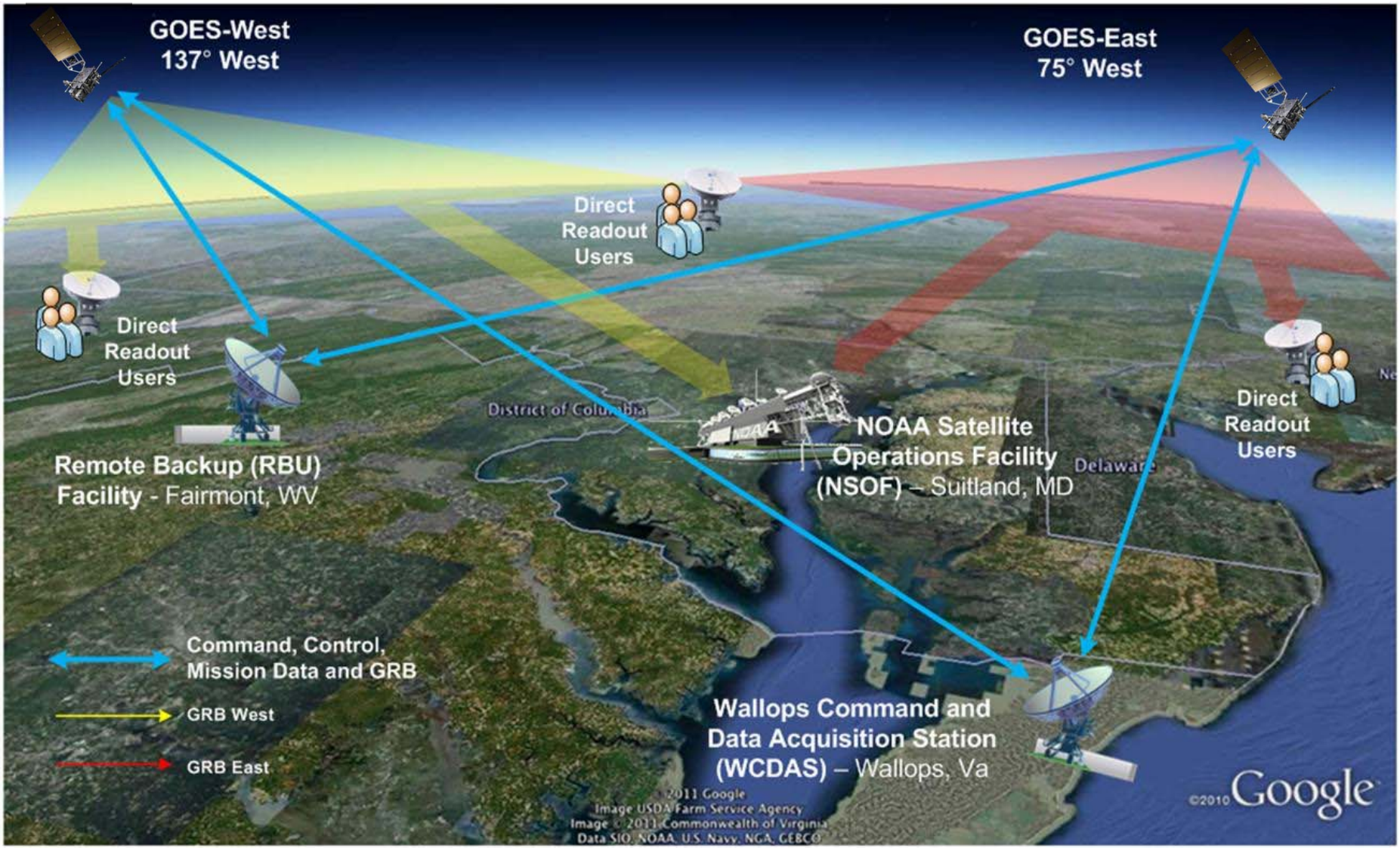
Getting Ready for GOES-R

Satya Kalluri, Randall Race, Richard G. Reynolds

GOES-R Ground Segment Project
Code 416, Building 6, Room C200
NASA Goddard Space Flight Center
Greenbelt, MD 20771
Satya.Kalluri@noaa.gov

http://www.goes-r.gov/

GOES-R Operational System Configuration



Transitioning from GOES NOP to GOES-R

- Improved data products for hemispheric retransmission
  - "GOES Rebroadcast" (GRB)
  - Faster full disk images
    - 5 minutes (Mode 4) and 15 minutes (Mode 3)
  - Full set of Level 1b data
    - Data from six GOES-R instruments including all ABI channels
- Requires new antenna, receiver hardware, and processing system to handle the new data volumes
  - Receiver frequency shift from 1685.7 MHz to 1686.6 MHz
  - Dual circular polarized signals
  - Going from 2.11 Mbps (GVAR) to 31 Mbps (GRB)

Transition from GVAR to GRB

	GOES Variable (GVAR)	GOES Rebroadcast (GRB)
Full Disk Image	30 Minutes	5 Minutes (Mode 4) 15 min (Mode 3)
Other Modes	Rapid Scan, Super Rapid Scan	3000 km X 5000 km (CONUS: 5 minute) 1000 km X 1000 km (Mesoscale: 30 seconds)
Polarization	None	Dual Circular Polarized
Receiver Center Frequency	1685.7 MHz (L-Band)	1686.6 MHz (L-Band)
Data Rate	2.11 Mbps	31 Mbps
Antenna Coverage	Earth Coverage to 5^0	Earth Coverage to 5^0
Data Sources	Imager and Sounder	ABI (16 bands), GLM, SEISS, EXIS, SUVI, MAG
Space Weather	None	~2 Mbps
Lightning Data	None	0.5 Mbps

GRB Downlink Characteristics

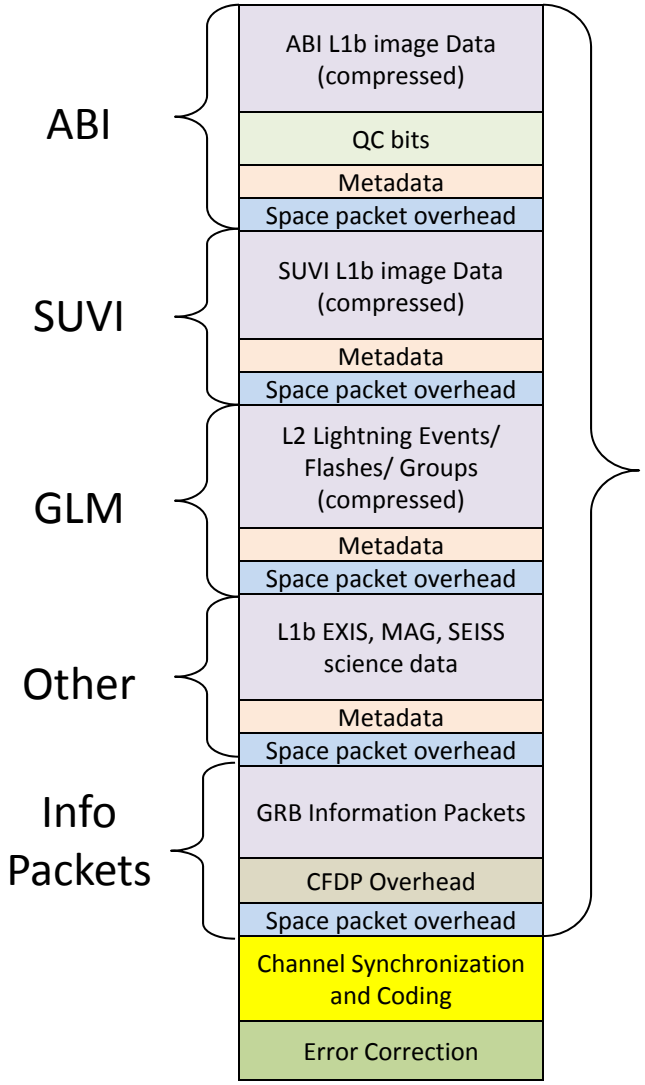
- Input Center Frequency: 1686.6 MHz
- Content (specified for each of two polarization channels: LHCP, RHCP)
  - L1b data, QC data and metadata: ABI, SUVI, EXIS, SEISS, MAG
  - L2 data, QC data, metadata: GLM
  - GRB Information Packets
- Data rate
  - 31 Mbps maximum data rate
  - 15.5 Mbps instantaneous maximum for each polarization channel
  - Downlink link margin: 2.5 db
- Compression - Lossless compression required
  - JPEG2000 (ABI, SUVI) and SZIP (GLM); EXIS, SEISS and MAG data will not be compressed
- Format
  - Outer Frame Format: DVB-S2
  - Inner Frame Format: CCSDS Space Packet
- Coding
  - BCH + LDPC (2/3) for 8-PSK and LDPC (9/10) for QPSK
- Modem Required C/No (dB-Hz): 78.6
- Maximum Demodulator Required Eb/No (dB) for $1x10^{-10}$ BER:
  - 3.7 dB (8 PSK); 3.9 dB (QPSK)
- Minimum Antenna System G/T (dB/K) : 15.2 db/K (at 5^0 Elevation)

Details of the Dual Polarized Signal

- GRB
  - LHCP: L1b products from ABI 0.64 um band and 6 IR bands (3.9, 6.185, 7.34, 11.2, 12.3, and 13.3 um)
  - RHCP: L1b products from ABI bands 0.47, 0.865, 1.378, 1.61, 2.25, 6.95, 8.5, 9.6 and 10.35um, L2+ GLM, L1b SUVI, L1b EXIS, L1b SEISS, and L1b Magnetometer products

- Ensures load balanced utilization of the two circular polarizations, allowing users to receive all GRB products with a dual-polarized system (both LHCP and RHCP), and allowing users flexibility to receive GOES Imager legacy channels with a single polarized system (LHCP only).

GRB Channel Content Summary

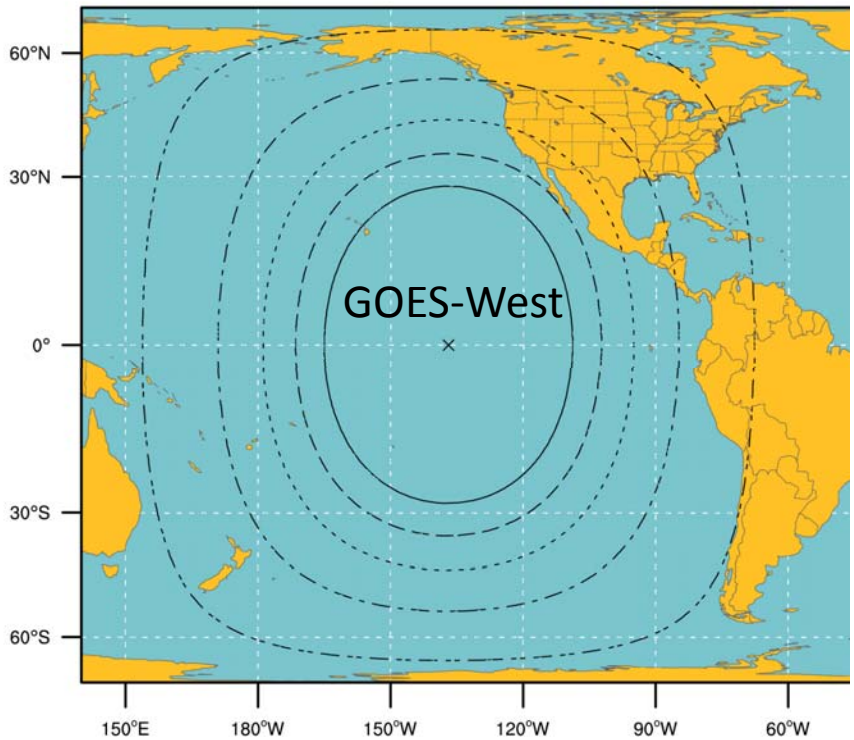


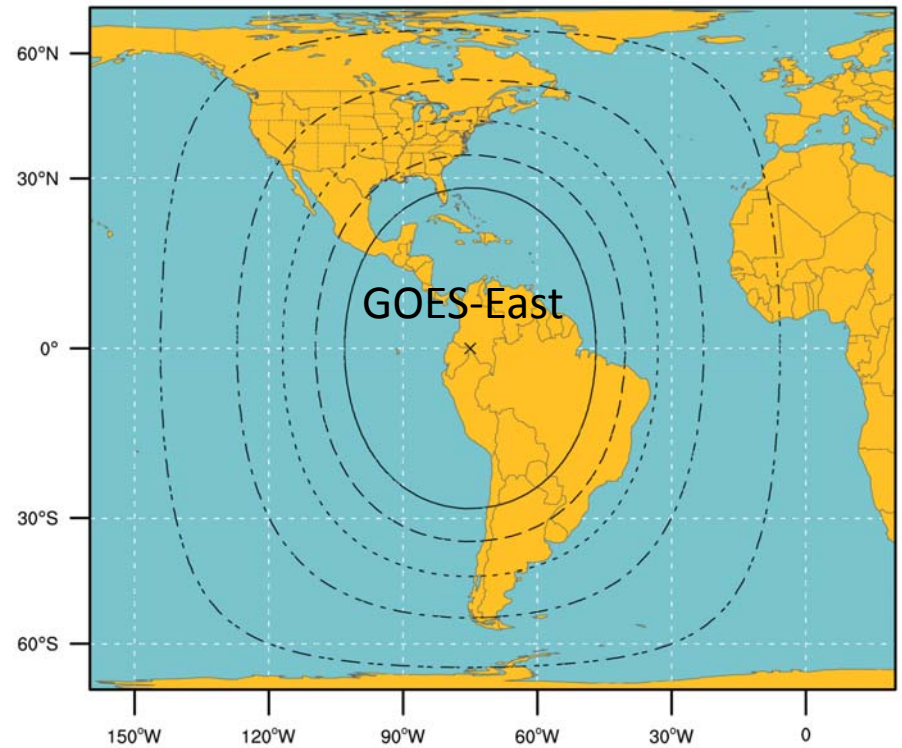
Note: This is a catalog of the contents and not a sequential organization of the stream

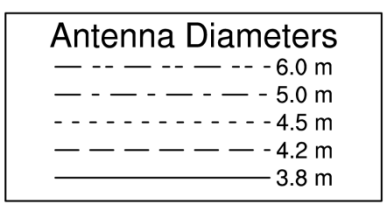
Included in two 15.5 Mbps Bandwidth channels

- For each instrument: image data + metadata + CCSDS Space Packet overhead
- ABI has per pixel QC bits, coded separately
- ABI, SUVI, GLM compressed
- GRB Info packets via CCSDS File Delivery Protocol (CFDP)
- Channel synchronization and coding (link layer) for DVB-S2
- Error correction (LDPC)

GRB Ground Antenna Sizes







NOTES:

1. Calculations based on available data as of May 2011
2. Each antenna size is usable within the indicated contour
3. Rain attenuations included are:
   1.3/1.6/2.0/2.2/2.5 dB (3.8 to 6 m)
4. An operating margin of 2.5 dB is included as the dual polarization isolation is likely to vary within each antenna size area

Planned GRB Resources for Users

- 5 GRB Simulators available in 2013

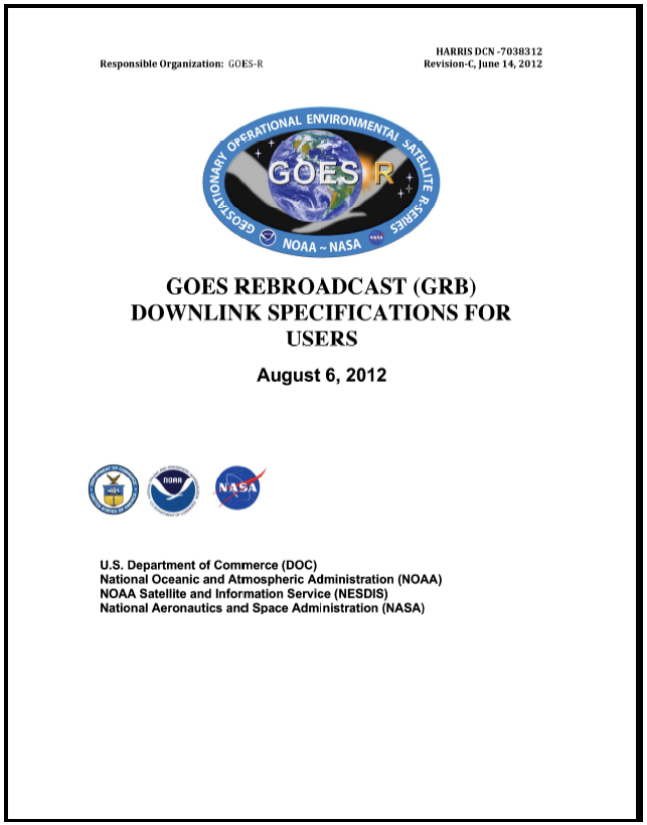
- GRB Downlink Specification Document for Users Provides GOES Rebroadcast radio frequency downlink characteristics, to enable the user community to develop GRB receivers
  - http://www.goes-r.gov/resources/docs.html

- GOES-R Product Users Guide (PUG)
  - Describes the format and content of GRB data
  - http://www.goes-r.gov/resources/docs.html

GRB Resources and Documentation

http://www.goes-r.gov/resources/docs.html

- GRB Downlink Specification



Responsible Organization: GOES-R

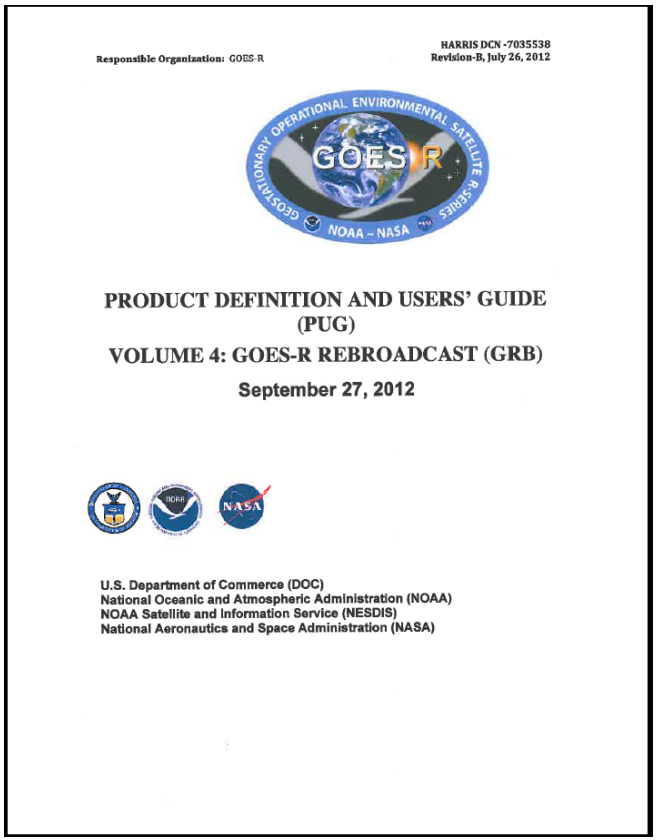
HARRIS DCN -7038312
Revision-C, June 14, 2012

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)

- Product Users Guide (PUG) for GRB



Responsible Organization: GOES-R

HARRIS DCN -7035538
Revision-B, July 26, 2012

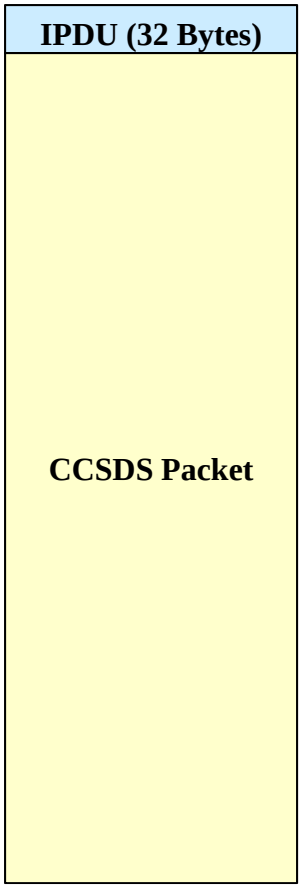
PRODUCT DEFINITION AND USERS' GUIDE (PUG)

VOLUME 4: GOES-R REBROADCAST (GRB)

September 27, 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)

GRB Data Characteristics



- Each GRB data packet contains two data structures.
  - IPDU header containing information extracted from the transfer frames
  - CCSDS packet containing instrument or satellite data

- Each CCSDS packet has a unique application identifier (APID):

APID Start (Hex)	APID End(Hex)	Instrument
000	0FF	Reserved
100	1FF	ABI GRB
200	2FF	GLM GRB
300	3FF	EXIS GRB
400	4FF	SEISS GRB
500	5FF	SUVI GRB
600	6FF	Mag GRB
700	710	Info GRB
711	7FF	Reserved

GRB CCSDS Packet Data

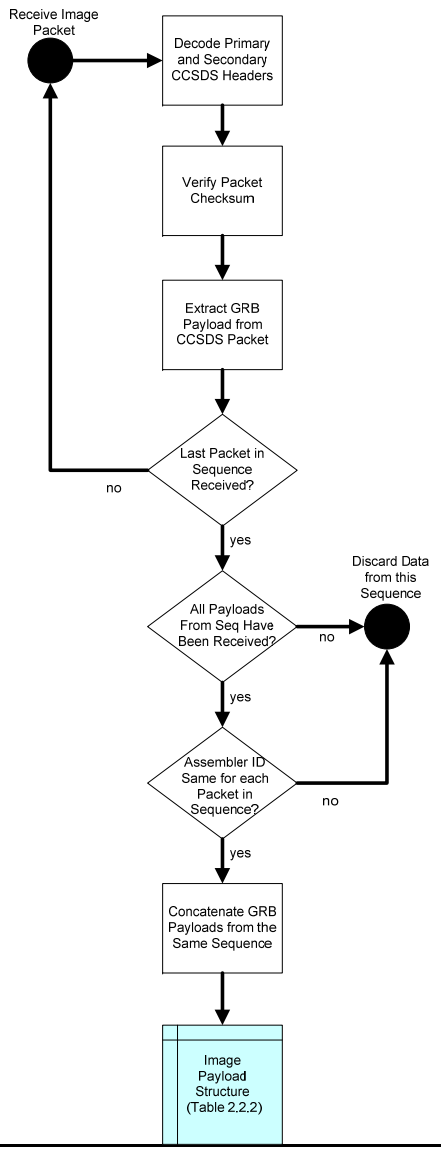
Each packet is made up of four segments:

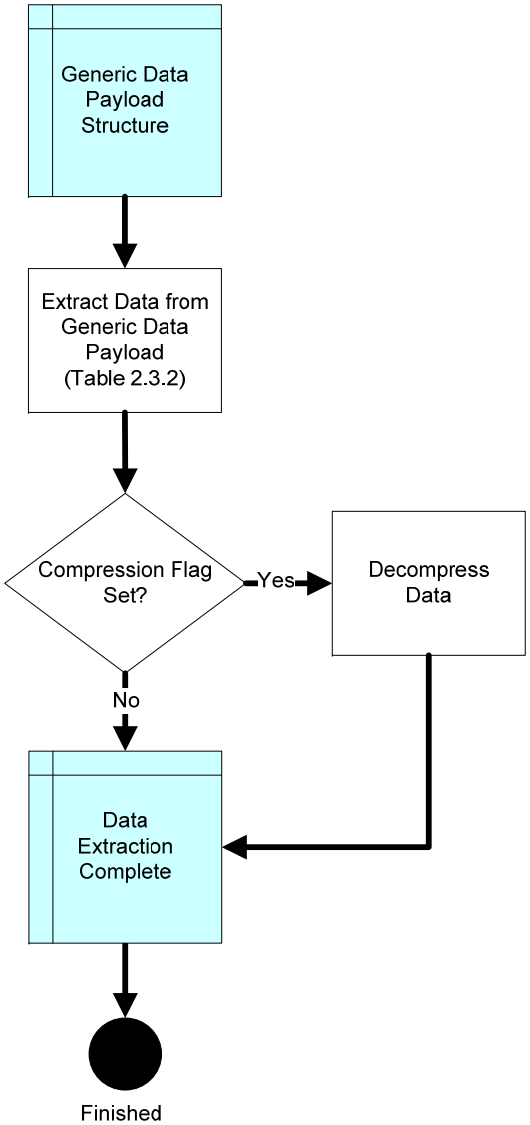
1. Primary Header
   - Specified by CCSDS
   - Separate products have their own APID
2. Secondary Header
   - Always present in GRB Packets
   - Conformant with CCSDS Secondary Header specification
   - Contains Version Number and Packet Type
   - Assembler ID identifies the uplink location of GRB Assembly generating the packet (WCDAS/RBU)
   - Operational Environment identifies the Data Production Environment within the Ground System (OE, ITE, DE)
3. GRB Data Payload (Science Data)
   - Contains the actual product data
   - Imagery, Atomic Blobs, or GRB Info
4. CRC
   - 32-bit Cyclic Redundancy Check (CRC) to assure packet was received correctly.

GRB Data Packet CCSDS Structure

	Bits	Field
1	3	Packet Protocol Version
	1	Packet Type
	1	Secondary Header Flag
	11	APID
	2	Sequence Flags
	14	Packet Sequence Count
	16	Packet Data Length
2	16	Days Since the Epoch
	32	Milliseconds of the Day
	3	GRB Version
	5	GRB Packet Type
	4	Assembler ID
	4	Operational Environment
3	130928	GRB Data Payload
4	32	CRC

GRB Data Extraction





GRB Simulators

- Purpose
  - On-site testing of user ingest and data handling systems, aka GRB field terminal sites
  - Simulate GRB downlink functionality by generating Consultative Committee for Space Data Systems (CCSDS) formatted GRB output data based on user-defined scenarios, test patterns, and proxy data files.
  - Available in 2013

- Key Capabilities and Features
  - Transportable
    - Fully self contained
    - Configurable hardware units
  - Outputs simulated GRB at baseband and IF levels
  - "Off-line Mode" to create and configure simulation scenarios
    - Also, create test patterns and process input proxy data
  - "On-line Mode" to continuously output GRB data stream
    - Includes monitoring and logging of events

GRB Simulator Concept

Simulated data/test patterns

Binary/PNG/JPEG
Proxy Data

GRB signal in Baseband and IF Frequencies

- CCSDS packets in LHCP and RHCP streams
- Lossless compression
- DVBS2 framing
- BCH/LDCP encoding
- 8-PSK or QSPK modulation

Modulator

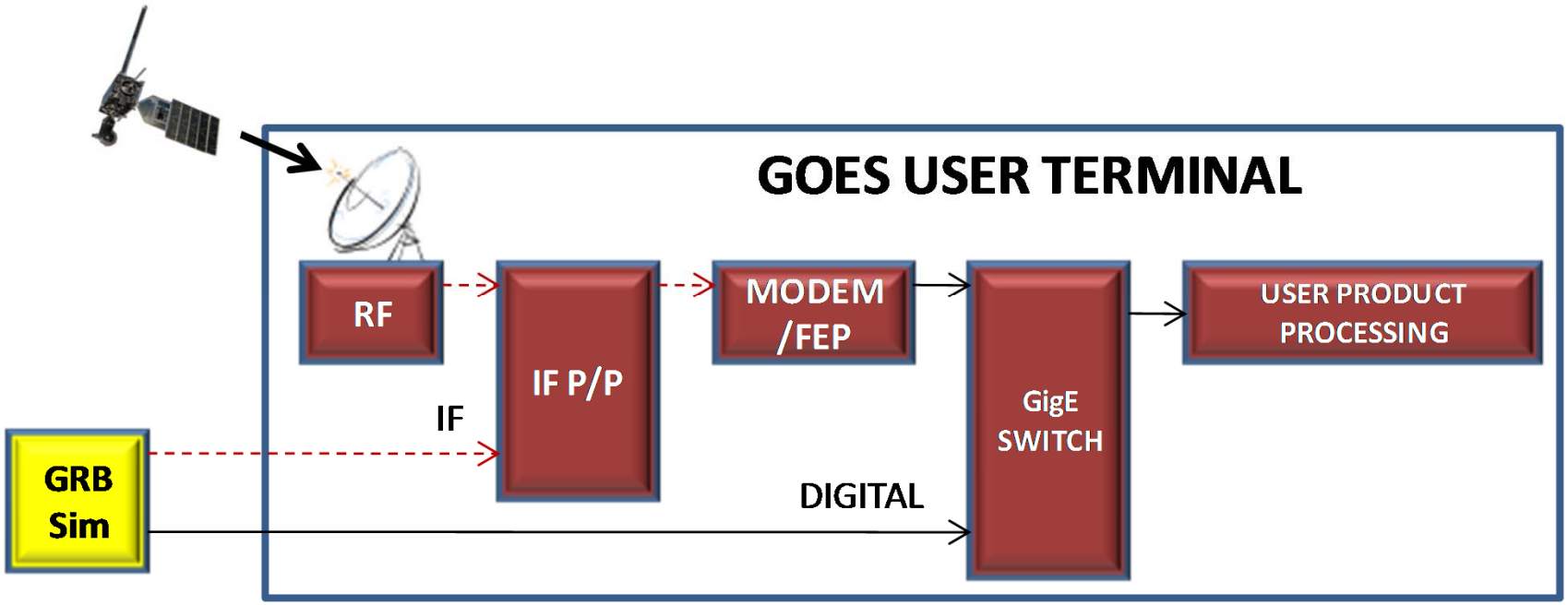
DVBS2/CCSDS Front End Processor

GRB Simulator Processor

Time code Reader/Generator

Network Switch

GRB Simulator Hardware
User Terminal Connectivity



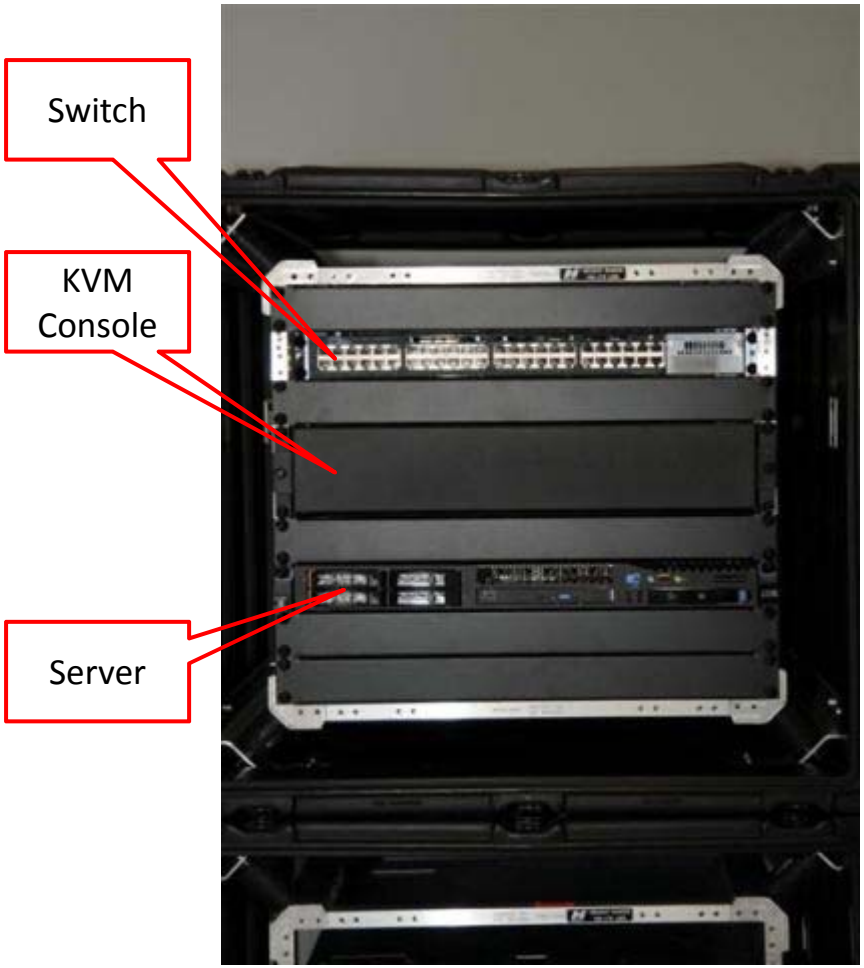
GRB Simulator Integrated Hardware

FRONT

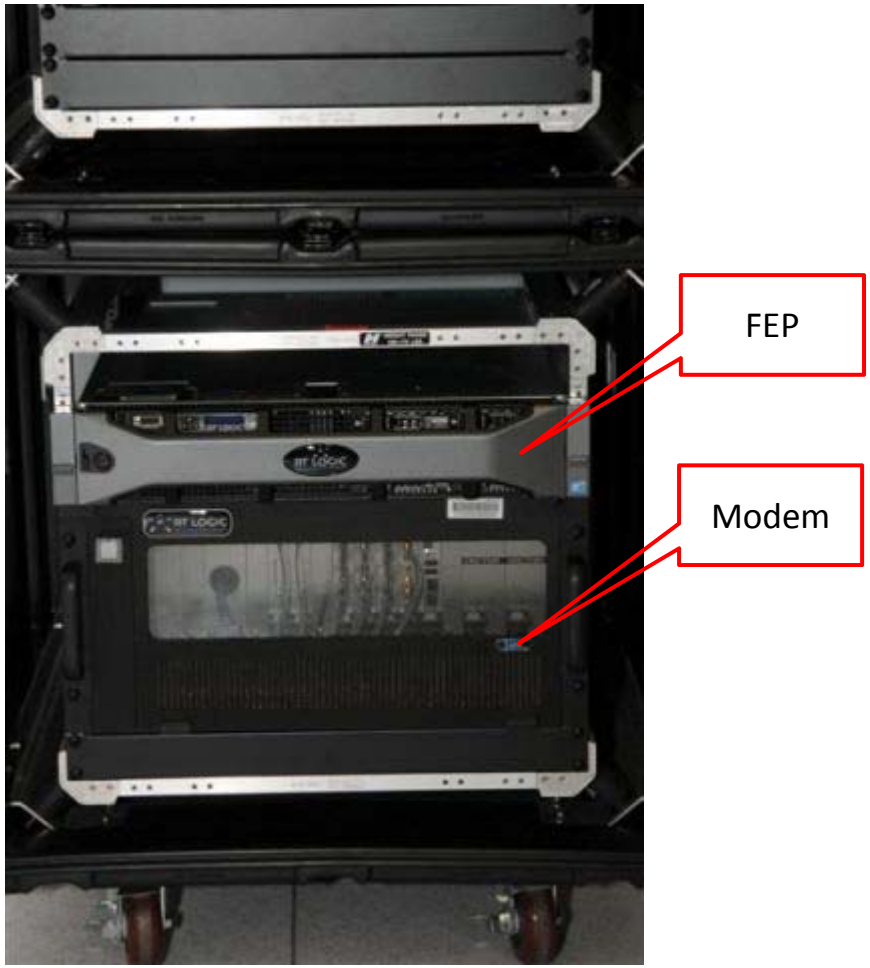
REAR

GRB Simulator Integrated Hardware

CASE 1



CASE 2



GRB Simulator Integrated Hardware

KVM Extended

Summary

- GRB allows real time distribution of all Level-1b GOES-R data products for direct read out users
- Direct Readout users need to upgrade their equipment for GOES-R
  - Significant increase in data rate
  - New data format
- GRB down link specifications and data format specifications have been published
- GRB simulators will be available by Summer 2013 for Direct Broadcast reception equipment testing
- Updates to be posted on the GOES-R web site:
  - **http://www.goes-r.gov/**