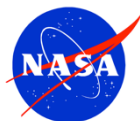


# **GOES REBROADCAST (GRB) DOWNLINK SPECIFICATIONS FOR USERS**

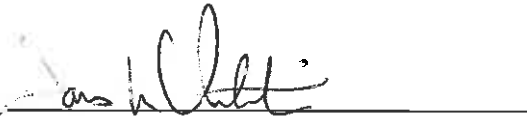
**August 6, 2012**



**U.S. Department of Commerce (DOC)  
National Oceanic and Atmospheric Administration (NOAA)  
NOAA Satellite and Information Service (NESDIS)  
National Aeronautics and Space Administration (NASA)**

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# GOES REBROADCAST (GRB) DOWNLINK SPECIFICATION FOR USERS



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08/06/12  
Date

Responsible Organization: GOES-R

| ISSUE    | CCR # | DATE       | PAGES AFFECTED | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                              |
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|          |       |            |                |                                                                                                                                                                                                                                                                                                                                                                                          |
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**GOES REBROADCAST (GRB) DOWNLINK  
SPECIFICATION FOR USERS**

**FOR  
GEOSTATIONARY OPERATIONAL ENVIRONMENTAL  
SATELLITE  
R SERIES (GOES-R) GROUND SEGMENT PROJECT  
ANTENNA SYSTEM DEVELOPMENT CONTRACT  
CONTRACT NO: DG133E-10-CN-0229  
DOCUMENT CONTROL NUMBER: 7038312  
CDRL SE-16  
REVISION C  
14 JUNE 2012**

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BLDG. 6, RM. C100  
GREENBELT, MD 20771**

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# GRB DOWNLINK SPECIFICATION FOR USERS

## FOR GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE R SERIES (GOES-R) GROUND SEGMENT PROJECT ANTENNA SYSTEM DEVELOPMENT CONTRACT

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**RECORD OF CHANGE**

| <b>REVISION</b> | <b>DATE</b>   | <b>DESCRIPTION</b>                                    |
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| A               | 14 July 2011  | Revised per Government comments.<br>Updated Table 3.1 |
| B               | 26 March 2012 | PTR-298: Revised per Government comments.             |
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**ITEMS TO BE RESOLVED**

The following TBx terminology is used in this document:

1. TBD: the item is To Be Determined. There is missing information where the TBD is placed. The missing information is unknown at this time.
2. TBR: the item is To Be Resolved or To Be Reviewed. The item is subject to review for appropriateness and/or subject to revision. The TBR immediately follows the item To Be Resolved or Reviewed.
3. TBS: the item is To Be Supplied. There is missing information where the TBS is placed

**TBS/TBD/TBR**

| <b>ITEM #</b> | <b>LOCATION</b> | <b>DESCRIPTION OF ITEM</b> |
|---------------|-----------------|----------------------------|
| none          |                 |                            |

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## **1.0 INTRODUCTION**

### **1.1 Scope**

This CDRL provides GOES Rebroadcast (GRB) radio frequency downlink characteristics, to enable the user community to develop GRB receivers. The interfaces addressed in this document support the flow of data between the Wallops Command and Data Acquisition Station/Remote Backup facility (WCDAS/RBU), space segment (SS), and the GRB ground segments. This document establishes functional and performance requirements related to these links.

## **2.0 SYSTEM DESCRIPTION**

### **2.1 GOES Mission**

The National Oceanic and Atmospheric Administration (NOAA) operates a system of Geostationary Operational Environmental Satellites (GOES) to provide continuous weather imagery and monitoring of meteorological and space environment data to protect life and property across the United States. Two GOES satellites remain operational at all times providing coverage for the eastern United States and most of the Atlantic Ocean and the western United States and Pacific Ocean basin. An on-orbit spare satellite is maintained to permit rapid recovery from a failure of either of the operational satellites. GOES satellites provide critical atmospheric, oceanic, climatic and space weather products supporting weather forecasting and warnings, climatologic analysis and prediction, ecosystems management, and safe and efficient public and private transportation. The GOES satellites also provide a platform for solar and space environmental observations. Auxiliary communications services are provided for the rebroadcast of GOES full resolution imagery, data collection platform relay, low resolution imagery, emergency weather communications, and satellite-aided search and rescue

The GOES program will consist of three series of satellites; GOES-I/M, GOES-N/O/P and GOES-R. Four satellites make up the present GOES satellite constellation. The operational satellites include one GOES-I/M series (GOES-12) and three GOES-N/O/P series (13-15) satellites. GOES-15 is operational in the west operational position, at 135 degrees West longitude, and GOES-12 is in an operational position for South America at 60 degrees West longitude. The first GOES-N/O/P series satellite to become operational is GOES-13, which is in the east position at 75 degrees West longitude. GOES-14 is in on-orbit storage at 105 degrees West longitude. The GOES-I/M and -N/O/P series share the same generation primary instrument payload. The GOES-R series represents a generational change in both spacecraft and instrument capability, with initial launch capability in 2015. GOES-R is a collaborative development and acquisition effort between NOAA and the National Aeronautics and Space Administration (NASA). The acquisition of the end-to-end GOES-R system includes spacecraft, instruments, launch services, and all associated Ground Segment (GS) elements, including ground station equipment.

### **2.2 GOES-R Mission Overview**

GOES-R series satellites will have two operational locations: 75 degrees West and 137 degrees West longitude. Any GOES-R series satellite stored on-orbit will be located at 105 degrees West longitude. The primary instrument is the Advanced Baseline Imager (ABI) that will provide hemispheric, synoptic, and mesoscale imagery for global and CONUS forecasting and severe weather warning. Secondary instruments include the Extreme ultraviolet and X-ray Irradiance Sensor (EXIS), Solar Ultraviolet Imager (SUVI), Space Environment In-Situ Suite (SEISS), Magnetometer (MAG), and Geostationary Lightning Mapper (GLM). Additionally, GOES-R will provide a set of communications services (Unique Payload Services) comprising the Data Collection System (DCS), Search-and-Rescue Satellite Aided Tracking

(SARSAT), High-Rate Information Transmission (HRIT), and Emergency Managers Weather Information Network (EMWIN, which is integrated with the HRIT data stream).

### 2.3 GOES-R Ground Segment

The GOES-R Ground Segment (GS) will operate from three sites. The NOAA Satellite Operations Facility (NSOF) in Suitland, MD will house the primary Mission Management (MM), Product Generation (PG), and Product Distribution (PD) functions. The Wallops Command and Data Acquisition Station (WCDAS) in Wallops, VA will provide space communications services and selected Ground Segment functions. The third site is a geographically isolated Remote Backup (RBU) facility located at Fairmont, WV. It will function as a completely independent backup for designated MM, PG and PD functions for the production and delivery of critical cloud and moisture imagery products, and GOES Rebroadcast

(GRB) data, and will be capable of remote operation from the NSOF and WCDAS. The RBU station will have visibility to all operational and on-orbit spare satellites. The Enterprise Management (EM) function supports GS components across all locations.

For GOES-R operations, the NSOF and WCDAS together comprise the “primary” sites and may be considered in certain respects as a single system. WCDAS provides the Earth-space communications functions, while primary console operations and higher-level product data functions are provided by NSOF. The RBU consolidates the mission-critical functionality of the NSOF and WCDAS into a single “backup” site that can operate completely independently. Figure 2.3 provides an overview of the Ground Segment within the GOES-R System.

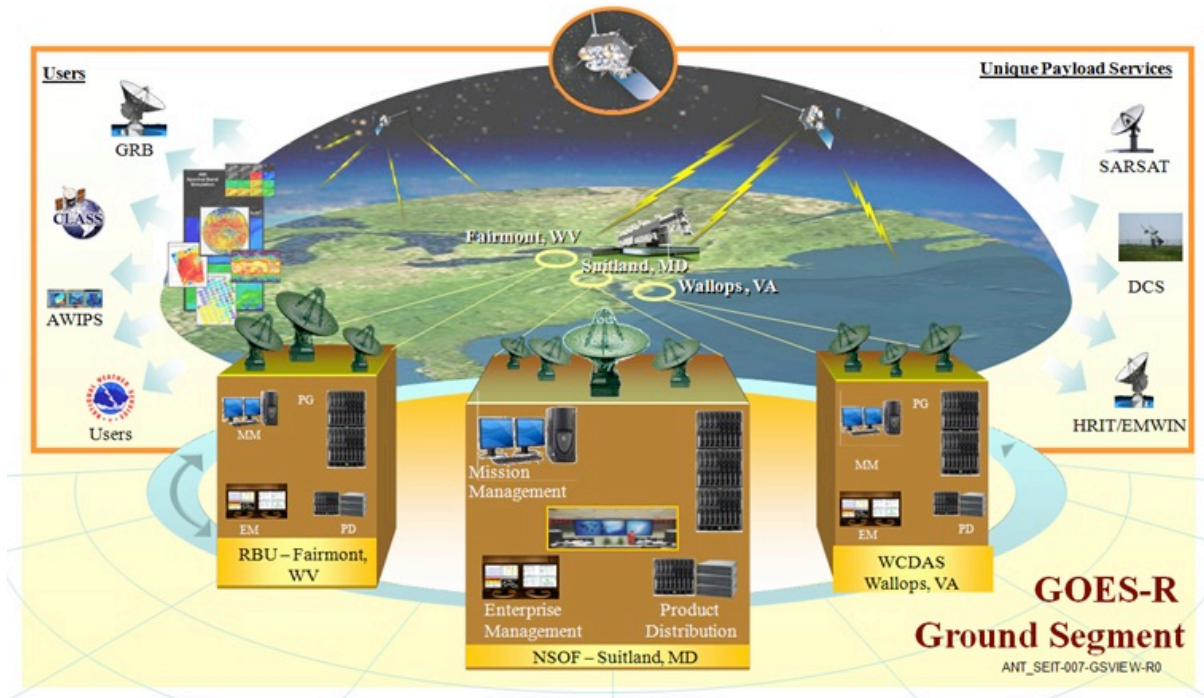
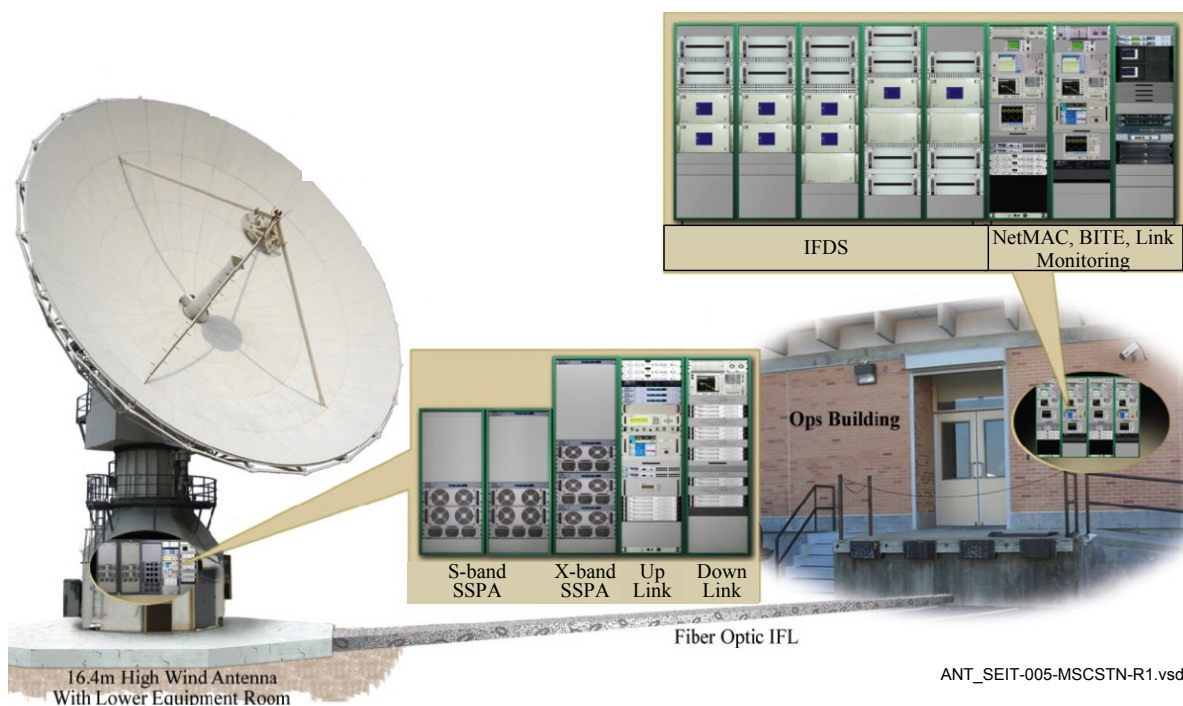


Figure 2.3 GOES-R Ground Segment Overview

#### 2.3.1 GOES-R GS Antenna System

The Antenna System is part of the comprehensive GOES-R Ground Segment and supports the Mission Management Element. The Antenna System includes all components across all three sites required to

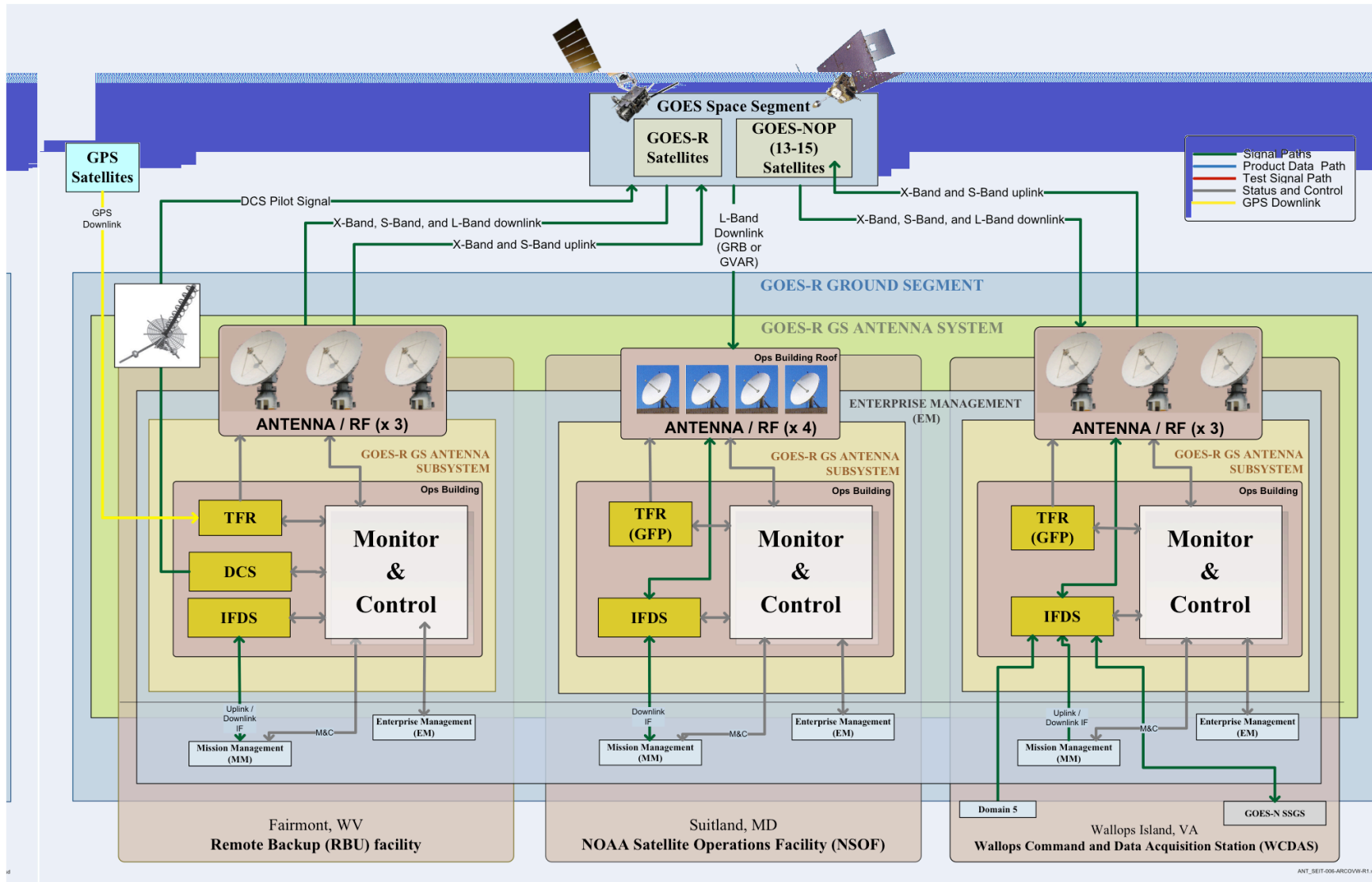
receive or transmit RF signals to/from the satellites through the Intermediate Frequency Distribution System (IFDS) interface demarcation point with the GS. The Ground Station resources consist of three new 16.4m hurricane-rated (HR) antenna stations at WCDAS, three new 16.4m HR antenna stations at RBU, and upgrades to four existing 9.1m GOES Variable (GVAR) receive-only systems at NSOF. Figure 2.3.1-1 provides a notional view of a 16.4m Antenna Station at site.



**Figure 2.3.1-1 Antenna Station**

The architecture is divided into three major functional subsystems: the Antenna Subsystem, the Monitor and Control (M&C) Subsystem and the Site Preparation and Construction Subsystem. The Antenna Subsystem consists of the components for the 16.4m Antenna (including Antenna Control, Tri-band feed design, reflectors, trusses, drive trains, and pedestal bases), the RF Uplink and Downlink functionality, Data Collection System (DCS), Intermediate Frequency Distribution Switch (IFDS) and Timing and Frequency Reference System (TFRS). The Antenna Subsystem also upgrades existing 9.1m antenna feed assemblies. The M&C Subsystem includes the functionality for Antenna Station Control, Link Monitoring, Built-In-Test/ Built-In-Test-Equipment (BIT/BITE), and Antenna System Interface Simulators (ASIS). The Site Preparation and Construction Subsystem consists of the foundation design, power interfaces, HVAC, physical security and safety components.

The integration of new GOES-R ground station resources into the GOES operational environment has the potential to conflict with ongoing operations. It is NOAA's overarching operational philosophy that the health & safety of on-orbit assets is paramount and national-critical meteorological data must not be interrupted. Therefore, no reduction in availability or gap in ground resources needed to ensure on-orbit spacecraft health & safety and data continuity is acceptable during the delivery, integration, test, and transition to operations of the GOES-R Antenna System. Figure 2.3.1-2 shows the Antenna System architecture components at each facility.





### **2.3.1.1 NSOF**

The NSOF will be the primary operations site housing the GOES-R constellation mission operations, PG, EM, and PD functions and will house the majority of operations and product staff. All GOES-R series mission operations, from pre-launch testing through sustaining operations, will be performed from NSOF. The NSOF will also house the product distribution interface to the GOES-R point(s) of presence for network distribution of products to users. GOES rebroadcast data is received directly at the NSOF via four 9.1m receive-only antennas located on the roof of the NSOF facility. These antennas will be upgraded to receive GRB from GOES-R in addition to GVAR data.

### **2.3.1.2 WCDAS**

The WCDAS will be the primary site for GOES-R Space/Ground RF communications. WCDAS will house the antenna suite required for dedicated links to each operational and stored spacecraft, the front-end equipment to acquire data and to uplink commands and data services, and the associated network interfaces to provide data to the GOES-R system. WCDAS will also process data through Level 1b to produce GRB for uplink to the satellite. In this way, WCDAS will be able to maintain the GRB generation and rebroadcast service in case communications to NSOF are interrupted. WCDAS will interface with and provide uplinks to the Unique Payload Services for broadcast. Also, the NSOF will have capabilities to perform remote operation of WCDAS functions.

WCDAS currently provides all primary space-ground communication functions and sensor data processing for the on-orbit GOES constellation.

### **2.3.1.3 RBU**

Continuity of Operations (COOP) requirements drive the GOES-R to include a remote site that provides the critical functions of WCDAS and NSOF through the production and distribution of GRB and key product data. Operation of the RBU is the primary contributor to fulfilling COOP requirements and may also be used to enhance system availability. Although the new GOES-R antennas at RBU will be compatible with GOES-N/O/P (i.e. their feed design will support GOES-N/O/P RF characteristics), the RBU build-out will not initially include the ground processing equipment to provide backup for the GOES-N/O/P satellites.

## **2.4 Document Description**

This document specifies required GOES Rebroadcast radio frequency downlink characteristics to enable the user community to design and develop compliant GRB receivers.



**3.0 REFERENCED DOCUMENTS****Table 3.1 Reference Documents**

| <b>Document Number</b>                           | <b>Title</b>                                                                                                                                                                                                            |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NTIA Redbook                                     | Manual of Regulations and Procedures for Federal Radio Frequency Management, Jan 2008 ed, Sept 2009 rev.                                                                                                                |
| ETSI EN 302 307, ver 1.2.1 (2009-08)             | Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2) |
| 417-R-IRD-0002<br>Version 2.4<br>August 05, 2011 | Interface Requirements Document (IRD) for the Geostationary Operational Environmental Satellite Series R (GOES-R) System,<br>Space Segment (SS) to GOES Rebroadcast (GRB) Service (NASA document)                       |

**4.0 RECEIVER SPECIFICATIONS****4.1 Simultaneous Links**

The GRB service should meet all of its performance requirements simultaneously with all the other GOES-R services operating under normal conditions. GRB data on the downlink is split approximately equally between two circular polarized signals, Right Hand Circular Polarized (RHCP) and Left Hand Circular Polarized (LHCP). In addition, other GOES-R downlink signals are located nearby in frequency as shown in Table 4.1. The GRB receiver must therefore contain adequate filtering to decode the GRB signals in the presence of these other signals.

**Table 4.1 L Band Downlink Signals Relative Levels**

| <b>Signal Name</b>  | <b>Center Frequency (MHz)</b>                     | <b>Approximate Bandwidth</b> | <b>Maximum Signal Level at the Antenna Relative to the GRB Signal (dB)</b> | <b>Notes</b>             |
|---------------------|---------------------------------------------------|------------------------------|----------------------------------------------------------------------------|--------------------------|
| GRB (for reference) | 1686.6                                            | 9.8 or 10.9 MHz              | 0.0                                                                        | Reference                |
| DCS (DCPR)          | 1679.9 (domestic)<br>or<br>1680.2 (international) | 400 kHz                      | -7.4                                                                       | Aggregate (250 carriers) |
| CDA TLM             | 1693.0                                            | 80 kHz                       | -17.0                                                                      |                          |
| HRIT/EMWIN          | 1694.1                                            | 1.2 MHz                      | -2.3                                                                       |                          |

## 4.2 Required Receive System Performance

The signals provided by the space segment are NTIA compliant. Minimum GRB receiver performance shall comply with the Table 4.2 and Table 4.3:

**Table 4.2 Required GRB Receive System Performance**

| Parameter                                                         | Value                                 |
|-------------------------------------------------------------------|---------------------------------------|
| Input Center Frequency                                            | 1686.6 MHz                            |
| Polarization                                                      | Dual Circular: RHCP & LHCP            |
| Polarization Isolation                                            | $\geq 27$ dB                          |
| Phase Noise (integrated from 1 kHz to 12 MHz)                     | $< 2^\circ$ rms Double Sideband (DSB) |
| Bit Error Rate (BER) at Minimum Receive Flux Density in Table 4.3 | $\leq 1 \times 10^{-10}$              |
| Minimum Antenna System G/T                                        | 15.2 dB/K (at $5^\circ$ elevation)    |
| Long Term Frequency Accuracy                                      | $< 1 \times 10^{-7}$                  |
| Short Term Frequency Stability (1 sec)                            | $< 1 \times 10^{-9}$                  |

## 4.3 Additional GRB Downlink Characteristics

**Table 4.3 GRB Downlink Signal Characteristics**

| Parameter                                                            | Description   |
|----------------------------------------------------------------------|---------------|
| Minimum Satellite EIRP at edge-of-coverage and end-of-life           | 60.5 dBmi     |
| Primary Modulation*                                                  | 8PSK          |
| Alternate Modulation*                                                | QPSK          |
| Signal Format                                                        | DVB-S2        |
| Output of the DVB-S2 Demodulator/Decoder                             | 15.5 Mbps     |
| Symbol rate for Primary Modulation and Coding, (each polarization),  | 7.825768 Mbps |
| Symbol rate for Alternate Modulation and Coding, (each polarization) | 8.665938 Mbps |
| Necessary bandwidth per polarization, Primary Modulation and Coding  | 9.8 MHz       |

\* Operational modulation will be selected between Primary and Secondary during spacecraft Post-Launch checkout and test

| <b>Parameter</b>                                                      | <b>Description</b>                                    |
|-----------------------------------------------------------------------|-------------------------------------------------------|
| Necessary bandwidth per polarization, Alternate Modulation and Coding | 10.9 MHz                                              |
| Theoretical Eb/No for $1 \times 10^{-10}$ BER, 8 PSK modulation       | 3.7 dB                                                |
| Theoretical Eb/No for $1 \times 10^{-10}$ BER, QPSK modulation        | 3.9 dB                                                |
| Coding: Primary Modulation                                            | 2/3 rate + BCH Outer Code                             |
| Coding: Alternate Modulation                                          | 9/10 rate + BCH Outer Code                            |
| Block Length                                                          | 64800 bits                                            |
| Pilot Blocks                                                          | Not Used                                              |
| Randomization                                                         | Per ETSI EN 302 307, sect.5.2.2                       |
| Transmit Data Filtering                                               | Square Root Raised Cosine (SRRC) with $\alpha = 0.25$ |
| Data Encoding                                                         | NRZ-L                                                 |

**5.0 ACRONYM LIST**

The following acronyms are used throughout this document and are applicable to this user guide.

|         |                                                            |
|---------|------------------------------------------------------------|
| 8PSK    | 8 Phase Shift Keying                                       |
| BER     | Bit Error Rate                                             |
| bps     | Bits per second                                            |
| CCSDS   | Consultive Committee for Space Data Systems                |
| CDA TLM | Command Data Telemetry                                     |
| dB      | Decibel                                                    |
| DCPR    | Data Collection Platform Reports                           |
| DCS     | Data Collection System                                     |
| DSB     | Double Sideband                                            |
| Eb/No   | The energy per bit to noise power spectral density ratio   |
| EMWIN   | Emergency Managers Weather Information Network             |
| ETSI    | European Telecommunication Standards Institute             |
| FEC     | Forward Error Correction                                   |
| G/T     | Gain-to-Noise Temperature Ratio                            |
| HRIT    | High Rate Information Transmission                         |
| IFDS    | IF Data Switch                                             |
| LDPC    | Low Density Parity Check                                   |
| Mbps    | Megabits per second                                        |
| MHz     | Megahertz                                                  |
| NOAA    | National Oceanic and Atmospheric Administration            |
| NSOF    | NOAA Satellite Operations Facility                         |
| NTIA    | National Telecommunications and Information Administration |
| QPSK    | Quadrature Phase Shift Keying                              |
| RBU     | Remote Backup (facility)                                   |
| SRRC    | Square Root Raised Cosine                                  |
| WCDAS   | Wallops Command and Data Acquisition Station               |