

SATELLITE VENDORS SYSTEMS

AND

USER PROVISIONS

FOR THE GOES-R SERIES OF SATELLITES

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August 2016

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1. Introduction

The GOES-R series of satellites will start launching from 2016 with the first in the series GOES-R scheduled to be launched on November 4th, 2016 and GOES-S to be launched in 2017. After the one-year testing of the satellites after successful launch on will be GOES-East at 75°W and the other will become GOES-West at 137°W. Figure 1 show the GRB coverage for GOES- East and West.

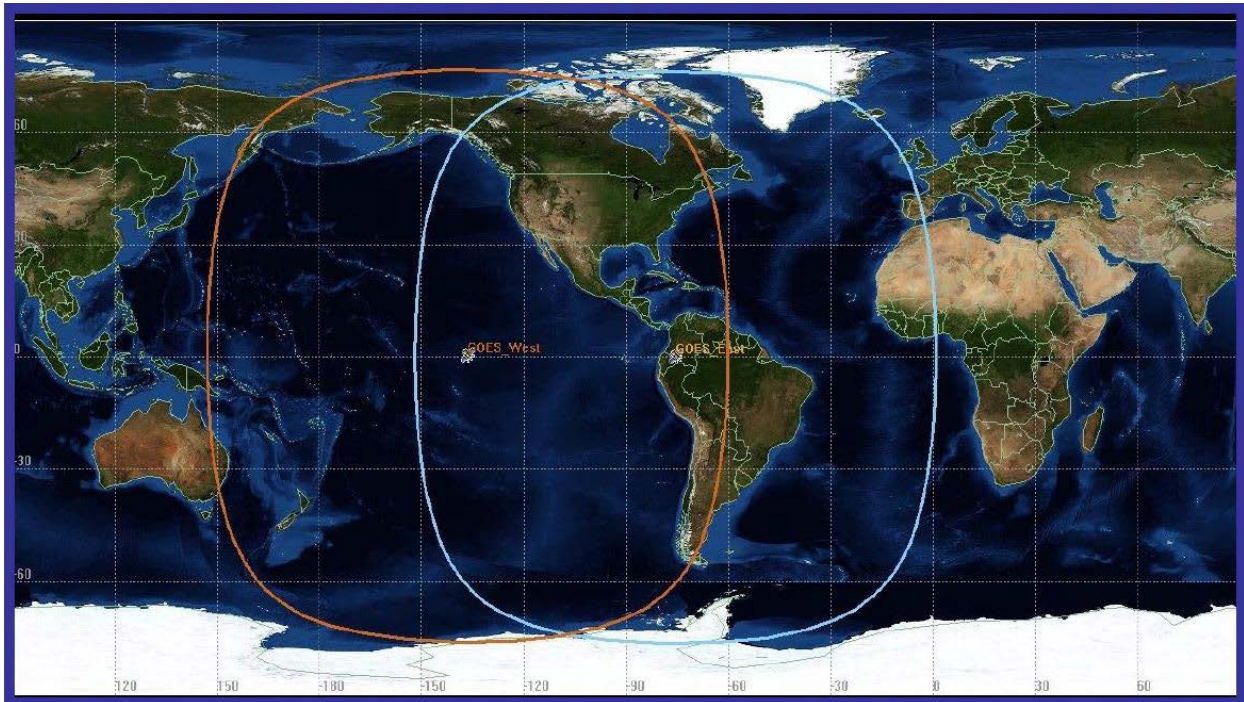


Figure 1: GOES-R series of satellites GRB coverage for the East and West satellite locations

Data will be transmitted from the satellite to users at the frequency of 1686.6MHz and the compressed data packet will be 31 Mb. However, once the data is uncompressed it will inflate to an approximate size of 330Mb.

There are many manufacturers of satellite receiving equipment and “data as a Service” providers offering different solutions to Members in WMO Regional Association III and IV (The Americas). The solutions can be briefly described as:

1. GRB access via satellite receiving systems;
2. GRB access from the “cloud” via the Internet;
3. Data as a Service via the Internet;
4. Data products as a Service via the Internet.

2. GOES-R Products

Before the systems can be described, Members need to understand the products which will be available from the GOES-R Series of satellites. GOES-R will make available thirty-four (34) meteorological, solar and space weather products, as shown in Figure 2. An additional thirty-one (31) products may be made available as future capabilities for the GOES-R Series. These products are:

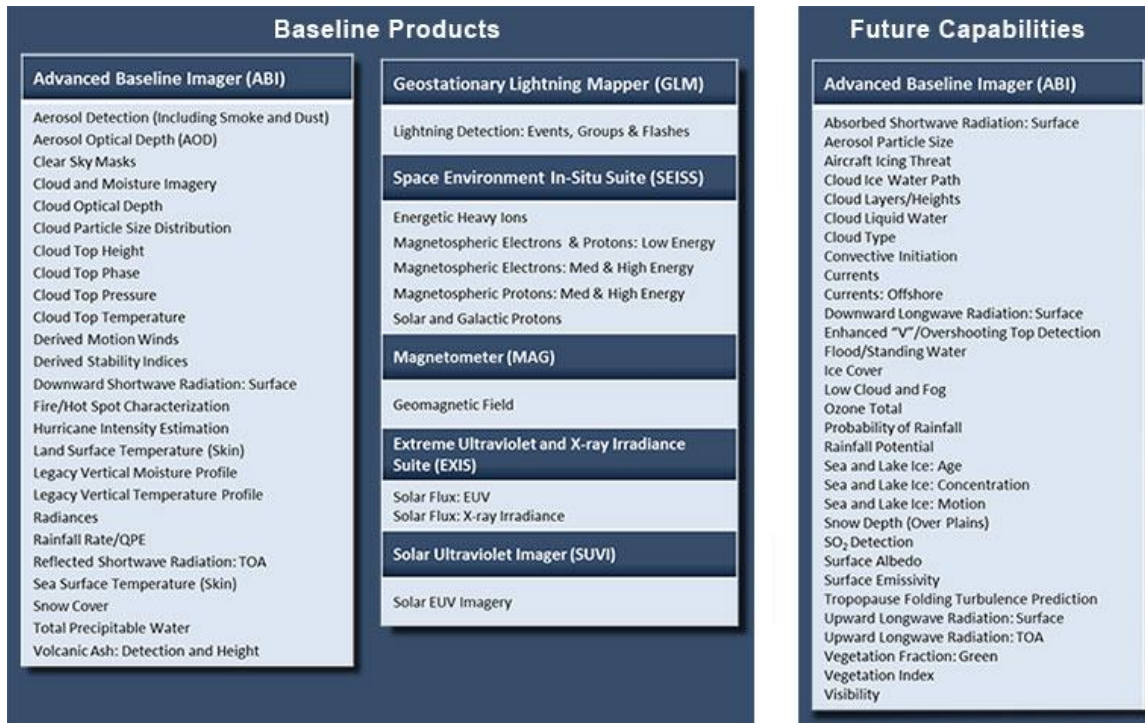


Figure 2: Product available from GOES-R Series of satellites:

Source: <http://www.goes-r.gov/products/overview.html>

They are further sub-divided into Level 1b (L1b and level 2 (L2) products, which are:

Level 1b Products

Advance Baseline Imager (ABI)

Radiances

Geostationary Lightning Mapper (GLM)

Lightning Detection: Events, Groups & Flashes

Space Environment In-Situ Suite (SEISS)

Energetic Heavy Ions

Magnetospheric Electrons & Protons: Low Energy

Magnetospheric Electrons & Protons: Med & High Energy

Solar & Galactic Protons

Magnetometer (MAG)

Geomagnetic Field

Extreme Ultraviolet and X-ray Irradiance Suite (EXIS)

Solar Flux: EUV

Solar Flux: X-ray Irradiance

Solar Ultraviolet Imager (SUVI)

Solar EUV Imagery

Level 2 Products

Aerosol Detection (Including Smoke/Dust)

Aerosol Optical Depth

Clear Sky Masks

Cloud and Moisture Imagery

Cloud Optical Depth

Cloud Particle Size Distribution

Cloud Top Height

Cloud Top Phase

Cloud Top Pressure

Cloud Top Temperature

Derived Motion Winds

Derived Stability Indices

Downward Shortwave Radiation: Surface

Fire/Hot Spot Characterization

Hurricane Intensity Estimation

Land Surface Temperature (Skin)

Legacy Vertical Moisture Profile

Legacy Vertical Temperature Profile

Rainfall Rate/QPE

Reflected Shortwave Radiation: TOA

Sea Surface Temperature (Skin)

Snow Cover

Total Precipitable Water

Volcanic Ash: Detection and Height

Table 1: Level 1b and Level 2 products

The *Radiances* product from the ABI consists of data from 16 visible, near-infrared, and infrared spectral bands and it will be used to identify cloudy and cloud-free regions within the satellites' field of view.

3. Satellite Vendor Systems

3.1 GRB Systems

The GOES-R Ground Segment (GS) will receive the raw data from GOES-R series spacecraft and generate Level 1b and Level 2+ products. These products are transmitted to the GOES-R satellite for distribution to direct readout users with an antenna to receive the products by means of the GOES Rebroadcast (GRB), or via the Product Distribution & Access (PDA) System for users including the Data Archive centers (CLASS). A draft technical specification document created by personnel of National Institute for Space Research (INPE) for the purchase of a GRB system is available in **Annex I**.

3.1.2 GRB Ground Station

Ground Station Receiving Equipment

- 4.5m Antenna, fixed Axis with Dual channel GOES-R feed
- GRB receiver
- Demodulator
- *Cabling

**Note: The standard length of cable from the antenna and the receiver is 100m. The maximum distance allowed between antenna and receiver is 200m. However, the additional cable length incurs more cost.*

Visualization system

- Hardware (computer, monitor, UPS)
- Proprietary software
- Software license

Installation and Training

- Manufacturer 's engineer(s) onsite for installation
- Onsite training
- training materials provided

3.1.2.1 User Provisions

- External site survey (must answer the following)
 - Is there line of site to either 75°W or 137°W for the proposed location of the antenna?
 - Is the location clear of interference which could affect the downlink at 1686.6MHz?
 - Will the proposed site minimize potential wind damage?
- Internal Site survey (must answer the following)
 - Is there sufficient space to house the rack for the receiver equipment, demodulator and ancillary equipment?
 - Electrical outlet for the UPS?
 - Is the space for the visualization equipment which may include two (2) monitors?
- License to use the frequency 1686.6MHz

3.2 GRB Access from the Cloud

3.2.1 Access

One Manufacturer is willing to provide data for the L1b and L2 products from the "cloud" via the Internet. This system does not require the antenna but the other hardware and software as in the above solution in 3.1.2 will be provided by the manufacturer. The user will only need to carry out the internal site survey for the housing of all equipment.

3.3 Data as a Service

3.3.1 Data Supplied

The Suppliers of "data as a service" will generate all Level 1b data files and transfer them to the user within five minutes of acquisition from the GOES satellite.

3.3.2 User Provisions

The user is required to provide:

1. The hardware for visualization
2. The software for visualization
3. An Internet pipe to accommodate a data download of approximately 330Mb every 15 minutes or shorter.

3.4 Data Products as a Service

One vendor is willing to provide user defined products from the "cloud." The products will reside in the "cloud" and the user will be provided with an account, the URL to locate its specific products and a password.

3.4.1 User Provisions

The user is required to provide:

1. The areal extent of satellite coverage required.
2. Map projection required.
3. Type of underlying map required (e.g. topographic, physical, road etc.).
4. Type of products required for display (e.g. radiances, lightning detection, fire/hot spot characterization etc.).
5. Computer(s) for accessing the products.
6. *Internet access.

**Note: All viewing will be within the "clouds" hence Internet bandwidth of 2Mbps should be sufficient.*

The users will also have to decide if the products which they are accessing with the "cloud" are need for the website of to be provided to special users.

4. Costs

4.1 Basic Costs - GRB Ground Station

The cost of GRB ground station with a receiving antenna ranges from US\$251,661.00 to \$271,692.42. However no quotation was the same e.g. there was one quotation for US\$251,661.00 included some Level 1b and Level 2 products Generally the quotation is for Level 1b products with Level 2 products offered as a future upgrade.

4.1.1 Factors which adds to Costs

All of the systems listed above will provide Level 1b products as its initial service. Generally, the addition of Level 2 products or any other products which are developed in the future can be provided at an additional cost. Further, maintenance and warranty is for a period of one year starting for the signing of the site acceptance test (SAT) document. A maintenance contract for the life of the satellite should be considered as necessary because of future changes to the data stream as new algorithms are created.

The provision of a site survey by the equipment manufacturer for the placement of the antenna can increase the cost of a system by \$12,000 to \$20,000.

**GOES-R EQUIPMENT SPECIFICATION
(draft)**

A) ITEMS TO BE PURCHASED:

L-Band Receiving Station, for GOES-R data reception, ingesting, and processing along with the installation, integration, configuration, testing and technical services support package.

The Direct Readout Station consists of the following items:

- a) An antenna with solid disc parabolic reflector of 4.5 meters diameter or greater and a R.F. cable with a minimum length of 90 m.
- b) A high efficiency dual polarity feed / downconverter, with a dual polarizer (RHCP and LHCP)
- c) An L-Band Receiver / Demodulator, DVB-S2 compatible, capable of recovering the original data stream in CADUS format.
- d) A Workstation for ingesting and storing the GRB dataflow, performing the CADUS data processing from the demodulator output in order to reconstruct the GRB-CCSDS packets, and extract, from the CCSDS packets, the Level-1B data (calibrated and georeferenced), output them in NETCDF-4.
- e) A Front-End Application Software ("FES"), whose main function is to perform the ingestion and disk storage of the original GRB data, already in Level-1b format, making them available in the NETCDF-4.
- f) A Workstation for processing, manipulation and visualization of the GOES-R Level-2 products.
- g) An Application Software to transform and process the Level-1b data (NETCDF-4) to Level-2 data, as their visualization and manipulation.
- h) A Mounting Rack to accommodate the workstations, local storage system and demodulator.
- i) A remote GPS antenna receiving system.
- j) Provision of Technical Services and Support Package for such activities as shipping, installation, integration, acceptance testing and technical guidance on system startup, operation and maintenance
- k) A set of critical spare items that should include at least one Feed / Downconverter.
- l) The system should be provided with at least one Operation Manual.

B) EQUIPMENT ESPECIFICATION AND DETAILED DESCRIPTION:

B1) Antenna / RF System with the following characteristics:

- Parabolic reflector, 4.5 m diameter, made of precision formed aluminum or polyester reinforced with glass fiber.
- Operational Wind speed of 80 km/h, gusting to 100 km/h and survival wind speed of 160 km/h.
- Built upon a galvanized steel pedestal with an azimuth pointing range of 180 degrees and an elevation pointing range of 90 degrees.

B2) High efficiency scalar waveguide feed / amplifier, dual polarized, pressurized, coupled to a downconverter, with the following characteristics:

- Dual Polarity (RHCP and LHCP)
- Center Frequency of 1686.6 MHz
- LNA Noise Temperature: 25 K
- LNA Noise Figure: 0.4 dB or better
- RF bandwidth: 20 MHz
- Image Rejection: > 100 dB
- Polarity Isolation: Better than 27 dB
- Downconverter Performance: "TOIP" better or equal to 36 dBm, and low phase noise (93 dBc/Hz at 10 KHz)
- Environmental conditions: -40 to 50 °C
- G/T: Better or equal than 15,5 dB/°K

Note: Mandatory that the RF chain reception subsystem (Feed and demodulator) contains matched filters, and provisions to ensure non-interference in the reception from signals of spurious frequencies of local mobile telephone networks.

B3) L-Band Receiver / Demodulator:

- Digital demodulation, DVB-S2 compatible
- Input frequency (dual channel): 140 MHz
- Data output in CADUS packet format
- Channels supported: Simultaneous LHCP and RHCP reception
- GRB Modes / Decoding Supported:

QPSK 9/10, symbol rate of 8.665938 Msps

8PSK 2/3, symbol rate of 7.825768 Msps

- Input Filtering: SAW filter matched to GRB signal bandwidth
- Typical Eb/No for QEF performance: 4.1 db (QPSK 9/10); and 3.9 dB (8PSK 2/3). (QEF = PER better than 1E-6)

B4) Workstation for GRB data ingestion (CADUS format) and Level 1b data extraction, with the following minimum requirements:

- 12 core, 2.4 GHz CPU with 64-bit instruction support, 15 MB Cache
- 32 GB RAM (minimum)
- 5 Hard Disk with 2 TB each, Serial ATA2, at least 7200 RPM
- 1 On-board RAID disk controller, supporting RAID 0, 1, 5 and 10
- A 1 GB Graphic Board, PCI-Express, with DVI and HDMI
- 10 Gigabit Ethernet communication
- 1 DVD/CD-RW Writer / Reader
- 8 USB-2 ports
- 1 "e-SATA" port; 1 "RJ-45" port; and 2 serial ports
- 1 Internal SATA port (spare)
- Redundant Power Supply
- CentOS 6 64-bit Linux (or other compatible 64-bit Linux distribution)

B5) Front-End Software (FES):

Its main functions are the ingestion and hard disk storage of the original GRB data in Level-1b format, the generation and display of "Quick-Look" images in real time, and the conversion of the Level-1b data to NETCDF-4. The software should also have features to monitor the reception and demodulator status, maintaining system logs for all operations. The software should also monitor the reception of GRB data.

During the data reception, a Reed Solomon decoding is performed, and the CSDS packages are extracted. The Level-1b data is extracted from these packages, stored on the hard disk and made available in the network. As data is received, "Quick-Look" images are generated and displayed in real time.

This software application should provide the Level-1a or Level-1b output data (radiance), in NETCDF-4 format, addressing them to the workstation responsible for the Level-2 product development.

The performance of ingestion system must be able to respond within the 3 minute interval, both to the so-called "mode 4" (1 image "full disk" every 5 minutes) "and the" mode 3 operation "(1 image" full disk "every 15 minutes)" with the data 1B Level (radiance, and brightness temperature, where applicable) be made available for each of the 16 channels of ABI and 5 other instruments, in their maximum spatial resolution.

The following GOES-R instruments are being considered:

ABI (16 channels Advanced Baseline Imager)

GLM (Geostationary Lightning Mapper) -

SEISS (Space Environment In-Situ SuiteMAG)

Magnetometer

EXIS (Extreme Ultraviolet and X-ray Irradiance Sensors)

SUVI (Solar Ultraviolet Imager)

B6) Workstation for the processing and visualization of Level-2 products, configured within the following minimum requirements:

- Intel Xeon E5 v2 “Ivy Bridge” or better, 20-core (2 x 10-core), 2.8GHz CPU with 64-bit instruction support, 192 GB RAM
- 14 TB Disk Space, Serial ATA2, at least 7200 RPM
- 1 On-board RAID disk controller, supporting RAID 0, 1, 5 and 10
- 10 Gigabit Ethernet communication
- 1 DVD/CD-RW Writer / Reader
- 8 USB-2 ports
- 1 “e-SATA” port; 1 “RJ-45” port; and 2 serial ports
- 1 Internal SATA port (spare)
- 1 24” Monitor, TFT, 1920 x 1200 resolution
- 1 Keyboard, 105 keys, “soft touch” and USB connection
- 1 Optical Mouse with USB connection
- Redundant Power Supply
- CentOS 6 64-bit Linux (or other compatible 64-bit Linux distribution)

B7) Application software:

Used for the processing and conversion of the Level-1b (NETCDF-4) data to Level-2 data, along with its visualization and manipulation. The Level-2 data are environmental variables derived from Level-1 products and should present temporal and spatial resolution comparable to those from Level-1.

The Level-2 products that must be made available from this application are as follows:

B.7.1) ABI Products:

- 1) Aerosol Detection (Including Smoke and Dust)
- 2) Aerosol Optical Depth (AOD)
- 3) Clear Sky Masks
- 4) Cloud and Moisture Imagery
- 5) Cloud Optical Depth
- 6) Cloud Particle Size Distribution
- 7) Cloud Top Height
- 8) Cloud Top Phase
- 9) Cloud Top Pressure
- 10) Cloud Top Temperature
- 11) Derived Motion Winds
- 12) Derived Stability Indices
- 13) Downward Shortwave Radiation: Surface
- 14) Fire/Hot Spot Characterization
- 15) Hurricane Intensity Estimation
- 16) Land Surface Temperature (Skin)
- 17) Legacy Vertical Moisture Profile
- 18) Legacy Vertical Temperature Profile
- 19) Rainfall Rate/QPE

- 20) Reflected Shortwave Radiation: TOA
- 21) Sea Surface Temperature (Skin)
- 22) Snow Cover
- 23) Total Precipitable Water
- 24) Volcanic Ash: Detection and Height
- 25) Synthetic Green band
- 26) RGB Products

B.7.2) GLM Product:

- 1) Lightning Detection: Events, Groups & Flashes

B.7.3) SEISS Products:

- 1) Energetic Heavy Ions
- 2) Magnetospheric Electrons & Protons: Low Energy
- 3) Magnetospheric Electrons: Med & High Energy
- 4) Magnetospheric Protons: Med & High
- 5) Solar and Galactic Protons

B.7.4) MAG Product:

- 1) Geomagnetic Field

B.7.5) EXIS Products:

- 1) Solar Flux: EUV
- 2) Solar Flux: X-Ray Irradiances

B.7.6) SUVI Product:

- 1) Solar Imagery (X-Ray): Coronal holes, solar flares, and coronal mass ejection source regions.

B.8) Mounting rack:

Used for the accommodation of the workstations, local storage system and demodulator, with provisions for KVM switchable monitor and keyboard, powered with a 3.5 KVA (minimum) UPS, and a minimum autonomy of 30 minutes. This rack will also accommodate a 10 Gigabit/second network switch. The rack should also have:

- 1 22" Monitor, TFT, 1680 x 1050 resolution
- 1 Keyboard, 105 keys, "soft touch" and USB connection

B.9) A remote GPS antenna receiving system:

- Cabling with a minimum of 50 m

B.10) A technical services and support package:

For the provision of activities such as shipping, installation, integration, acceptance tests and the technical guidance regarding the initialization, operation and maintenance of the system.

The vendor shall carry out these activities with the participation of technical experts appointed by the contractor, for a period not less than seven working days, ensuring that the contractor technical team is sufficiently familiar with the operation, monitoring and adjustments (where applicable) of the provided equipment/processes, as well with the functionality of the associated software applications. (Note: activities related to shipment are also going to be part of this package).
