header

UTC TIME TAG	CONTROL	TRACKING NUMBER
9 Bytes	1 Byte	2 Bytes

UTC Time Tag

YEAR	DAY	HOUR	MINUTES	SECONDS	MSB milliSECS	LSB milliSECS
16 Bits	16 Bits	8 Bits	8 Bits	8 Bits	8 Bits	8 Bits

Figure 5.2-2 Transfer Frame Primary Header and Packet Primary Header and Packet Secondary Header Formats

5.2.2 CORTEX Telecommand Messages

The "Satellite TeleCommand Data" section in document IN-SNEC, Command, Ranging and Telemetry Unit - CORTEX Series TCP/IP Ethernet Interface, STI 100013_TTC provides information on the message formats for the Real-Time CORTEX Telecommanding Message interface.

The SOCC shall connect to this interface to issue all CORTEX Telecommand messages and process the CORTEX Telecommand Acknowledgment reply messages.

Table 5.2-3 provides the format of the CORTEX Clear Satellite Telecommand Request Message.

The Telecommand TCP-IP Message Header "Flow Identification" value is set to 0 for COSMIC.

Table 5.2-3 CORTEX TC - Telecommand Request Message Format

OFFSET	TYPE	VALUE	DESCRIPTION
0	Integer	1234567890	Start of message
1	Integer	×	Size of message in bytes (including header and postamble)
2	Integer	User Configurable (Zero for COSMIC)	Flow identification
3	Integer	1 (clear satellite TC request)	Request code
4	Integer	Any 32-bit word for logging purpose	Command tag
5	Integer	0 to 24736 (in bits)	TC message length
6	-	First word to send (MSB first)	Data 0
7	-	Next word to send if length > 32 bits	Data 1
⋯	-	...	...
N - 3	-	Last word to send	Data n
N - 2	Integer	×	Check-Sum
N - 1	Integer	-1234567890	Standard TCP-IP postamble

The CORTEX telecommanding acknowledgement messages are used to provide an "echo" back to the SOCC on the telecommanding status. Table 5.2-4 provides the format of the CORTEX Telecommand Message Reply Acknowledgement to the Telecommand message. The TC acknowledgement message is a 40-byte message.

Table 5.2-4 CORTEX TC - TC Message Reply – TC - Acknowledgement Format

OFFSET	TYPE	VALUE	DESCRIPTION
0	Integer	1234567890	Start of message
1	Integer	40	Size of message in bytes (including header and postamble)
2	Integer	User Configurable (Zero for COSMIC)	Flow identification
3	Integer	Same request code as per corresponding request	Acknowledged operation code
4	Integer	Operation dependant	Data (see Notes sections)
5	Integer	First field (see note 1)	Time (see Notes sections)
6	Integer or Float	Second field (see note 1)	Time (see Notes sections)
7	Integer	Operation dependant	Status (see Notes sections)
8	Integer	2's complement 32-bit Check-Sum (including everything except the checksum itself, so that the check-sum of the whole packet is 0)	Check-Sum
9	Integer	-1234567890	Standard TCP-IP postamble

Data is the command tag of the corresponding satellite TC request (or a counter for local TC requests). **Time** is the date at which the first bit of the TC message was modulated or the TC request ignored. **Status**: 0: Successful (Accepted, modulated) 1: Operation ignored: TC encoder locked out 2: Operation ignored: Invalid check-sum or invalid syntax 4: Operation ignored: CMM1 checking failed (time-out) 5: Operation ignored: CMM2 checking failed 6: Operation ignored: Group rejected 7: Operation ignored: TCU failure 8: Operation failed: Bad TC demodulation 11: Operation ignored. Bad TC chain configuration (TCU not selected on IFM) Acknowledgement returned to the TC Client upon TC message modulation.

The RTS/RTS-R shall be configured to provide an Uplink Idle pattern. Uplink idle pattern is an all-ones "FFFFFFFF" setting.

The 16-bit uplink Telecommand Sync pattern is 0x7EC0.

NO uplink sweep is required for receiver acquisition. The spacecraft receiver will be ready to accept commands within a few seconds after the ground transmitter uplink has been activated

5.2.3 CORTEX Monitoring Messages

The “CORTEX CRT Monitoring Data” section in document ***IN-SNEC, Command, Ranging and Telemetry Unit - CORTEX Series TCP/IP Ethernet Interface, STI 100013_TTC*** provides information on the message formats for the Real-Time CORTEX Monitoring Messages.

The SOCC shall connect to this CORTEX interface to issue the Monitoring request message and process the Monitoring Status reply responses. The CORTEX Monitoring (MON) status interface is a polling-type interface. The CORTEX provides one Monitor Status Message reply for each Monitor Status Request Message sent. The Monitor Status Request rate shall be limited to a maximum rate of 1 request per second on this real-time interface.

Table 5.2-5 provides the Message Format for the 20-byte COSMIC Monitor Status Request message. The "All Component Tables" component code is used in the CORTEX MON Status

Request message on the COSMIC mission.

Table 5.2-5 CORTEX MON - Monitoring Status Request Message Format

OFFSET	TYPE	VALUE	DESCRIPTION	COSMIC VALUE
0	Integer	1234567890	Start of message	1234567890
1	Integer	×	Size of message in bytes (including header and postamble)	20
2	Integer	User Configurable	Flow identification	0
3	Integer	CORTEX Component Code	The "All Component Tables" code is used for COSMIC to send status on all active CORTEX components	0x1100
4	Integer	-1234567890	Standard TCP/IP postamble	-1234567890

The Monitoring TCP-IP Message Header "Flow Identification" value is set to 0 for COSMIC.

Table 5.2-6 provides the definition of the CORTEX MON Status Message reply. One Status Message Reply is sent for every Status Message Request.

Table 5.2-6 CORTEX MON - Monitoring Status Message Format (All Components)

OFFSET	TABLE	COMMENTS
0	CORTEX table	Always returned
1 to 80	Global CORTEX CRT table	Always returned
see note 1	TCU table	Returned if TCU is mounted
see note 1	TMS table	Returned if TMS is mounted
see note 1	RAU table	Returned if RAU is mounted
see note 1	IFM-i table	Returned if IFM-i is mounted (order: IFM-1, 2)
see note 1	IFR-I table	Returned if IFR-i is mounted (order: IFR-1, 2, 3)
see note 1	TMU-i table	Returned if TMU-i is mounted (order: TMU-A, B, C, D, E, F)
see note 1	Noise generator table	Returned if Noise Generator is mounted
see note 1	TSU table	Returned if TSU is mounted
see note 1	DCU table	Returned if DCU is mounted
see note 1	CORTEX*NT* CRT project specific table	Always returned

Note 1: Refer to the above table sections in IN-SNEC, Command, Ranging and Telemetry Unit - CORTEX Series TCP/IP Ethernet Interface, STI 100013_TTC for the data formats associated with all tables shown above in Table 5.2-6 The Global CORTEXNT CRT table includes fields that identify which components are mounted.

5.2.4 Antenna Monitoring Message

The RTS/RTS-R's will not send Antenna Monitoring Messages to the SOCC.

5.3 Non Real-Time Post-Contact Telemetry Data Files

This section defines the interfaces associated with the non real-time post-contact processing of telemetry data from the FORMOSAT-3/COSMIC spacecraft.

The spacecraft downlink telemetry data is sorted into Virtual Channel files at the RTS and RTS-R sites. This data is stored on the RTS/RTS-R FTP Server. The RTS and RTS-R sites provide temporary storage of telemetry data files for customer specified data retention intervals.

5.3.1 Post-Contact Telemetry Data File Format

All COSMIC CCSDS Transfer Frame data is recorded to a raw binary file in the CCSDS transfer frame format. One telemetry message record is generated for each transfer frame received. The entire frame is included in the Telemetry File Record, starting with 4-byte sync pattern and ending with 160 bytes of Reed-Soloman code words. This raw telemetry file includes the data for all virtual channels. The COSMIC Telemetry Frame Format is defined in Figure 5.2-1 and Figure 5.2-2.

5.3.1.1 Post Contact Telemetry File Processing

There are four Virtual Channels defined for the FORMOSAT-3/COSMIC mission. The RTS/RTS-R shall sort the raw downlink telemetry file into three unique Virtual Channel Identifier (VCID) files for each spacecraft contact. The file record format is the same as the raw file. Virtual Channel 7 is Fill Frames and is discarded at the RTS/RTS-R site. Table 5.3-2 identifies the Virtual Channels used on the FORMOSAT-3/COSMIC mission.

Table 5.3-2 Virtual Channel Archive Files

Virtual Channel Number	Description
VCID 0	Spacecraft Real-time SOH
VCID 1	Spacecraft Bus Stored SOH
VCID 2	Payload Science/SOH
VCID 7	Fill Frames – Not Archived

5.3.2 Post-Contact Telemetry File Data Archival Requirements

Each RTS/RTS-R site shall provide 40 Gbytes of local storage for telemetry data. The RTS and RTS-R shall keep the raw data files for 24 hrs (action item for RTS/RTS-R to check). The RTS/RTS-R sites shall archive the VC-Sorted Telemetry Files for 10 days. Files are automatically deleted from the RTS/RTS-R data servers when the retention period has been exceeded.

The archive files shall be compressed with GZIP.

The 10-day Retention Periods are set based on the estimated daily downlink volume plus some contingency storage. With 42 contacts of 20 MBytes approximately 1GByte of data is downlinked every day at each RTS/RTS-R site. The oldest archive files may be deleted if an increase in the number of daily contacts requires storage capacity that approaches the specified RTS/RTS-R 40GB archive sizes.

5.3.3 Post-Contact Telemetry File Naming Convention

Table 5.3-4 specifies naming convention used on the VC-Sorted recorded telemetry data files.

Table 5.3-4 Telemetry File Name Format

Filename Format: <spacecraft>_<rts>_<starttime>_<VCIDx>.tlm.gz	
Field	Comment
<spacecraft>	Spacecraft Name: COSMIC1, COSMIC2, COSMIC3, COSMIC4, COSMIC5, COSMIC6
<rts>	RTS/RTS-R Identifier: FBKS01 = Alaska Site (Primary RTS) FBKS02 = Alaska Site (backup RTS) NORTG5 = Norway Site Tromso (Primary RTS-R) NORSG4 = Norway Site Svalbard (backup RTS) WALL01 = USA Site (Backup RTS)

<starttime>	Estimated start time: YYYY_DOY_HH_MM YYYY = 4 digit year DOY = 3 digit day of year HH = 2 Digit Start hour (GMT) MM = 2 Digit Start Minute (GMT) NOTE: This is the estimated Start Time obtained from the COSMIC Schedule
VCIDx	Telemetry Virtual Channel ID: VCID0 = Spacecraft Real-Time SOH VCID1 = Spacecraft Bus Stored SOH VCID2 = Payload Science/SOH
.tlm	Extension used to identify Telemetry Files
.gz	The GZIP extension is appended after compression at the RTS/RTS-R site.
Example: COSMIC6_ FBKS 01_2004_007_06_14_VCID0.tlm.gz COSMIC6_ FBKS 01_2004_007_06_14_VCID1.tlm.gz COSMIC6_ FBKS 01_2004_007_06_14_VCID2.tlm.gz COSMIC1_ NORTG5_2004_007_18_04_VCID0.tlm.gz COSMIC1_ NORTG5_2004_007_18_04_VCID1.tlm.gz COSMIC1_ NORTG5_2004_007_18_04_VCID2.tlm.gz NOTE: The ".gz" extension is removed when the files are decompressed with the GZIP utility	

5.3.4 Post-Contact Telemetry File Compression

All telemetry data files shall be compressed at the RTS/RTS-R site prior to transfer to the SOCC/CDAAC. Compression shall use GZIP software. The filenames will have a ".gz" extension when the compression has completed. The decompression of the file removes the ".gz" extension from the filename.

5.3.5 Post-Contact Telemetry File Delivery Sequence

The transmission of compressed VC data files is started within three minutes of satellite LOS. The VC0 and VC1 files are first transferred to SOCC. After completion of this transfer, the mission data VC2 file is transferred to CDAAC, then the VC1 file is transferred to CDAAC, and then the VC2 file is transferred to the SOCC. Transmission of VC2 files to the SOCC may be delayed depending upon network bandwidth limitations and conflicts with any higher priority data. For back-to-back passes the transmission of real-time VC0 data to SOCC and the non-realtime VC0/VC1 files to SOCC and VC2 mission data to CDAAC take precedence over VC2 mission data transmissions to SOCC. Manual re-transmissions of requested data to SOCC and CDAAC are performed on a non-interference basis with on-going RTS/RTS-R activities

5.4 Mission Planning Interface

The following sections document the interfaces that SOCC shall utilize to support contact scheduling, special configuration considerations and transfer of satellite ephemeris updates.

5.4.1 Contact Schedule Requests

The SOCC shall provide weekly Schedule Requests to the NOAA RTS/RTS-R sites, these files will be generated on a weekly basis (Mondays by 09:00 UTC) and will be placed on the SOCC FTP server for download by the RTS/RTS-R and CDAAC. The RTS/RTS-R shall delete the schedule request files after pulling them from the SOCC FTP server. For all contacts, the SOCC is responsible for providing NOAA with a contact schedule formatted per Table 5.4-1 in ASCII format. One file contains requests for all satellites for a single ground station for one week starting with Thursday of the current week. Once the request(s) is/are received, processed, and accepted into the Contact Schedule, a confirmation schedule shall be sent via FTP to the SOCC by 22:00 UTC on Tuesday of every week.

The SOCC shall provide contact start and Stop times that take site masking into consideration. Refer to Appendix A for Fairbanks, Tromso, Wallops, and Svalbard antenna locations and masking information. Only passes of 10 degrees or higher are scheduled.

The RTS/RTS-R has a requirement for 5-minute turnaround between passes. The schedule requests shall leave a minimum of 5-minute duration between contracts.

Table 5.4-1 Schedule Request Content Format

Field	Description	Format
1	Project/Spacecraft Identification	Options: COSMIC1, COSMIC2, COSMIC3 COSMIC4, COSMIC5, or COSMIC6
2	Remote Ground Station	FBKS01 = Alaska Site (Primary RTS) FBKS02 = Alaska Site (backup RTS) NORTG5 = Norway Site Tromso (Primary RTS-R) NORSG4 = Norway Site Svalbard (backup RTS) WALL01 = USA Site (Backup RTS)
3	Action	Schedule Request - Add or Delete Schedule Confirmation: Scheduled, Deleted, Conflict
4	Contact Start Date	mm/dd/yy
5	Contact Start DOY	ddd
6	Contact Start Time	hh:mm:ss
7	Contact Stop Date	mm/dd/yy
8	Contact Stop DOY	ddd
9	Contact Stop Time	hh:mm:ss
10	Contact Duration	hh:mm:ss
11	Comments or Configurations	High rate or low rate -Uplink

NOTE:

1. The ASCII Schedule Request and Schedule Confirmation File contain comma-delimited columns. All fields must be separated by a comma, even if they are blank. Field 11 is terminated by a CR/LF.
2. All Times are GMT times
3. All time/date fields must always contain two characters. (e.g. 00, 01, 10, 22)
4. All DOY fields must always contain three characters (e.g. 001, 022, 233)
5. No spaces are allowed in columns 1-10. Column 11 "comments" may have spaces
6. The comma character "," is used as a delimiter in this file and may not be used in the comments column of this file.
7. To modify a previously Scheduled pass the User should send a DELETE for the original scheduled pass, followed by an "ADD" for the updated pass.

Example:
COSMIC1,FBKS01,Add,08/11/04,223,17:20:51,08/11/04,223,18:20:51,01:00:00,High Rate – Uplink

Table 5.4-2 provides a sample of the header information that is included at the top of the Schedule Request File.

Table 5.4-2 Schedule Request Headers

```
RTS Schedule Request v2.0 (101304)
Request File: d:\R3TEST\reports\RTS_requests\FM6_RTS_2005171000000_2005178000000.txt
Generated: 06/20/05 18:29:48
Schedule requests are listed below this line.
--------------------------------------------
COSMIC6,FBKS01,Add,06/20/05,171,00:56:32,06/20/05,171,01:05:41,00:09:09,High Rate-Uplink
```

Table 5.4-3 Schedule Request and Confirm File Name Format

Filename Format: _<rts/rts-r>_<Plan/Confirm> <starttime>_<stoptime>.txt	
Field	Comment
<rts/rts-r>	RTS/RTS-R Identifier: FBKS01 = Alaska Site NORTG5 = Norway Site Tromso (Primary RTS-R) NORSG4 = Norway Site Svalbard (backup RTS) WALL01 = USA Site (Backup RTS)
<Plan/Confirm>	Schedule request/confirm: Plan = schedule request Confirm = schedule confirm
<starttime>	Start time: YYYY_DOY_HH YYYY = 4 digit year DOY = 3 digit day of year HH = 2 Digit Start hour (GMT)
<stoptime>	Stop time: YYYY_DOY_HH YYYY = 4 digit year DOY = 3 digit day of year HH = 2 Digit Stop hour (GMT)

.txt	Extension used to identify schedule request/confirm Files
Example: FBKS01_Plan_200807300_200807900.txt FBKS01_Confirm_200807300_200807900.txt	

Table 5.4-4 TLE File Name Format

Filename Format: _<spacecraft>_<rts>_<starttime>_<VCIDx>.tlm.gz	
Field	Comment
Spacecraft Identification	Options: FM1(=COSMIC1), FM2(=COSMIC2), FM3(=COSMIC3), FM4(=COSMIC4), FM5(=COSMIC5), or FM6(=COSMIC6)
Date	yyyy/mm/dd
Time	hh:mm
.nor	Extension used to identify TLE Files
Example: FM1_20080310_1000.nor FM2_20080310_1000.nor	

5.4.2 Contact Schedule Confirmation

The RTS/RTS-R shall send the Schedule Confirmation information to the SOCC via FTP to the SOCC by 22:00 UTC on Tuesday of every week. The format of this file is identical to the Schedule Request files shown in Table 5.4-1 with one difference, the Field 3 "Action" shall contain the confirmation status of "SCHEDULED, DELETED, or CONFLICT)

5.4.3 Contact Configuration

The NOAA RTS/RTS-R device parameters are setup via RTS/RTS-R configuration files. The default configurations utilizing the dedicated string of equipment shall support uplink (where available) and both high and low rate downlink rates at all times (the satellites can autonomously change to low data rate without ground command). SOCC can set the RTS/RTS-R high rate or low rate default configurations through coordination with NOAA via the comment section in the contact schedule.

5.4.4 Satellite Ephemeris Update

SOCC shall provide the IP address of an FTP server, directory path specification, and name of a file containing the two-line orbital element (TLE) information used by the NOAA RTS/RTS-R. This FTP Server information shall be documented in the FORMOSAT-3/COSMIC NOAA To SOCC IT Configuration Document The NOAA COSMIC Mission Support Plan shall document the times at which the NOAA RTS/RTS-R can retrieve an update of the orbital elements from the designated location. The NOAA RTS/RTS-R sites shall have a capability to FTP-pull files from the SOCC FTP Server. The RTS/RTS-R shall delete the TLE files after pulling them from the SOCC FTP server.

If the SOCC provides no Two Line Element set (TLE), then the TLE will be obtained from the publicly accessible site listed in the FORMOSAT-3/COSMIC NOAA To SOCC IT Configuration Document. The TLE file naming convention is specified in Appendix C.

The ephemeris file format is detailed in Appendix C. Use of IIRV format is not planned for FORMOSAT-3/COSMIC mission.

6 Link Budgets

6.1 Spacecraft Characteristics

The RF characteristics are listed in Table 6-1.

Table 6-1 FORMOSAT-3 RF Characteristics

Parameter	Downlink	Uplink
Carrier Frequency	2215 MHz	2039.5 MHz
Carrier Frequency Stability	Within 25 ppm	Within 25 ppm
RF Modulation Type	BPSK	BPSK
Polarization	RHCP	RHCP
Signal 3-dB Bandwidth	≤ 2 MHz	≤ 1.6 MHz
Effective Isotropic Radiated Power (EIRP)	31.9 dBm over 130 deg(conical) about satellite nadir direction	N/A

The baseband characteristics are listed in Table 6-2.

Table 6-2 FORMOSAT-3 Baseband Characteristics

Parameter	Downlink	Uplink
Data Rate	2 Mbps for high rate 32 kbps for low rate	32 kbps
Data Rate Accuracy	≤ 1%	≤ 1%
Data Transition Density	≧1 per 50 bits	≧1 per 50 bits
Error Control Coding	CCSDS Reed-Solomon (255, 223) code	N/A
Modulation Format	Non-Return-to-Zero-Mark (NRZ-M)	Non-Return-to-Zero-Mark (NRZ-M)
Modulation Type	BPSK	BPSK

The parameters for link performance evaluation are summarized in Table 6-3.

Table 6-3 Link Performance

Parameter	Value
Link margin at 10 deg ground antenna elevation angle	≧ 6 dB for telemetry and command
Bit error rate	≦ 10^{-6} for telemetry and ≦ 10^{-7} for command

6.2 Link Analysis

NOAA shall provide RF Link Analysis (document name: FORMOSAT-3/COSMIC NOAA Link Budget). This document is to be provided by NOAA.

ACU Antenna Control Unit

AGC Automatic Gain Control

ASA Cisco ASA 5500 device

ASCII American Standard Code for Information Interchange

BOT Beginning of Test

BPSK Binary Phase Shift Keying

CCSDS Consultative Committee for Space Data Systems

CDAAC COSMIC Data Analysis and Archive Center

COSMIC Constellation Observing System for Meteorology Ionosphere, and Climate Program

CRC Cyclic Redundancy Check

DCU Diversity Combining Unit

DOY Day of Year

EOT End of Test

FM Frequency Modulation

FSK Frequency Shift Keying

FTP File Transfer Protocol

HDLC High-Level Data Link Control

ICD Interface Control Document

IFM IF Modulator

IFR IF Receiver

IPSEC IP Security

KSAT Kongsberg SATellite Services AS

LAN Local Area Network

LOS Loss of Signal

LSB Least Significant Bit

MHz Megahertz

MSB Most Significant Bit

MSP Mission Support Plan

NOAA National Oceanic and Atmospheric Administration

NRZ-L Non-Return-to-Zero-Level

NRZ-M Non-Return-to-Zero-Mark

NSP Network Service Provider

NSPO National Space Organization

PCM Pulse Code Modulation

PPS Packets per Second

PSK Phase Shift Key

QPSK Quadrature Phase Shift Keying
RAU Ranging Unit
RF Radio Frequency
RS Reed-Solomon
RTS Remote Terminal Services
RTS-R Remote Terminal Services –Receive only
SOCC Satellite Operation Control Center
SOH State of Health
SRD Science Research Division
STI Service Transport Interface
TBD To Be Determined
TC Telecommand
TCP/IP Transmission Control Protocol/Internet Protocol
TCU Telecommand Unit
TLE Two Line Element
TMS Telemetry Simulator
TMU Telemetry Unit
TNOC Tromso Network Operation Control
TSU TC Sync Unit
UCAR University Corporation for Atmospheric Research
VPN Virtual Private Network
WAN Wide Area Network
VCID Virtual Channel Identifier

Appendix B Station Locations and Masking

To Be Provided By NOAA

Example:

The NOAA RTS/RTS-R sites each have a dedicated "primary" antenna for the COSMIC mission. The backup will only be used when the primary is offline due to hardware failure or system maintenance. Appendix B provides information on both primary and backup antenna systems.

The Primary Antenna mask should be used for generating the RTS/RTS-R contact schedules.

Table B-1 NOAA RTS/RTS-R Antenna Locations

Designator Antenna Location (Country)	Antenna Size (Meters)	Latitude (Degrees)	Longitude (Degrees)	Elevation (Meters)
FBKS01-5.0 Range Tracking Station (Alaska)	5.0	TBD	TBD	TBD
FBKS02	5.0	TBD	TBD	TBD
NORTG5-3	3	N69˚39’ 44.8”	E18˚56’ 27.6”	143.7
NORSG4-13	13	N 78˚13’ 40.7”	E 15˚24’ 32.4”	512.2
WALL01-5.0 Range Tracking Station (USA)	14.2	N37˚56’ 48.39”	E284˚32’ 23.773”	–25.8
WGS 84 latitude, longitude, ellipsoid height Sexagesimal system used, degrees, minutes and decimal seconds				

Table B-2 FBKS01 5.0-Meter Primary Antenna Mask (example)

Azimuth (degrees)	Maximum Elevation Mask (degrees)		Azimuth (degrees)	Maximum Elevation Mask (degrees)		Azimuth (degrees)	Maximum Elevation Mask (degrees)
0	0.9		120	0		240	3.7
10	1.1		130	0.8		250	3.5
20	1.7		140	2.8		260	2.2
30	1.4		150	5.0		270	1.8
40	1.0		160	5.0		280	1.3
50	0.9		170	3.0		290	0.5
60	0.4		180	2.5		300	0.4
70	0.7		190	2.4		310	0.3
80	0.5		200	3.5		320	1.1
90	0.3		210	5.3		330	0.8
100	0.4		220	4.6		340	1.2
110	0		230	4.5		350	1.6

NOTE: Minimum uplink transmission elevation is 5 Degrees per ITU Regulation S21.14

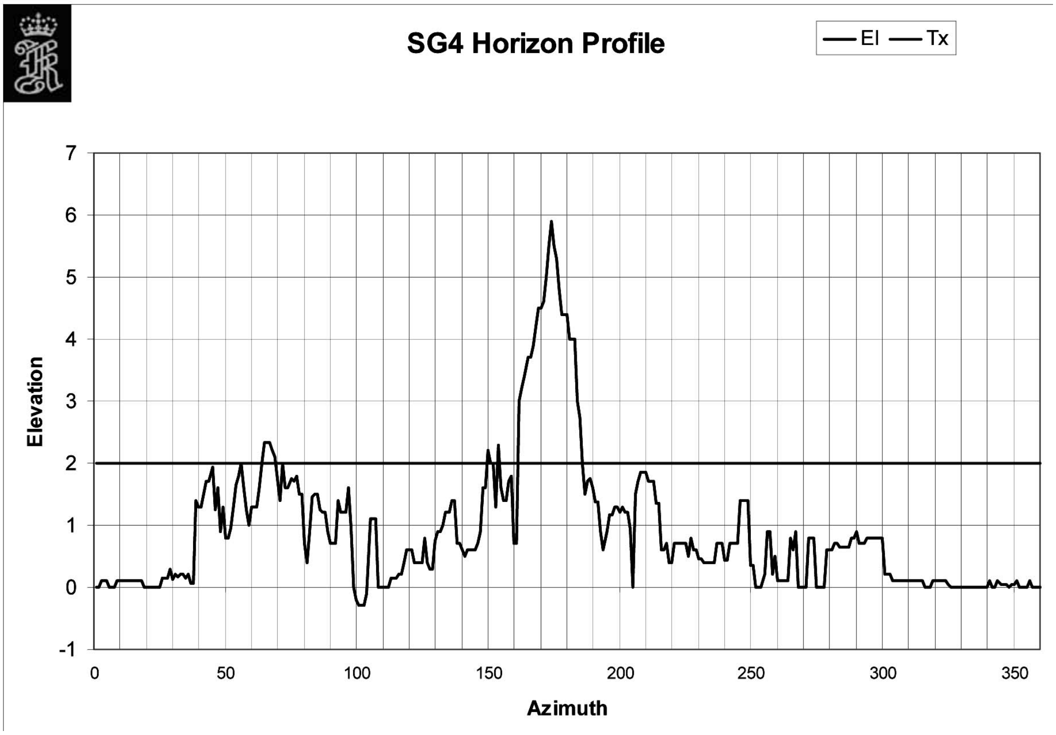
Table B-4 NORTG5 3.0-Meter Primary Antenna Mask

Azimuth (degrees)	Maximum Elevation Mask (degrees)		Azimuth (degrees)	Maximum Elevation Mask (degrees)		Azimuth (degrees)	Maximum Elevation Mask (degrees)
0	1.5		120	5.1		240	2.0
10	4.7		130	6.2		250	2.3
20	6.5		140	4.8		260	3.2
30	2.6		150	6.2		270	2.6
40	2.7		160	6.1		280	2.7
50	2.9		170	4.5		290	2.5
60	2.8		180	2.1		300	3.3
70	3.4		190	2.1		310	3.5
80	4.5		200	2.2		320	3.9
90	5.5		210	10,0		330	3.3
100	5.9		220	2.7		340	2.8
110	5.1		230	5.3		350	1.4

Table B-5 NORSG4-13-Meter Primary Antenna Mask

Azimuth (degrees)	Maximum Elevation Mask (degrees)		Azimuth (degrees)	Maximum Elevation Mask (degrees)		Azimuth (degrees)	Maximum Elevation Mask (degrees)
0	0.1		120	0.6		240	0.7
10	0.1		130	1.2		250	1.4
20	0.1		140	1.4		260	0.9
30	0.3		150	3.4		270	0.8
40	1.9		160	5.9		280	0.7
50	1.9		170	5.9		290	0.9
60	2.0		180	5.5		300	0.8
70	2.3		190	2.7		310	0.1
80	1.8		200	1.3		320	0.1
90	1.4		210	1.9		330	0.1
100	1.6		220	1.4		340	0.1
110	1.1		230	0.8		350	0.1

Each azimuth entry in the table show maximum elevation in the azimuth sector. For example at azimuth 110 degrees show maximum elevation mask to be 1.1 degree for the azimuth sector 105 to 114.


SG4 Horizon Profile
El
Tx
7
6
5
4
3
2
1
0
-1
Elevation
0
50
100
150
200
250
300
350
Azimuth

Appendix C SATELLITE EPHEMERIS DATA Interface Description

The COSMIC TLE information shall be provided on the SOCC FTP Server and available for FTP Pull by the NOAA RTS/RTS-R sites. The IP Address, Login Username, Password, and Directory Path shall be documented in the FORMOSAT-3/COSMIC NOAA To SOCC IT Configuration Document. A public NORAD FTP server shall be used as a backup for TLE information if the SOCC FTP server is not available.
The TLE file naming convention will be as follows for the six spacecraft:

FM1_yyyymmdd_hhmm.nor

FM2_yyyymmdd_hhmm.nor

FM3_yyyymmdd_hhmm.nor

FM4_yyyymmdd_hhmm.nor

FM5_yyyymmdd_hhmm.nor

FM6_yyyymmdd_hhmm.nor

where:

yyyy= 4 digit year

mm = 2-digit month

dd = 2-digit day

hh = 2-digit hour

mm = 2-digit minute

nor = Filename extension

The following mapping applies:

FORMOSAT 3A (satellite number 29047) = COSMIC6 (FM6)

FORMOSAT 3B (satellite number 29048) = COSMIC1 (FM1)

FORMOSAT 3C (satellite number 29049) = COSMIC5 (FM5)

FORMOSAT 3D (satellite number 29050) = COSMIC3 (FM3)

FORMOSAT 3E (satellite number 29051) = COSMIC4 (FM4)

FORMOSAT 3F (satellite number 29052) = COSMIC2 (FM2)

Table C-1 provides information on the format of the ASCII TLE file.

Table C-1 Two-Line Element File Format

Line 0 is a twenty-four-character name (to be consistent with the name length in the NORAD SATCAT). Lines 1 and 2 are the standard Two-Line Orbital Element Set Format identical to that used by NORAD and NASA. Example: NOAA 14 1 23455U 94089A 97320.90946019 .00000140 00000-0 10191-3 0 2621 2 23455 99.0090 272.6745 0008546 223.1686 136.8816 14.11711747148495	
Line 1	
Column	Description
01	Line Number of Element Data

03-07	Satellite Number
08	Classification (U=Unclassified)
10-11	International Designator (Last two digits of launch year)
12-14	International Designator (Launch number of the year)
15-17	International Designator (Piece of the launch)
19-20	Epoch Year (Last two digits of year)
21-32	Epoch (Day of the year and fractional portion of the day)
34-43	First Time Derivative of the Mean Motion
45-52	Second Time Derivative of Mean Motion (decimal point assumed)
54-61	BSTAR drag term (decimal point assumed)
63	Ephemeris type
65-68	Element number
69	Checksum (Modulo 10) (Letters, blanks, periods, plus signs = 0; minus signs = 1)
Line 2	
Column	Description
01	Line Number of Element Data
03-07	Satellite Number
09-16	Inclination [Degrees]
18-25	Right Ascension of the Ascending Node [Degrees]
27-33	Eccentricity (decimal point assumed)
35-42	Argument of Perigee [Degrees]
44-51	Mean Anomaly [Degrees]
53-63	Mean Motion [Revs per day]
64-68	Revolution number at epoch [Revs]
69	Checksum (Modulo 10)

NOTE: All other columns are blank or fixed.