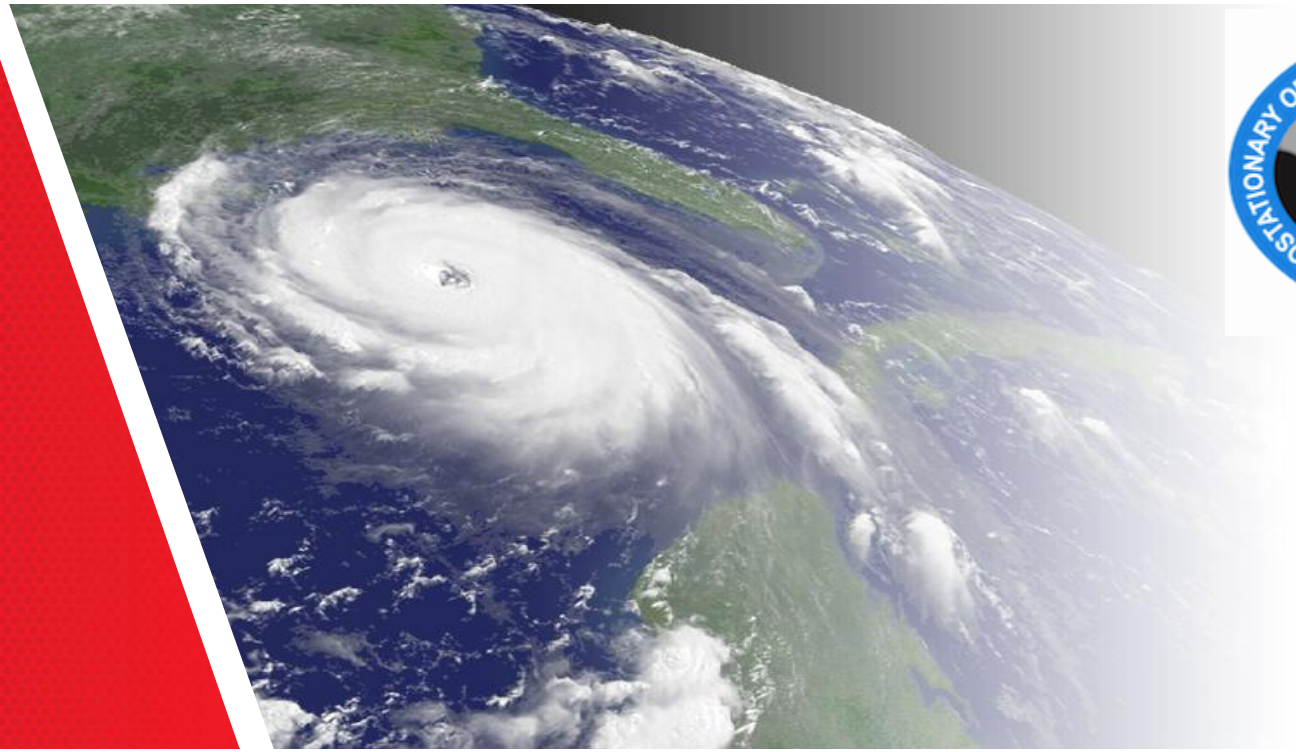
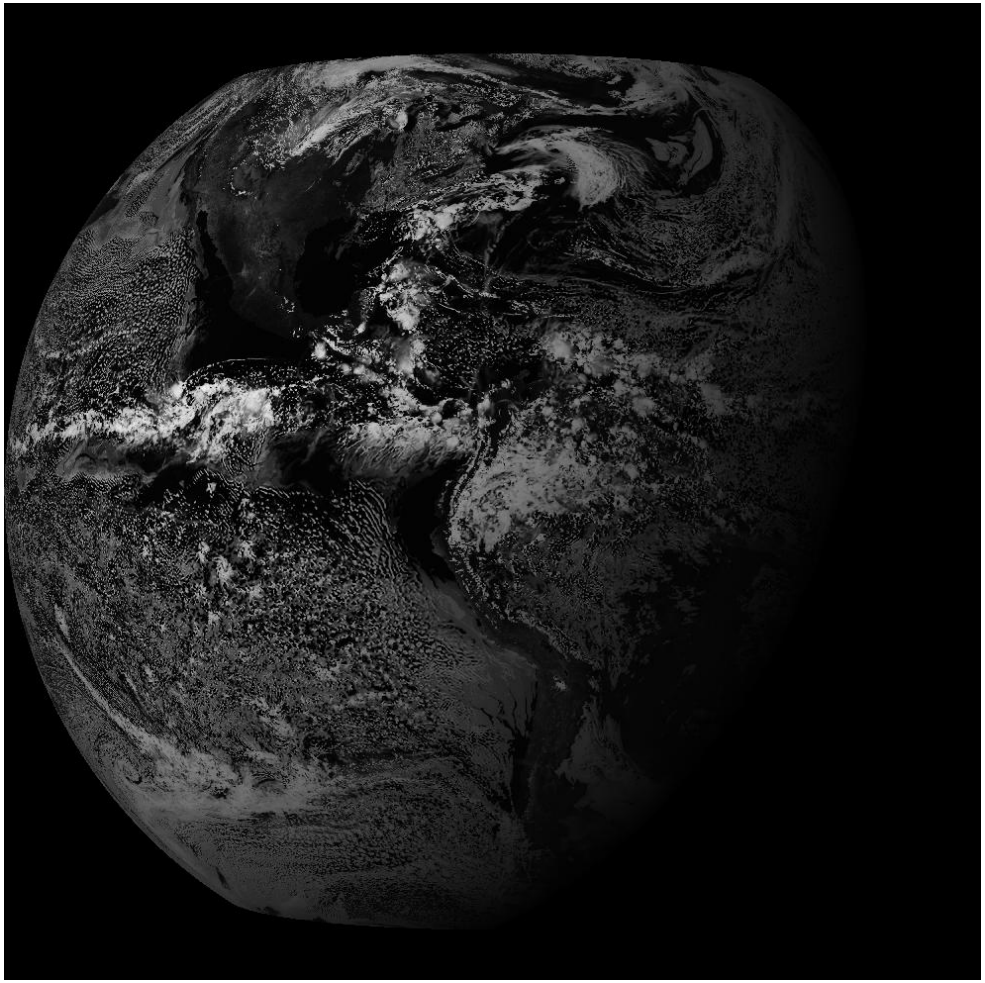


Early Performance from the GOES-R Product Generation System

Allan Weiner, Harris Corporation
S. Kalluri, NOAA/NESDIS
D. Hansen, Harris Corporation
G. Dittberner, Harris Corporation

Cloud and Moisture Imagery

(Channel 2 - Visible)



Sample product

GOES-R Operational System Configuration

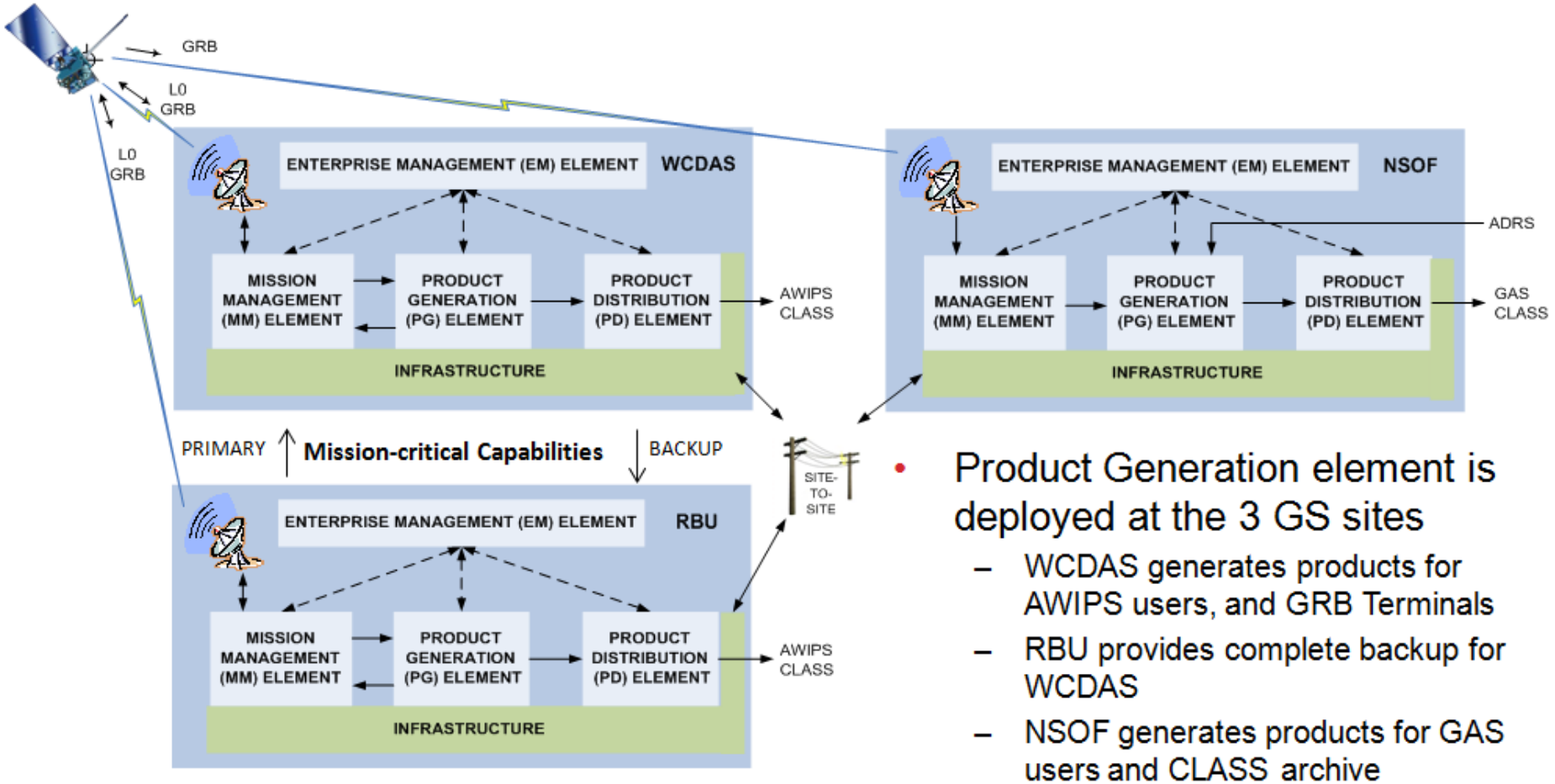
GOES-R L1b & L2+ Product Data

Inst	CBB SW2	Product	Qty	Inst	CBB SW2	Product	Qty
LEVEL 1B PRODUCT DATA							
ABI	ABIEE	Radiances	16	SEISS	Non-ABI	Solar & Galactic Protons	1
SEISS	Non-ABI	Energetic Heavy Ions	1	MAG	Non-ABI	Geomagnetic Field	1
SEISS	Non-ABI	Magnetospheric Electrons & Protons: Low Energy	1	EXIS	Non-ABI	Solar Flux: EUV	1
SEISS	Non-ABI	Magnetospheric Electrons: Med & High Energy	1	EXIS	Non-ABI	Solar Flux: X-ray Irradiance	1
SEISS	Non-ABI	Magnetospheric Protons: Med & High Energy	1	SUVI	Non-ABI	Solar EUV Imagery	2
LEVEL 2+ PRODUCT DATA							
ABI	ABIL2	Aerosol Detection (Including Smoke and Dust)	3	ABI	R2ALG	Fire/Hot Spot Characterization	4
ABI	ABIL2	Aerosol Optical Depth (AOD)	2	ABI	R2ALG	Hurricane Intensity Estimation	1
ABI	ABIL2	Clear Sky Masks	3	ABI	R2ALG	Land Surface Temperature (Skin)	3
ABI	ABIL2	Cloud and Moisture Imagery	51	ABI	ABIL2	Legacy Vertical Moisture Profile	3
ABI	ABIL2	Cloud Optical Depth	2	ABI	ABIL2	Legacy Vertical Temperature Profile	3
ABI	ABIL2	Cloud Particle Size Distribution	3	ABI	R2ALG	Rainfall Rate / QPE	1
ABI	ABIL2	Cloud Top Height	3	ABI	R2ALG	Reflected Shortwave Radiation: TOA	1
ABI	ABIL2	Cloud Top Phase	3	ABI	R2ALG	Sea Surface Temperature (Skin)	1
ABI	ABIL2	Cloud Top Pressure	2	ABI	R2ALG	Snow Cover	3
ABI	ABIL2	Cloud Top Temperature	2	ABI	ABIL2	Total Precipitable Water	3
ABI	R2ALG	Derived Motion Winds	18	ABI	R2ALG	Volcanic Ash: Detection and Height	1
ABI	ABIL2	Derived Stability Indices	15	GLM	R2ALG	Lightning Detection: Events, Groups, Flashes	3
ABI	R2ALG	Downward Shortwave Radiation: Surface	3				

Transition from GVAR to GRB

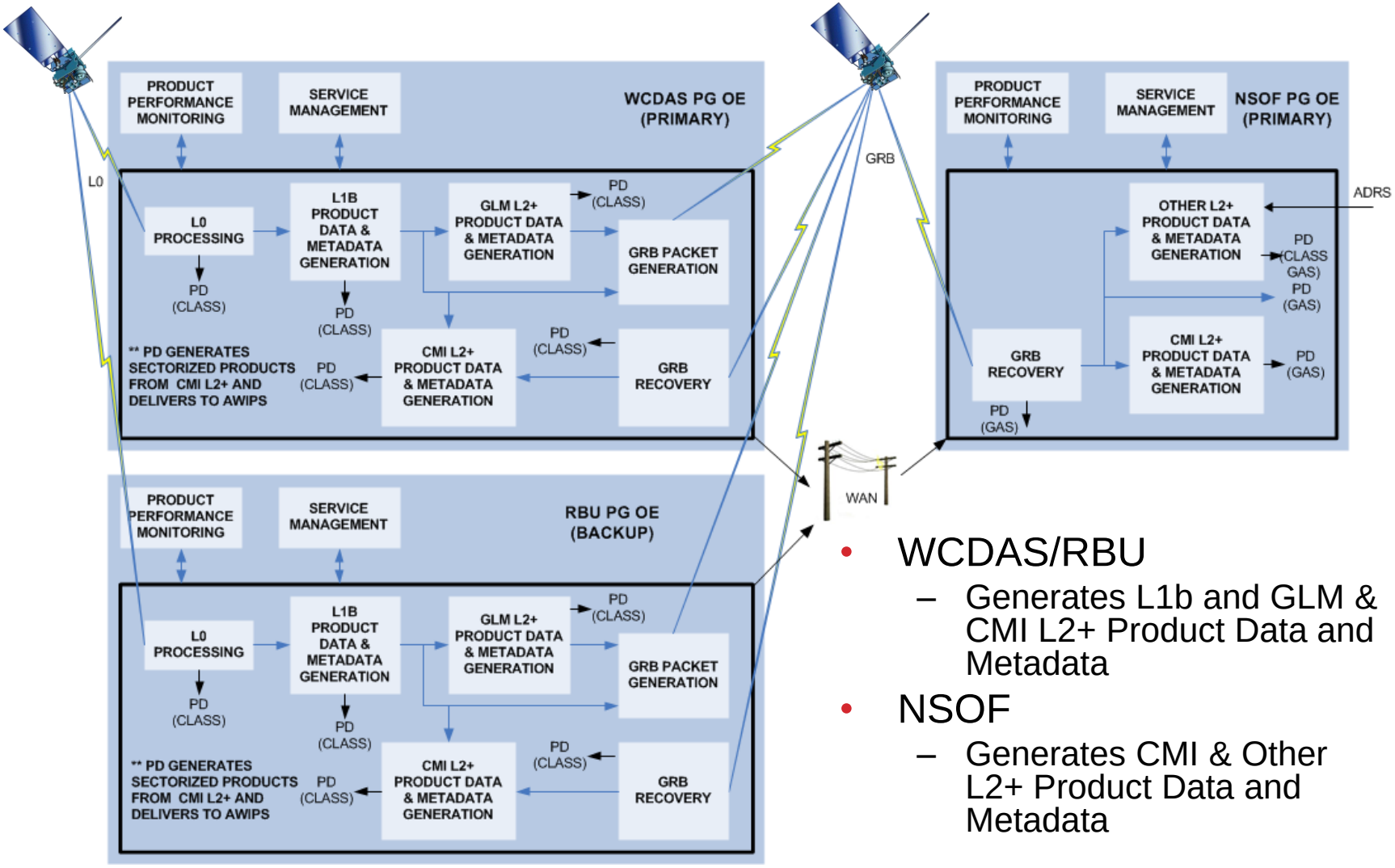
	GVAR	GOES Rebroadcast (GRB)
Full Disk Image	30 Minutes	5 Minutes (Mode 4) 15 min (Mode 3)
Other Modes	Rapid Scan, Super Rapid Scan	3000 km X 5000 km (CONUS: 5 minute) 1000 km X 1000 km (Mesoscale: 30 seconds)
Polarization	None	Dual Circular Polarized
Receiver Center Frequency	1685.7 MHz (L-Band)	1686.6 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

GS Simplified Architecture
PG's 2 Primary and 1 Backup Site



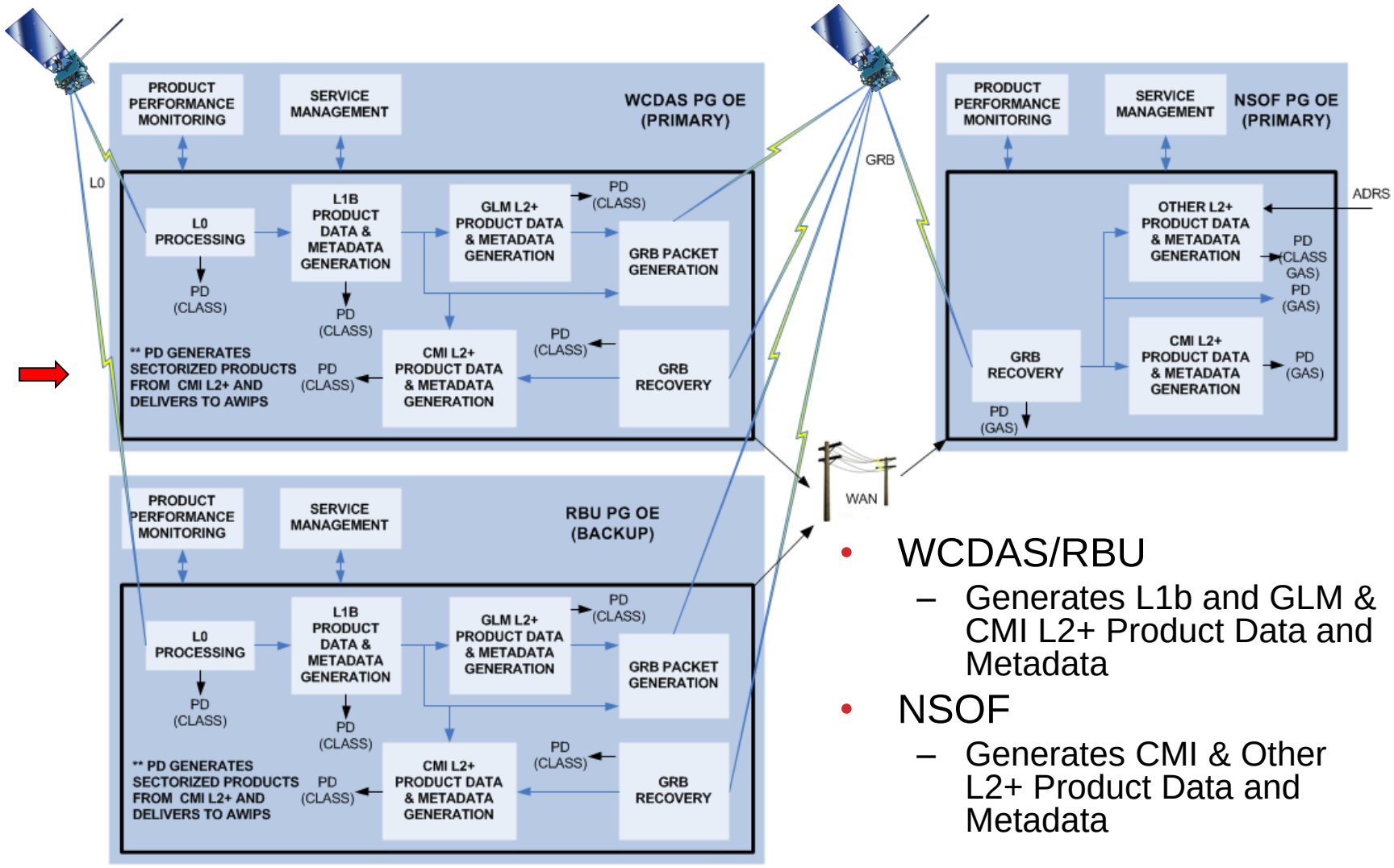
- Product Generation element is deployed at the 3 GS sites
  - WCDAS generates products for AWIPS users, and GRB Terminals
  - RBU provides complete backup for WCDAS
  - NSOF generates products for GAS users and CLASS archive

GS Simplified Architecture
PG Element-level Design



- WCDAS/RBU
  - Generates L1b and GLM & CMI L2+ Product Data and Metadata
- NSOF
  - Generates CMI & Other L2+ Product Data and Metadata

GS Simplified Architecture
PG Element-level Design



- WCDAS/RBU
  - Generates L1b and GLM & CMI L2+ Product Data and Metadata
- NSOF
  - Generates CMI & Other L2+ Product Data and Metadata

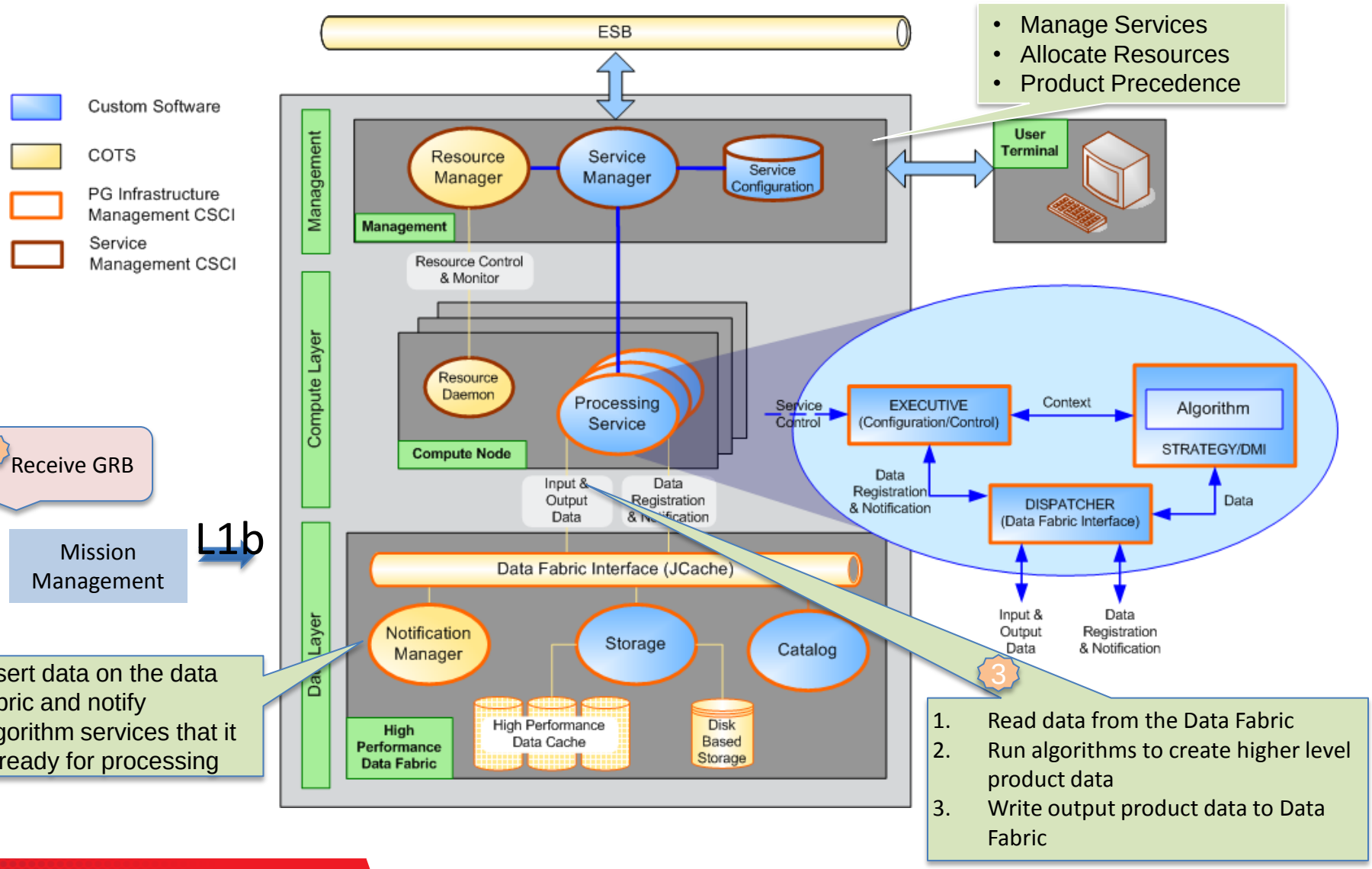
GOES-R Ground Segment Product Generation (PG) System on Track to Fulfill Requirements

- The GOES-R PG System requirements:
  - Produce L1b and L2+ Products at low latency operationally in real time
    - Cloud and Moisture Imagery (KPPs): CONUS and Full Disk – 50 seconds; Mesoscale – 23 seconds
  - Be modular/plug-and-play: accommodate individual algorithm changes, deletion of existing and the addition of new algorithms, without the need for recompilation of other software modules.
  - Be Scalable and Expandable
  - Maintain a minimum Operational availability of 0.9999, averaged over a 30-day period, for those functions associated with the distribution of End Products

Product Generation System Features

- The PG design is based on Service Based Architecture (SBA)
  - Each algorithms works as a service
    - Receives lower level data (e.g. L1b radiances) and creates higher level products (e.g. Imagery, Cloud Mask, Soundings, Winds, Volcanic Ash. etc.)
  - Data are moved among algorithms (services) through a high performance data cache called the Data Fabric
  - A Service Manager orchestrates and manages the services
  - Messages are sent across services using an Enterprise Service Bus (ESB)

SBA Architecture Diagram at NSOF



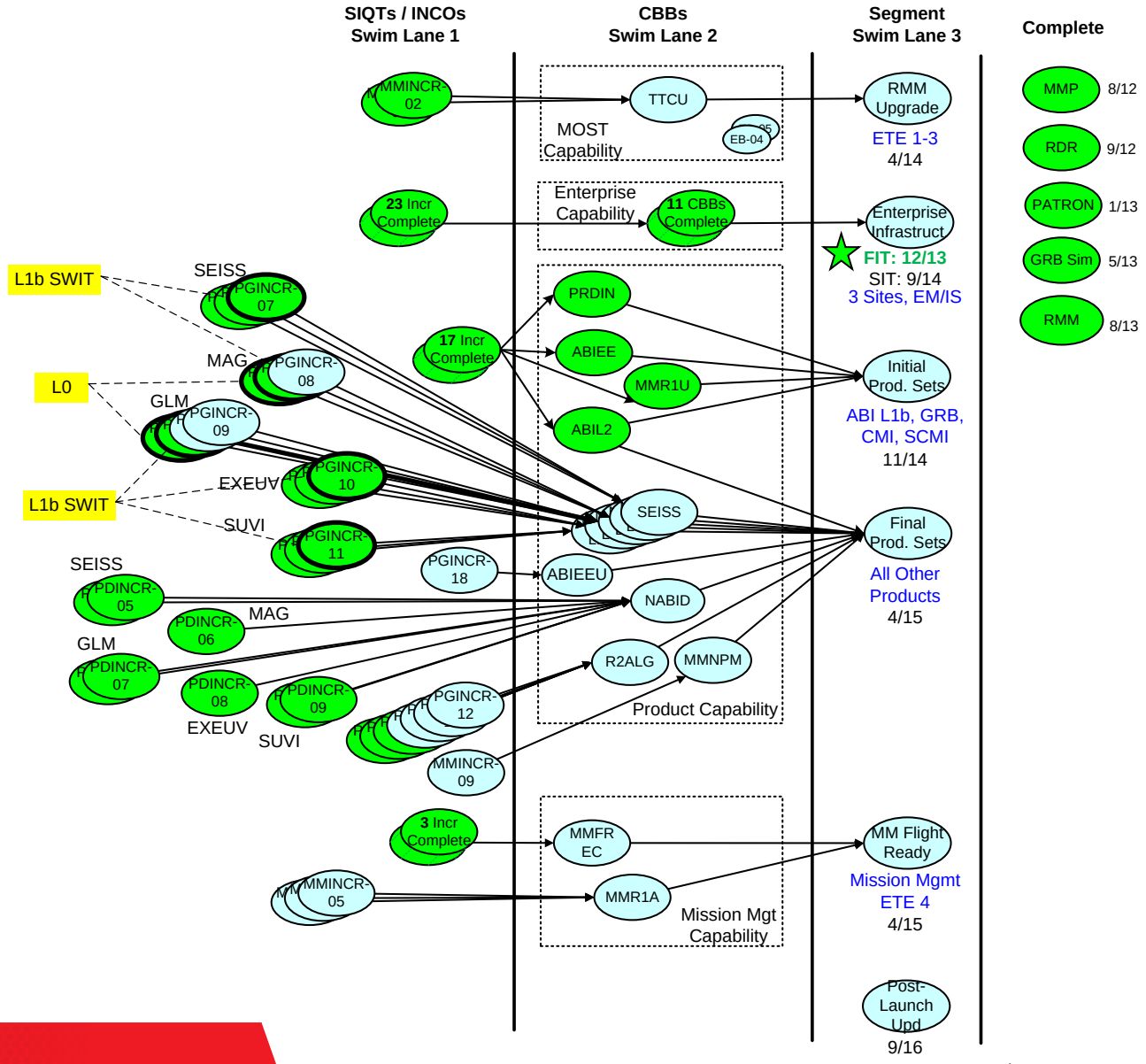
PG Status

- Science & Operationalization phase for all ABI L0/L1b algorithms completed
  - Decompression of ABI L0 packets
  - Decommutation of ABI data fields
  - Calibration
  - Navigation and Resampling

- Science & Operationalization phase for ABI L2+ products for Initial Product Set (IPS) completed
  - Imagery (KPPs), Clouds, Aerosols, Soundings

- Integration of Mission Management, All Product Generation (L1b, L2+) and All Product Distribution to be completed by mid 2014

Completed/Implemented Algorithms Ready for Production



Initial Product Set Preliminary Latencies for PG Segment at NSOF

	Full Disk		CONUS		Meso	
	Average	Required	Average	Required	Average	Required
Aerosol Detection (including Smoke and Dust)	15.3	716	15.1	230	13.4	716
Aerosol Optical Depth	13.9	806	41.4	230	NA	NA
Clear Sky Masks	9.3	716	9.4	230	15.1	230
Cloud Optical Depth	82.2	716	144	230	NA	NA
Cloud Particle Size Distribution	82.2	716	144	230	NA	NA
Cloud Top Height	20.4	716	47.9	230	36.6	230
Cloud Top Phase	14.0	716	19.6	230	20.3	230
Cloud Top Pressure	20.8	716	48.0	230	NA	NA
Cloud Top Temperature	21.0	230	NA	NA	36.6	230
Cloud and Moisture Imagery Band 01	4.6	11	4.4	11	3.9	11
Cloud and Moisture Imagery Band 02	4.9	11	5.1	11	4.6	11
Cloud and Moisture Imagery Band 03	4.5	11	5.1	11	4.1	11
Cloud and Moisture Imagery Band 04	4.6	11	3.9	11	3.8	11
Cloud and Moisture Imagery Band 05	4.6	11	4.4	11	4.1	11
Cloud and Moisture Imagery Band 06	3.9	11	3.9	11	3.8	11
Cloud and Moisture Imagery Band 07	3.9	11	2.4	11	2.5	11
Cloud and Moisture Imagery Band 08	3.0	11	2.9	11	2.4	11
Cloud and Moisture Imagery Band 09	2.9	11	2.6	11	2.5	11
Cloud and Moisture Imagery Band 10	3.0	11	2.8	11	2.3	11
Cloud and Moisture Imagery Band 11	3.3	11	2.3	11	2.5	11
Cloud and Moisture Imagery Band 12	3.0	11	2.4	11	2.3	11
Cloud and Moisture Imagery Band 13	3.2	11	3.0	11	2.3	11
Cloud and Moisture Imagery Band 14	2.8	11	2.6	11	2.5	11
Cloud and Moisture Imagery Band 15	3.2	11	2.9	11	2.4	11
Cloud and Moisture Imagery Band 16	3.3	11	2.8	11	2.4	11
Derived Stability Indices	35.1	159	109.3	133	32.2	230
Legacy Vertical Moisture Profile	35.1	230	109.3	230	32.2	230
Legacy Vertical Temperature Profile	35.1	230	109.3	230	32.2	230
Total Precipitable Water	35.1	230	109.3	230	32.2	230

NOTE: Required latencies are requirements for the Product Generation segment and not for the full GOES-R system.

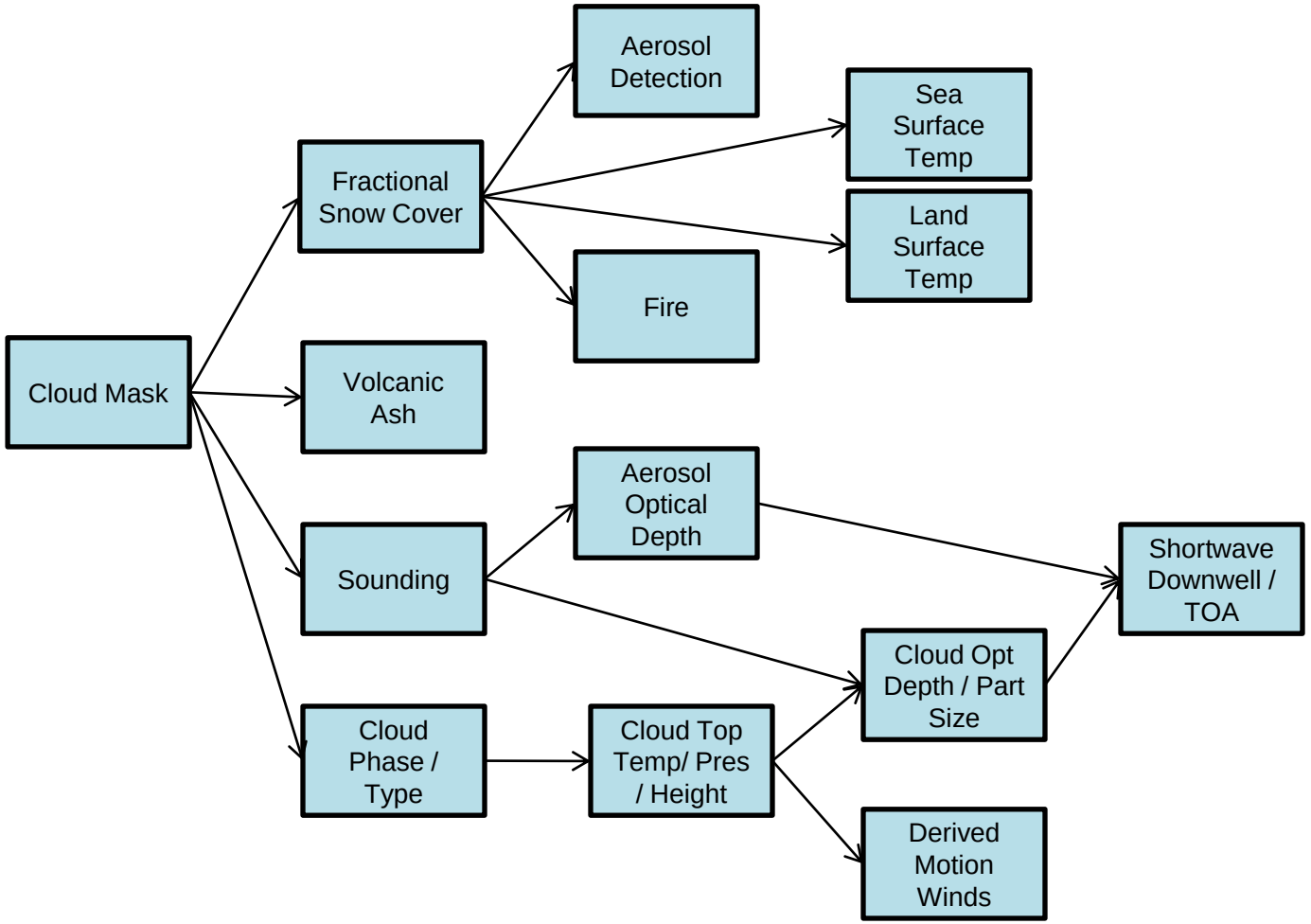
Average latency may be much lower than requirement due to precedence product processing.

blue = truly excelled or NA

green = Passed requirement

red = fail

L2+ Algorithm Precedence



Note: Abbreviated Precedence flow shown

High Volume Data Processing Implemented with High Performance Computing

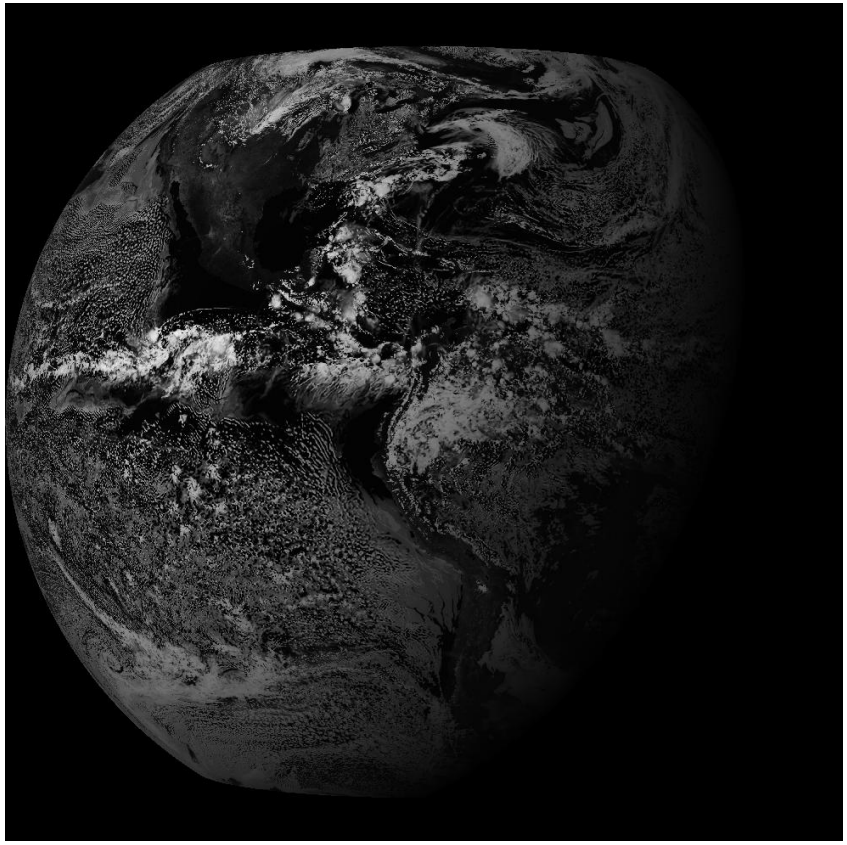
- High throughput (106 Mbps for each satellite)
  - Direct Readout - 31Mbps
  - L1b Products 480 GB / day
  - L2+ Products 1.37 TB / day
- Low latency
  - < 1min for Key Performance Parameters
  - < 5 min for most products
- High availability
  - Planned Outage < 3 hrs/year
- Enterprise Class Data Center
  - 2 primary and one backup site
  - >200 servers with >2000 cores
  - ~20TFLOPS of processing capacity

Monday, January 20:
Equipment Delivered to WCDAS

39 Racks Delivered to Wallops Command and Data Acquisition Station

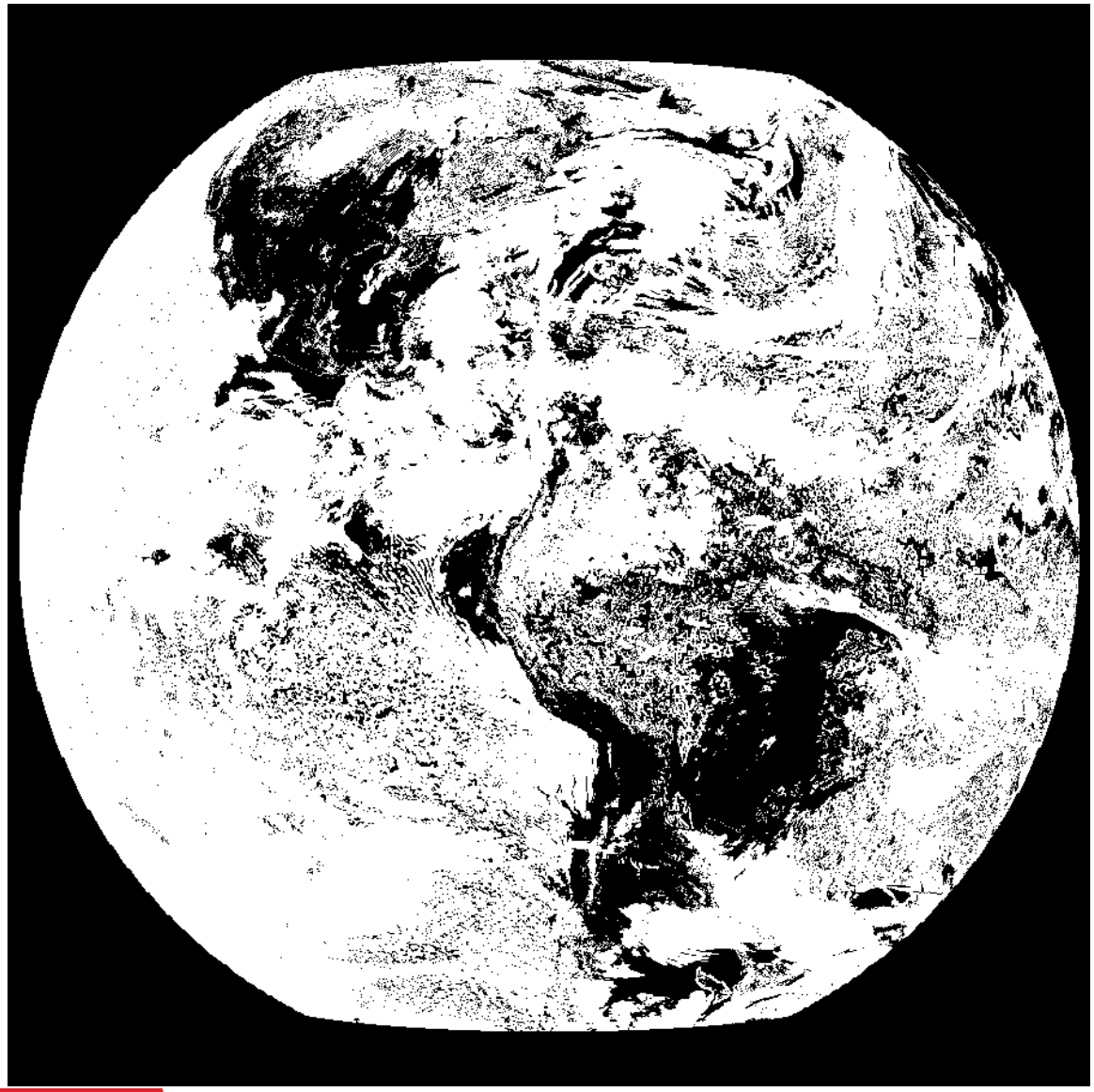
Cloud and Moisture Imagery

(Channel 2 - Visible)

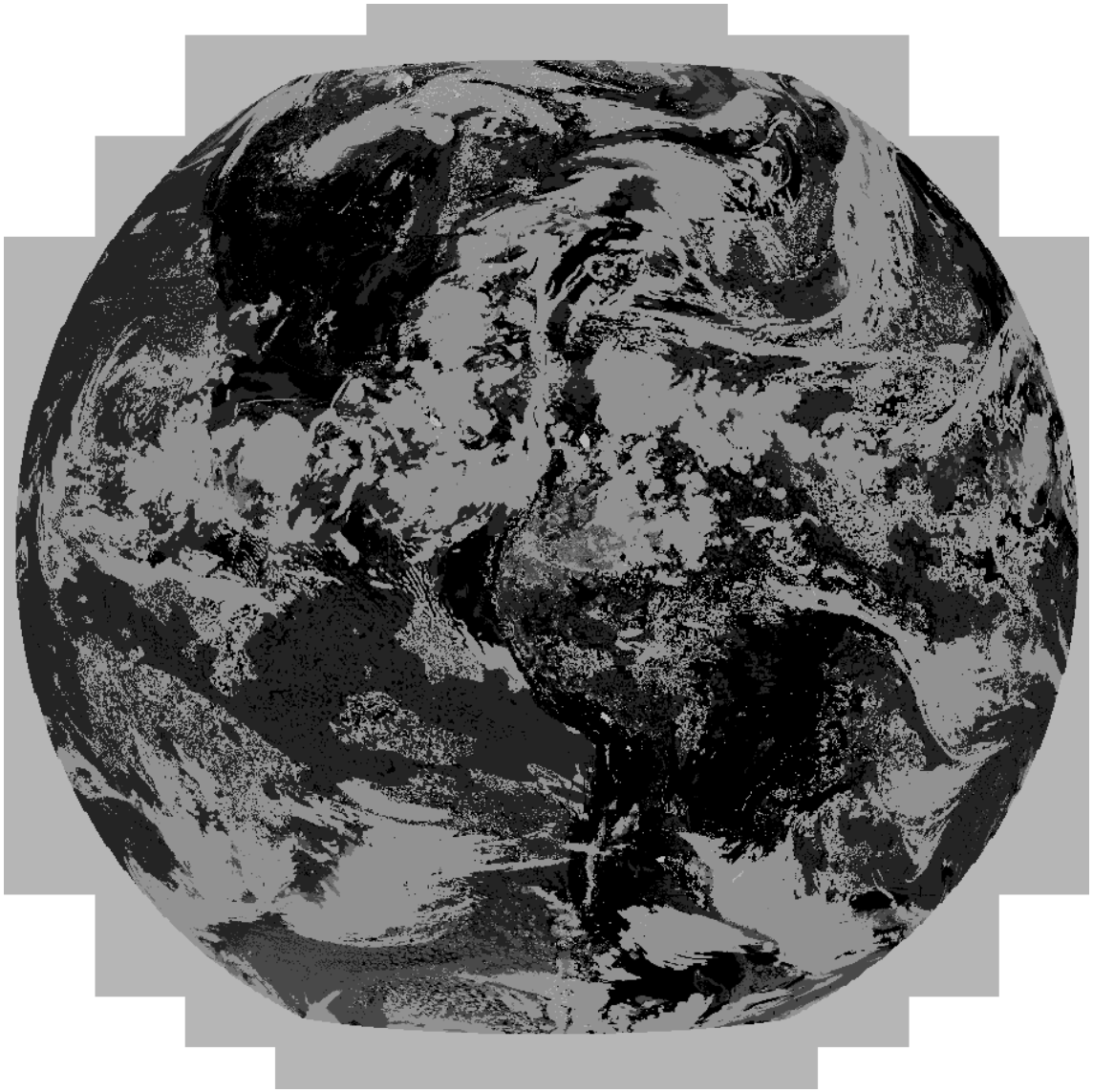


- Sample Product Image for channel 2 (visible)
  - Based on simulated GOES-R channel 2 image
  - Reformatted into GRB proxy data
  - Reconstructed into L1b for development
  - Used for extensive algorithm and systems testing in SBA environment
  - Output is the L2 Cloud and Moisture Image (CMI) for channel 2

Cloud Mask



Cloud Phase



Early Results Summary

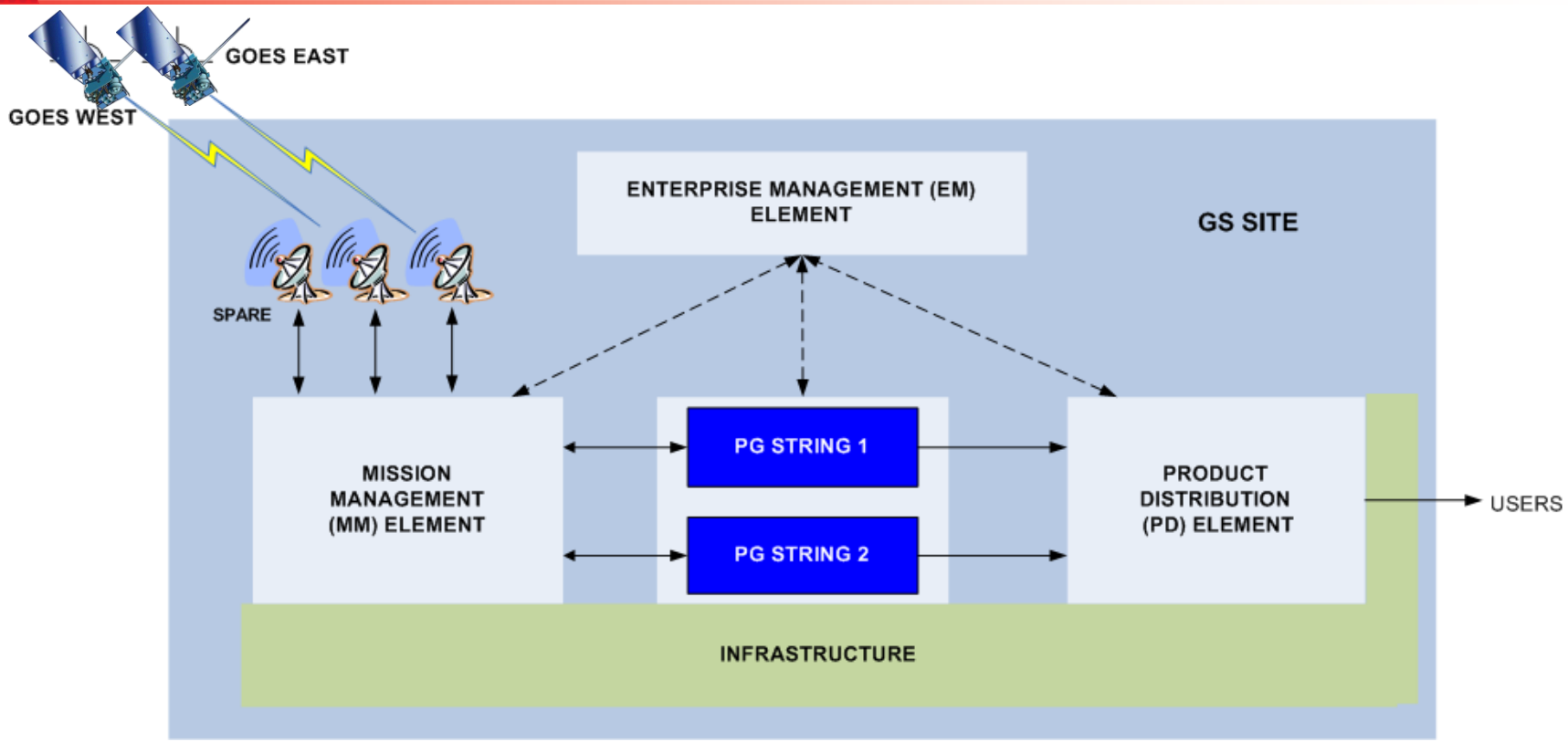
- Implementation addresses major architecture challenges
  - Flexibility, Scalability, Expandability, and Availability
  - Continuous data stream
  - Data error handling
  - Interdependence of data and product streams
  - Resolves finite limitations of available computers and software
  - Capable of resolving obsolescence from evolving COTS computer hardware and software products
- In Conclusion
  - Design of the GOES-R Ground System processing capability is complete
  - Processing And Testing Data is moving through the integration phases
  - Performance is proving to be as predicted (or better) by system models

Backup Charts

Abstract

- **Early Performance Results from the GOES-R Product Generation System**
- Allan Weiner, Harris Corporation, Melbourne, FL; and S. Kalluri, D. Hansen, and G. Dittberner
- Enhancements to remote sensing capabilities for the next generation of Geostationary Operational Environmental Satellite (GOES R-series) scheduled to be launched in 2015 require high performance computing capabilities to output meteorological observations and products at low latency compared to the legacy processing systems. GOES R-series (GOES-R, -S, -T, and –U) represents a generational change in both spacecraft and instrument capability, and the GOES Re-Broadcast (GRB) data which contains calibrated and navigated radiances from all the instruments will be at a data rate of 31 Mb/sec compared to the current 2.11 Mb/sec from existing GOES satellites. To keep up with the data processing rates, the Product Generation (PG) system in the ground segment is designed on a Service Based Architecture (SBA). Each algorithm is executed as a service and subscribes to the data it needs to create higher level products via an enterprise service bus. Various levels of product data are published and retrieved from a data fabric. Together, the SBA and the data fabric provide a flexible, scalable, high performance architecture that meets the needs of product processing now and can grow to accommodate new algorithms in the future. The algorithms are linked together in a precedence chain starting from Level 0 to Level 1b and higher order Level 2 products that are distributed to data distribution nodes for external users. Qualification testing for more than half the product algorithms has so far been completed the PG system.

GS Simplified Architecture
PG Supports 2 GOES Satellites



- PG has 2 Operational "strings" to support two satellites; each string has built-in redundancy
  - Together, the 2 strings can generate products for GOES-East and GOES-West
- PG ITE strings can be reconfigured to make a 3rd PG operational string
  - This PG capability has been demonstrated in the lab
- PG "strings" are autonomous instances of the PG architecture
  - One PG string has no dependencies on another PG string
  - Autonomy simplifies mixed-mode support and tech refreshes – many advantages