Geostationary Operational Environmental Satellite (GOES)

GOES-R Series

Interface Requirements Document (IRD)

Space Segment (SS)
To
Low Rate Information Transmission (LRIT)
Service

Draft

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To verify the correct version of this document, please contact the GOES R Series Requirements Management Office on 301-286-7898

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1 Introduction

The Geostationary Operational Environmental Satellite Series R (GOES-R) System will provide an expanded capability series of spacecraft to follow those developed and launched under the GOES N-Q Program. The expanded capabilities will follow from anticipated developments of the payload instrument suites as well as the several ancillary services included in the program mission. Six GOES-R Mission Segments interface and function to support the total GOES-R mission. They are:

- **Space Segment (SS)**
- Launch Support Segment (LSS)
- Ground Located - Command, Control, and Communications Segment (GL-C3S)
- Product Generation and Distribution Segment (PGDS)
- User Interface Segment (UIS)
- Archive and Access Segment (AAS)

As part of the Space Segment (SS), the GOES-R will support several NOAA auxiliary services

- GOES Rebroadcast Service (GRB)
- **Low Rate Information Transmission (LRIT) Service**
- Emergency Managers Weather Information Network (EMWIN) Service
- Data Collection System (DCS)
- Search and Rescue (SAR) Service

1.1 Purpose

The purpose of this document is to describe and specify the functional and performance interface requirements for the communication links between the GOES-R Space Segment (SS) and the Low Rate Information Transmission (LRIT) service.
This document it also intended to provide a basis for the subsequent development of a SS-LRIT Interface Control Document (ICD).

1.2 Scope

The interfaces addressed in this document support the exchange of data between the SS and the LRIT ground segment.
Only those parameters that are necessary to specify the interface requirements are given here; full specifications for the satellite transponder will be contained in a satellite performance specification. This IRD therefore:

- Identifies required RF links between the SS and the LRIT ground segment
- Establishes functional and performance requirements related to these links

1.3 Document Overview

This document contains six Sections and two Appendices.
Section 1 explains the purpose and scope of the IRD. It contains a list of applicable and reference documents relevant to the interface.
Section 2 describes the LRIT system functional elements that must be supported by the subject interfaces. Section 3 contains describes the characteristics of the LRIT terminals

relevant to the interface with the GOES-R Space Segment. Section 4 describes the relevant characteristics of the Command and Data Acquisition Station (CDAS) that is used to uplink the LRIT signal.
Section 5 provides the functional and performance requirements that must be met by the SS to support the link interfaces.
Section 6 specifies the overall link performance that must be met under specified assumptions.
Section 7 lists "To Be Determined" (TBD) and "To Be Reviewed" (TBR) parameters and issues in the IRD.
Section 8 lists abbreviations and acronyms used in the IRD.

1.4 Reference Documents

The LRIT Service will commence with the GOES-R series of satellites. It is, however, an evolution from the current generation WEFAX system and will be engineered to employ the same antennas and RF equipment. As such, WEFAX documents are primarily useful as background. The following documents contain information about the WEFAX Service and are useful references.
[1] …….. WEFAX Documents … [To be supplied] ……..
Information in the specification for the communication parameters used for the preceding series of GOES satellites, the GOES-N Series, is also of use, particularly for areas not well covered by the WEFAX or LRIT documents:
[2] Performance Specification for the GOES-N,O,P,Q, S-415-22, Attachment B, Table 10, 27 August 1997, NASA/GSFC
[3] GOES N-Q Space-to-Ground Interface Control Document, Doc. No. DS80667-H00-003, Version 1.0, 31 March 1999, prepared by Hughes Space and Communications Co., prepared for NASA GSFC
The following document contains information about the capabilities of the NOAA Command and Data Acquisition Stations (CDAS), which will be used to uplink the LRIT broadcast signal:
[4] NOAA/NESDIS Antennas and RF System Capabilities Handbook, NOAA/OSD3-2001-0043R0UD0, 10 August 2001

2 Low Rate Information Transmission (LRIT) Service and Interface Description

2.1 General Description

The GOES support to the Low Rate Information Transmission (LRIT) service is provided by GOES satellites located at 75º and 135º W. Longitude. This system provides a unidirectional broadcast link connectivity between the originating uplink from the NOAA Command and Data Acquisition Stations (CDAS) and a large number of outlying LRIT terminals. These LRIT terminals are typically small receive-only stations. It is the intent that the LRIT service evolves from the current WEFAX system, which provides a wide dissemination of GOES imagery and other data at the relatively low information rate of

128 kbit/s. The LRIT has a requirement to upgrade this user information rate to 256 kbit/s.
The SS satellite transponder that supports the LRIT service is bent-pipe, i.e., it receives the uplink signal within a certain frequency band, translates it to a new frequency band, amplifies it, and retransmits it on the downlink, but with no demodulation. For LRIT, the uplink is S-Band and the downlink is L-Band. The uplink coverage must include the CDAS, primary and backup; for simplicity and in accord with current GOES-N Series guidelines, this will be met utilizing an earth coverage antenna. The downlink coverage must provide earth coverage out to a ground station elevation angle of 5º.
The LRIT modulation will employ offset QPSK (OQPSK) with forward error correction coding. This coding shall consist of an inner convolutional code (Rate-1/2, Constraint length 7) and an outer Reed-Solomon block code (255, 233) with interleaving depth of [TBD] [TBR].
Figure 2-1 shows the SS-to-LRIT interface. The required connectivity through the GOES-R Series satellites is shown in Figure 2-2. Not shown in this figure are other links that support downlinking of the instrument data (Sensor Data or SD) and the transponder support to the other auxiliary services.

Figure 2-1: SS-to-LRIT Interface Diagram

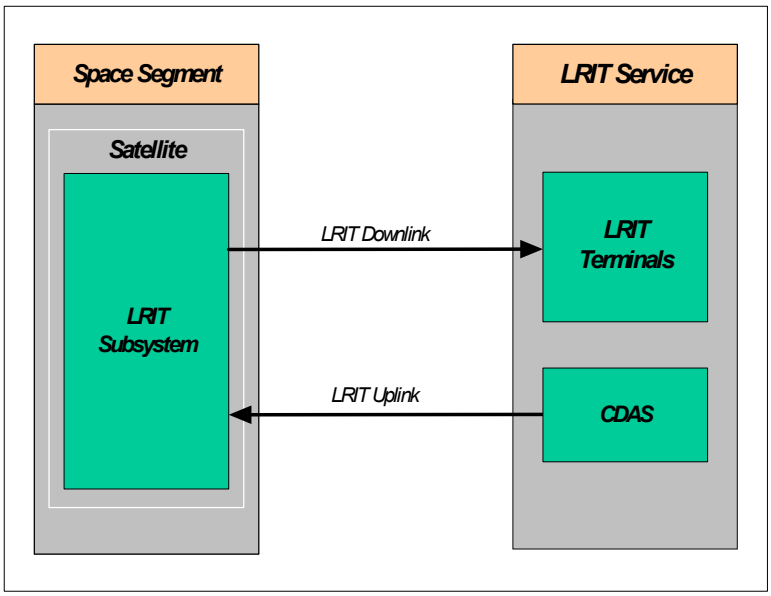
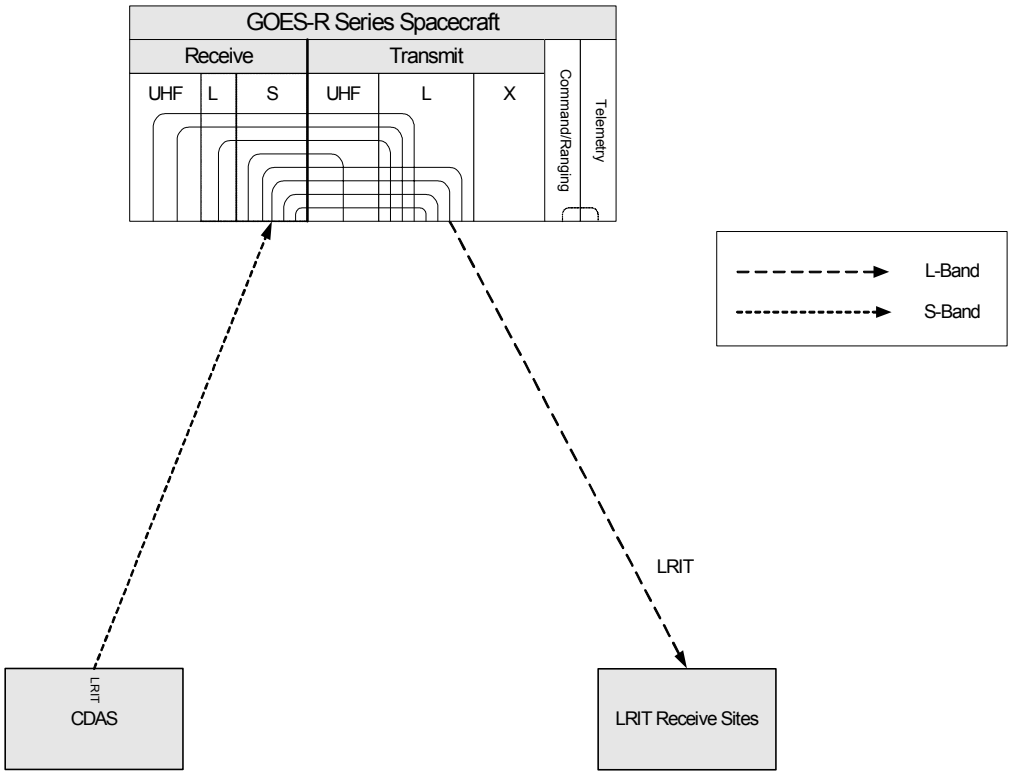


Figure 2-2: LRIT Connectivity through GOES-R Series Satellites



3 LRIT Terminal Interface Requirements

3.1 Downlink Frequency

The LRIT transmission is received at a nominal downlink frequency of 1693.4 MHz.

3.2 Terminal G/T

The LRIT terminal G/T, including any mispointing, polarization mismatch, or other degradations, **shall** be a minimum of -0.3 dB/K

3.3 Antenna Polarization

The LRIT terminal antenna **shall** be linear polarization nominal N-S, adjustable to match the downlink received signal.

3.4 Receiver Characteristics

3.4.1 Data Rate

The LRIT information rate **shall** be 256 kbit/s.

3.4.2 Modulation and Coding (TBR)

The LRIT signal **shall** be offset QPSK (OQPSK) with raised cosine filtering (50% rolloff).

Forward error correction **shall** be a concatenated Convolutional Code, Rate-1/2 with constraint length 7, and a Reed-Solomon block code (255,233) with interleaving depth [TBD].

3.4.3 Frequency Tracking

The LRIT receiver **shall** be capable of acquiring and tracking input signals within ±25 kHz of the nominal receive frequency

3.4.4 E_b/N_0 Perfomance

The LRIT receiver **shall** provide a BER of $1 \cdot 10^{-8}$ at a measured E_b/N_0 of 6.0 dB [TBR]. This includes an approximate 2.3 dB degradation from theoretical performance for the concatenated Convolutional/Reed-Solomon code.

4 CDAS Interface Requirements

4.1 UpLink Frequency

The nominal uplink frequency for the LRIT uplink **shall** be 2028.4 MHz.

4.2 UpLink EIRP

The nominal uplink EIRP **shall** be 88 dBmi.

4.3 UpLink Polarization

The transmit polarization **shall** be linear, nominal N-S, and adjustable to match the satellite receive polarization.

4.4 Transmitter Characteristics

4.4.1 Data Rate

The data rate is specified in § 3.4.1.

4.4.2 Modulation and Coding (TBR)

The modulation and coding are specified in § 3.4.2.

4.4.3 Frequency Stability

The transmission frequency stability **shall** be ≤ 1 part in 10^8 long term (1 year) and adjustable to maintain this accuracy over the mission duration.

4.4.4 Phase Noise

Transmission phase noise **shall** meet the mask given in Figure [TBD].

5 Space Segment (SS) Interface Requirements

5.1 CDAS-to-SS UpLink Interface

5.1.1 Frequency Band

The uplink frequency signal is a narrowband DCPI signal at 2034.8375 MHz for GOES-E, 2034.8125 MHz for GOES-W or the GOES-Spare, and 2034.8250 MHz for GOES-W.

5.1.2 Nominal Signal Level

The uplink signal level at the satellite antenna input is approximately [TBD]. [NOTE in DRAFT: for the GOES-N Series this range is -104 to -114 dBm [9].]

5.1.3 Satellite Receive G/T

The satellite receive G/T **shall** be a minimum of -17 dB/K at edge of coverage.

5.1.4 Satellite Receive Antenna Coverage

The satellite receive antenna coverage **shall** be earth coverage with minimum elevation angle of 5°.

5.1.5 Satellite Receive Antenna Polarization

The satellite receive antenna polarization **shall** be linear N-S with a minimum cross-polarization isolation of [TBD] dB over the specified coverage area. [NOTE in Draft: GOES-N Series value is unspecified [3].]

5.2 SS-to-LRIT Terminal Downlink Interface

5.2.1 Frequency Band

The downlink frequency band for the LRIT consists of a single 300 kHz bandwidth channel at the following center frequency:

Satellite	Channel Center Frequency (MHz)
GOES-East/West	1691.34

5.2.2 Satellite EIRP

The downlink EIRP **shall** be a minimum of 56 dBmi [TBR] over the required coverage area.

5.2.3 Satellite Transmit Antenna Coverage

The downlink satellite beacon transmit antenna coverage **shall** be earth coverage to a minimum elevation angle of 5º.

5.2.4 Satellite Transmit Antenna Polarization

The downlink satellite beacon transmit antenna polarization **shall** be linear N-S with a minimum cross-polarization isolation of [TBD] dB. [NOTE in Draft: GOES-N Series value is unspecified [3].]

6 Link Performance Specification

Based on the assumed link parameters of Section 6.1, the link performance **shall** meet the performance criteria of Sections 6.2 and 6.3. Performance is specified for the combined up and downlinks, i.e., for the full path between CDAS and the LRIT terminals.

6.1 Assumed Link Parameters

The following conditions **shall** be assumed in the calculation of expected link performance.

1. Propagation impairments due to atmospheric absorption and rain of 0.5 dB for the L-Band and S-Band links **shall** be assumed.
2. Scintillation losses shall be considered to be 1.5 dB [TBR] for both the up and downlinks; however, it may be assumed that scintillation occurs independently on the up and downlinks and is not simultaneous.
3. The elevation angle at the LRIT shall be assumed to be the worst case value of 5º.
4. Worst case polarization mismatches on the uplink and downlink shall be assumed. Effects of non-ideal axial ratios shall be included.
5. Interference: Co-channel interference for the LRIT links shall be assumed small and no specific entry is required. Adjacent channel interference for the LRIT links shall assume a two-sided C/I of [further study required].
6. At the LRIT receiver, the required E_b/N_0 shall be as specified in § 3.4.4 before applying (a) an implementation loss of 1.2 dB, (b) a modulation loss due to non-orthogonal PSK of 0.5 dB, and (c) a satellite distortion and other loss of 0.5 dB. [NOTE: loss values TBR].

6.2 Link Availability

The link calculations **shall** demonstrate link closure, i.e., positive link margin, under the assumptions specified in Section 6.1. Due to the benign propagation environment at these frequencies, this should result in link availability of at least 99.9% except for links that may exhibit undue scintillation.

6.3 Link Bit Error Rate

The end-to-end link bit error rate (BER) **shall** be $1 \cdot 10^{-6}$ or better under the worst-case assumptions of Section 6.1.

7 TBR/TBD Listing

Number (SS/LRIT)	Description	Resolution Plan	Date
TBR/TBD1			
TBR/TBD2			
TBR/TBD3			
TBR/TBD4			
TBR/TBD5			
TBR/TBD6			
TBR/TBD7			
TBR/TBD8			

8 Abbreviations and Acronyms

ALC	Automatic Level Control
AM	Amplitude Modulation
AS	Archive Segment
β	Modulation Index
BCH	Bose-Chaudhuri-Hocquenghem (Forward Error Correction Code)
BER	Bit Error Rate
BiΦ-L	Bi-Phase Level
BPSK	Binary Phase Shift Keying
BW	Bandwidth or Beamwidth (context dependent)
C3S	Command, Control and Communications Segment
CDA	Command and Data Acquisition
CDAS	Command and Data Acquisition Station
CCSDS	Consultative Committee on Space Data Systems
C/N_0	Carrier to Noise Density Ratio (dB-Hz)
COSPAS	(Russian: Cosmicheskaya Sistyema Poiska Avariynich Sudov) Space System for the Search of Vessels in Distress
CP	Circularly Polarized or Circular Polarization
DCP	Data Collection Platform
DCPI	Data Collection Platform Interrogate
DCPR	Data Collection Platform Report
DCS	Data Collection System
DRGS	Direct Readout Ground Station
EIRP	Effective Isotropically Radiated Power
ELT	Emergency Locator Transmitter
EMWIN	Emergency Managers Weather Information Network

EPIRB	Emergency Position Indicating Radio Beacons
GEOLUT	Geostationary Local User Terminal
GOES	Geostationary Operational Environmental Satellite
GRB-F	GOES Rebroadcast - Full
GRB-L	GOES Rebroadcast - Lite
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
G/T	Gain-to-Noise Temperature Ratio (dB/K)
ICD	Interface Control Document
IRD	Interface Requirements Document
ITU	International Telecommunications Union
L-Band	1.5 - 1.6 GHz Frequency Band
LEO	Low Earth Orbit
LHCP	Left Hand Circularly Polarized
LP	Linearly Polarized or Linear Polarization
LRIT	Low Rate Information Transmission
LSS	Launch Support Segment
LUT	Local User Terminal
MCC	Cospas-Sarsat Mission Control Center
NASA	National Aeronautics and Space Administration
NOAA	National Oceanographic and Atmospheric Administration
PGDS	Product Generation and Distribution Segment
PLB	Personal Locator Beacon
PM	Phase Modulation
ppm	Parts per million
PSK	Phase Shift Keying
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
RMS	Root Mean Square
RVTM	Requirements Verification Traceability Matrix
SAR	Search and Rescue
SARSAT	Search and Rescue Satellite-Aided Tracking
S-Band	2.5 - 2.7 GHz Frequency Band
SS	Space Segment
TBD	To Be Determined
TBR	To Be Reviewed

TBS	To Be Supplied
TRD	Technical Requirements Document
UHF	300 - 3000 MHz Frequency Band (Generally taken to be below 1000 MHz)
UIS	User Interface Segment
USG	United States Government
X-Band	7.25 - 8.4 GHZ Frequency Band