GOES-R Ground System Architecture for Product Generation

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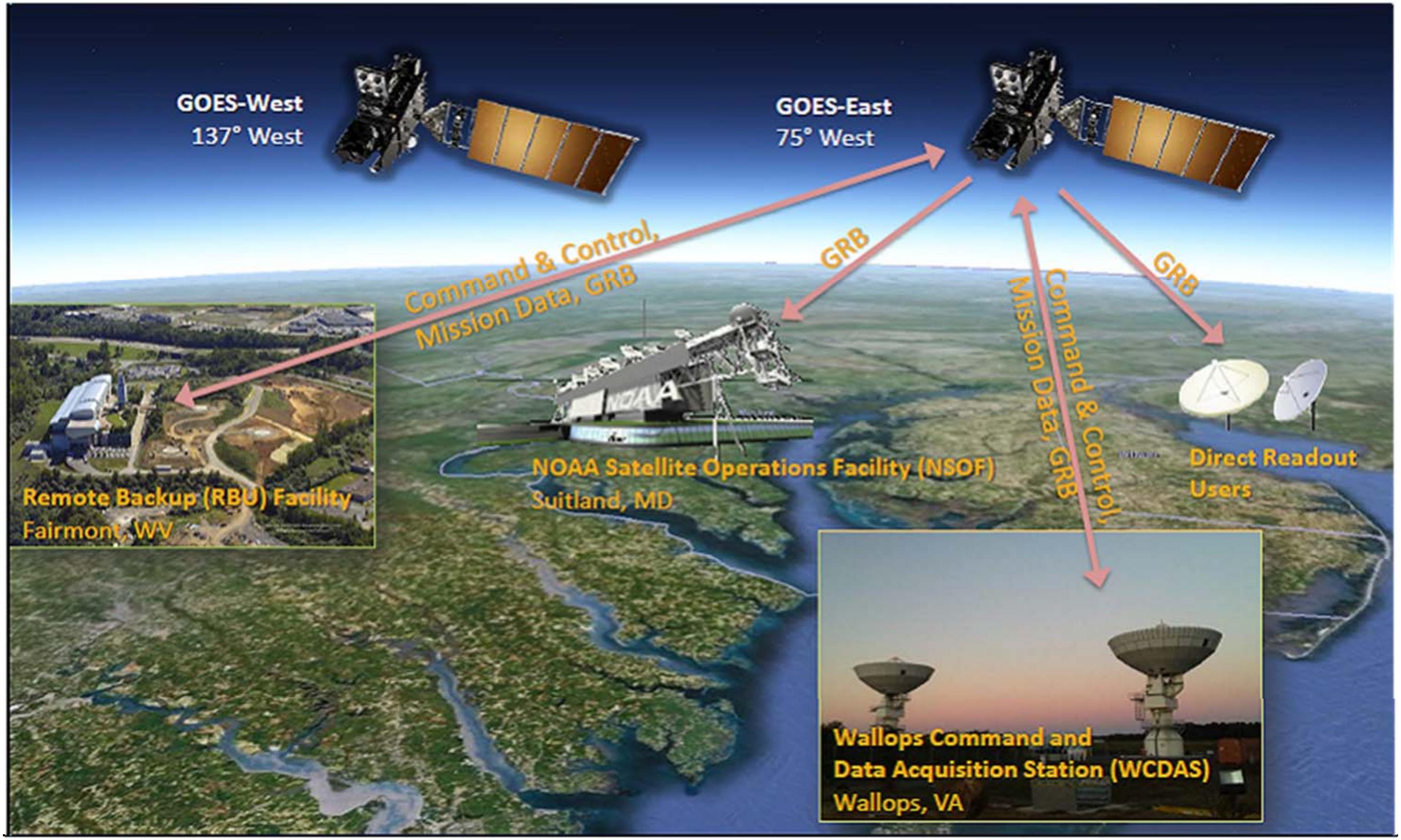
GOES-R Operational System Configuration



Transition from GVAR to GRB

	GVAR (GOES VARiable Format)	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 secononds)
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

GOES-R GRB Simulator

- GRB simulator enables users to test GOES-R data broadcasts, it simulates the generation of Consultative Committee for Space Data Systems (CCSDS) formatted GRB output Level 1b data from five GOES-R Instruments (ABI, SUVI, EXIS, SEISS, and MAG) and also simulates Level 2 data packets from GLM

- The GRB Simulator simulates GRB outputs based on image and non image test patterns in addition to GOES-R proxy data

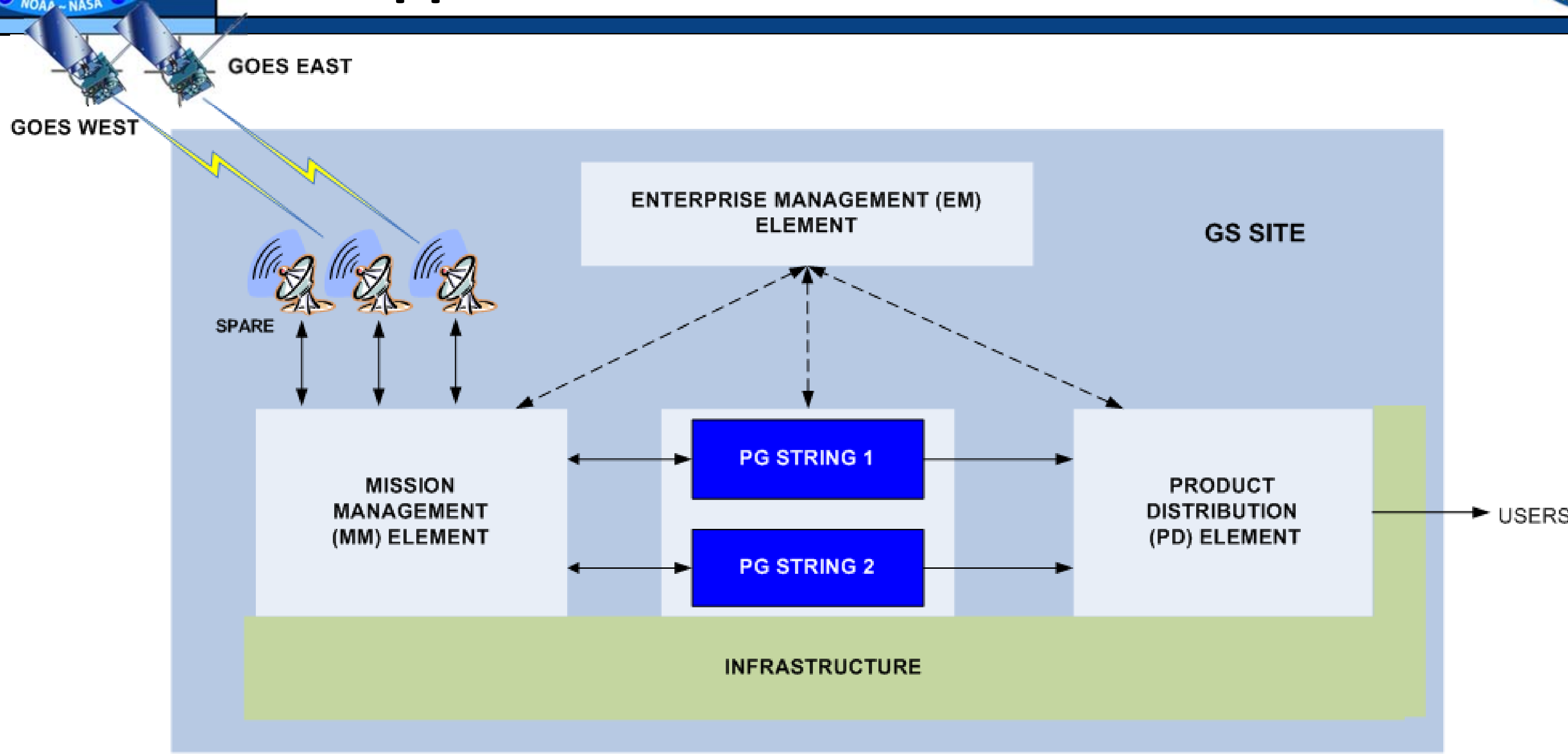
- Weather organizations and manufacturers can test receivers in advance to ensure smooth transition from current GVAR to GRB.

New Antennas Are Being Built to Receive Increased Volume of Data From GOES-R

Raw Data Downlink at WCDAS and RBU is 72Mbps

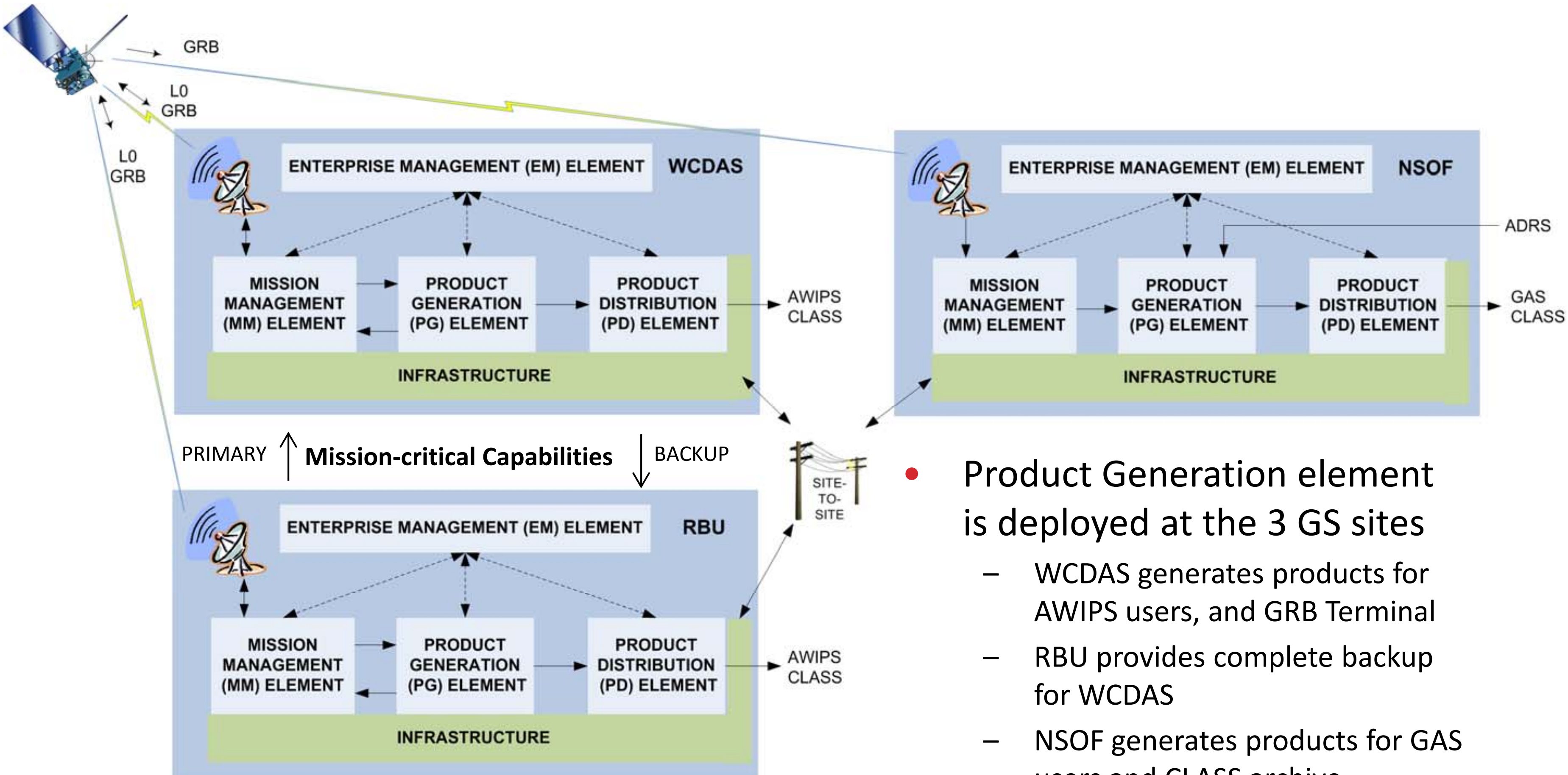
WCDAS

GS Simplified Architecture
PG Supports 2 GOES Satellites



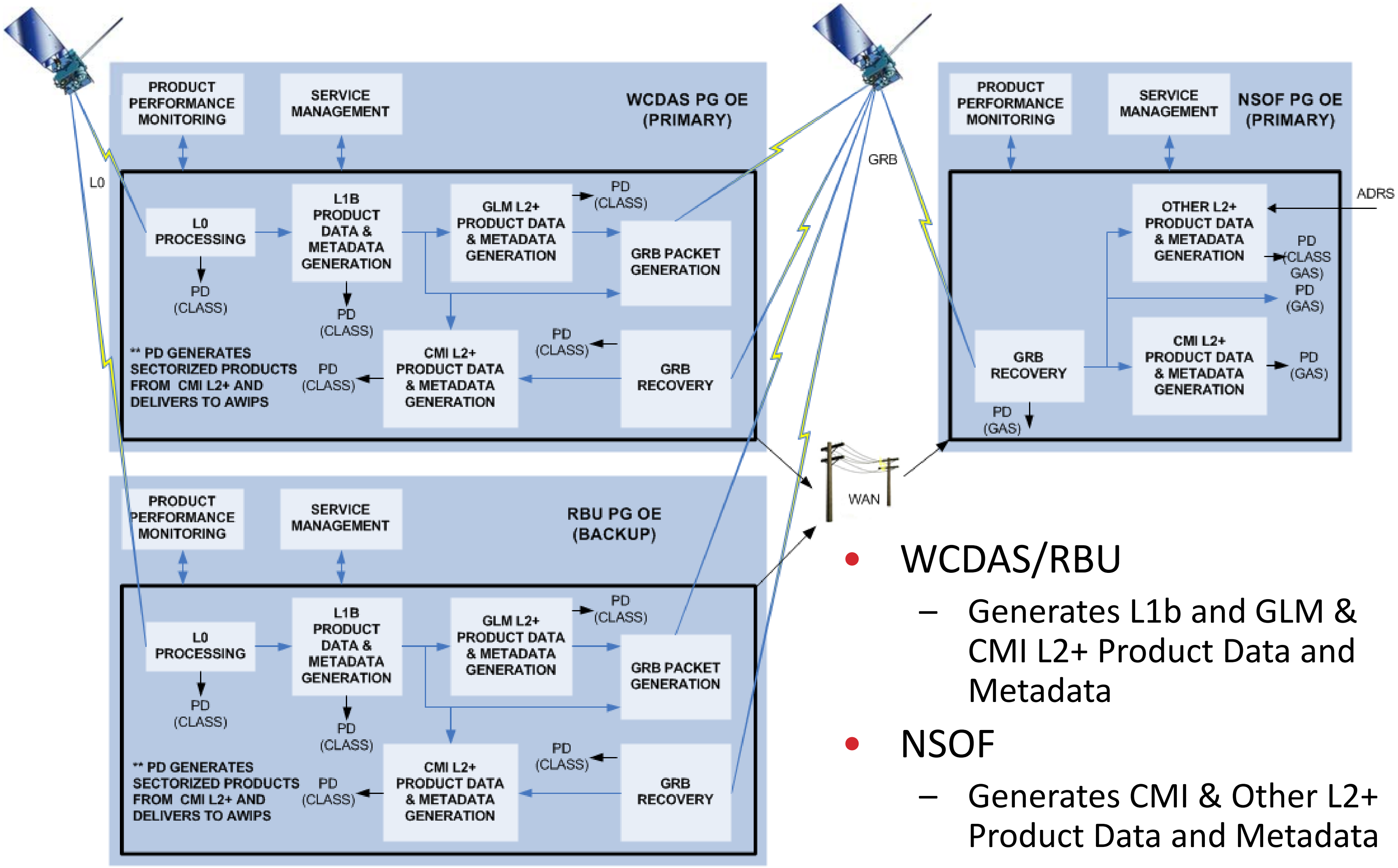
- PG has 2 Operational “strings” to support two satellites; each string has built-in redundancy
  - Together, the 2 strings can generate products for GOES-East and GOES-West
- PG ITE strings can be reconfigured to make a 3rd PG operational string
  - This PG capability has been demonstrated in the lab
- 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

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 Terminal
  - 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

GOES-R Products

GOES-R PRODUCTS

Advanced Baseline Imager (ABI)
Aerosol Detection (Including Smoke and Dust)
Aerosol Optical Depth (AOD)
Clear Sky Masks
Cloud and Moisture Imagery (KPP)
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
Radiances
Rainfall Rate/QPE
Reflected Shortwave Radiation: TOA
Sea Surface Temperature (Skin)
Snow Cover
Total Precipitable Water
Volcanic Ash: Detection and Height

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: Med & High Energy
Magnetospheric Protons: Med & High Energy
Solar and 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 Imagery (X-ray): coronal holes, solar flares, coronal mass ejection source regions

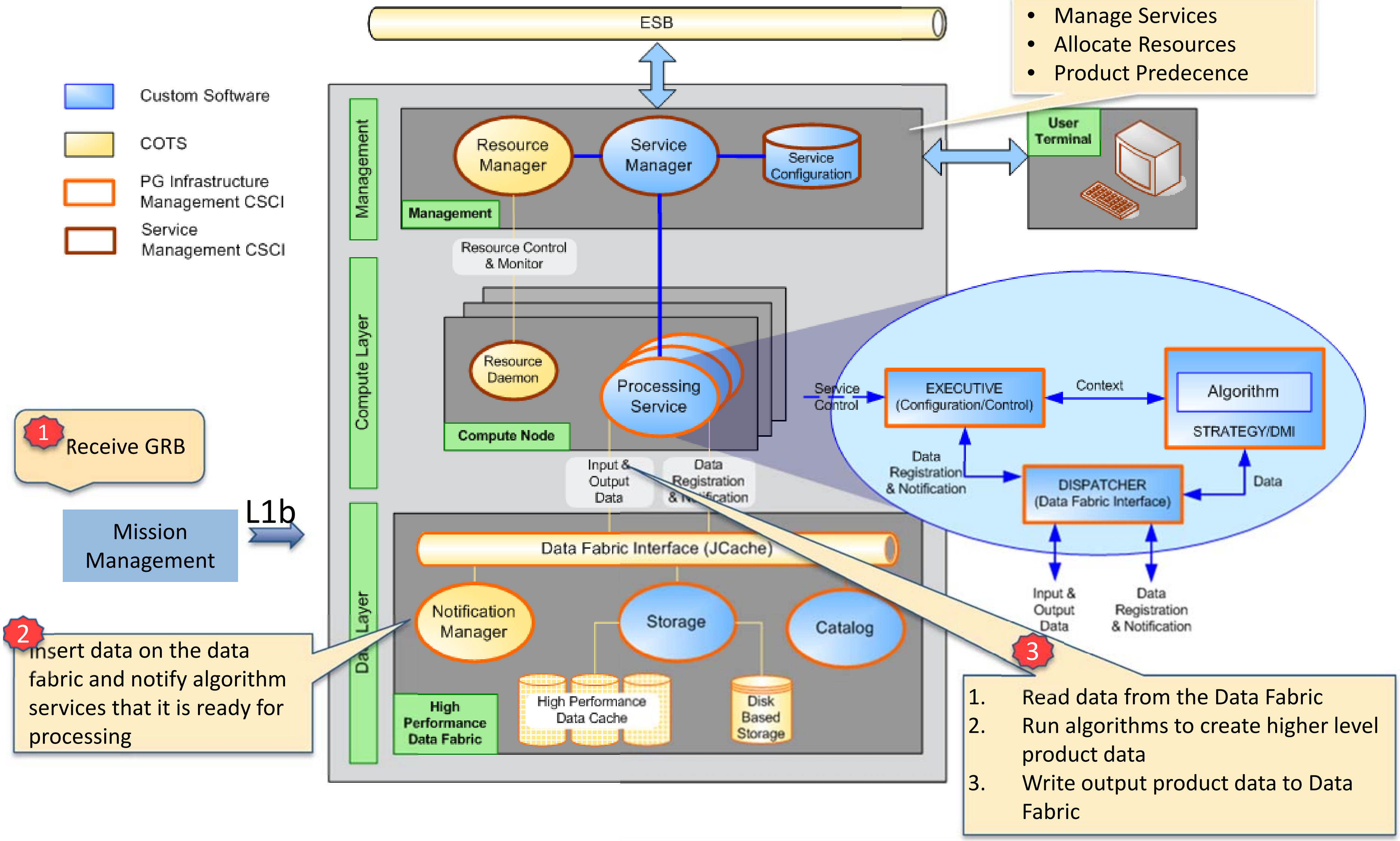
GOES-R Ground Segment Product Generation (PG) Design System Drivers

- The GOES-R PG System has requirements to:
  - 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

PG Design 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)
  - Data is 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



Algorithm Development Overview

- Development of Algorithms divided into two phases
  - Science Phase – Implementation of L1/L2 Algorithm and Algorithm Specific Interfaces
    - Develop Science Software
  - Operationalization Phase – Integration of Science Algorithm into PG Infrastructure
    - Optimize the Science Software to run faster to meet Latency

Science Software Development Overview

- Science Phase of Development Includes:
  - Implementation of Algorithm Design as defined in ATBDs
  - Implementation of interfaces to specific to Algorithm; i.e. ancillary data, product precedence
  - Responsible for producing:
    - Block Level Products for Images
    - Binary Products for non-imagery
    - Intermediary Products
    - Data Quality Flags
    - Metadata
  - Tested to meet:
    - Science Functional Requirements
    - Reproducibility of test outputs to verify accurate implementation
  - Handed off to Operationalization Team

Operationalization Overview

- Operationalization (OPZ) Phase of Development Includes:
  - Integration and configuration of science Algorithm into SBA Architecture
  - Configuring Services to meet Latency Requirements
  - Ingesting Semi-Static Data/Processing Parameters into the Data Fabric for use by Algorithms
  - Additional logging to gather performance metrics
  - Responsible for Producing Product Level Metadata
    - Consolidated Metadata generated at the block level
    - Used by Product Distribution to signify the full product is available
  - Tested on Operational Infrastructure to meet
    - Science and Reproducibility Requirements
    - Performance and Non-Functional Requirements

PG Implementation 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

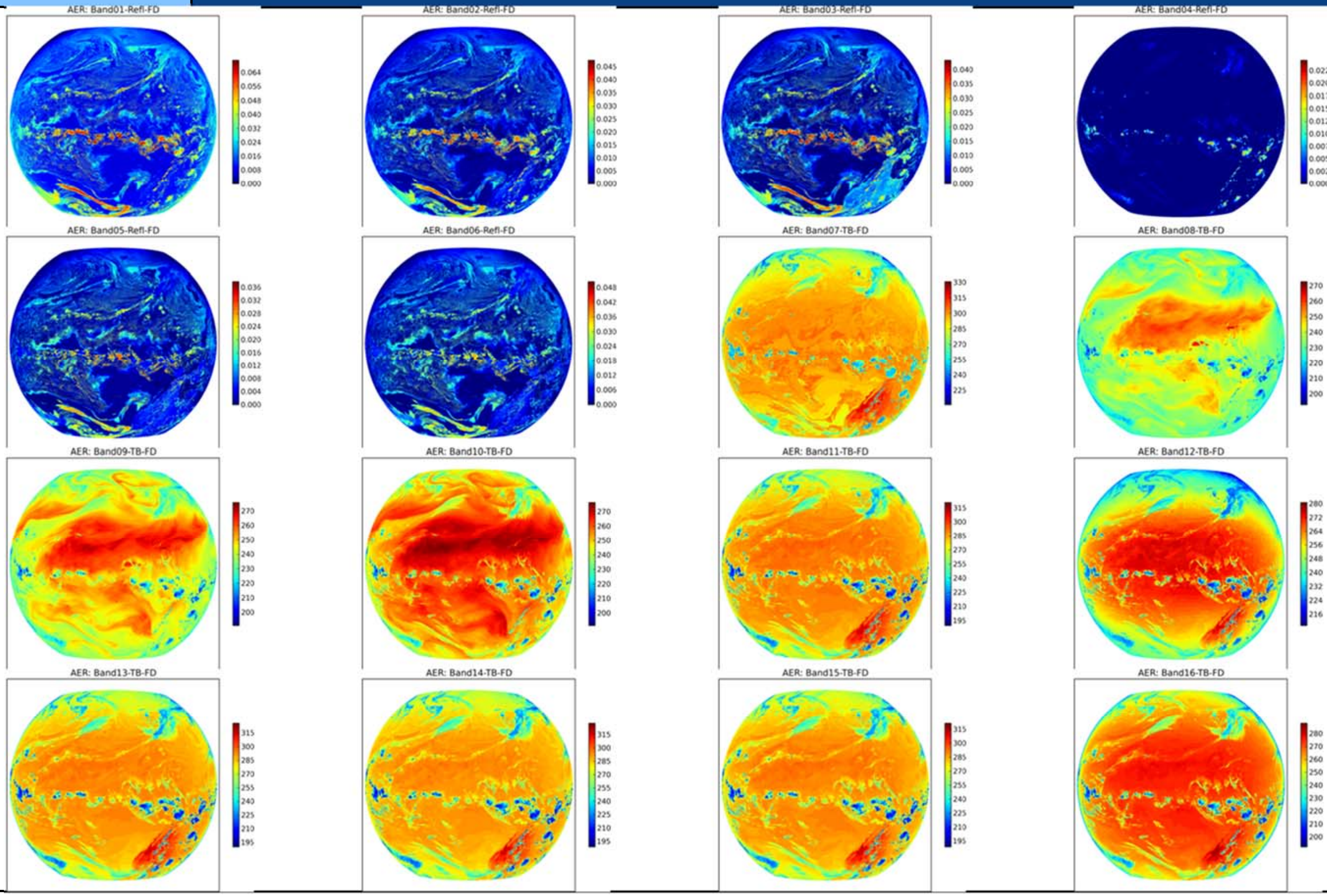
- Science & Operationalization phase for all space weather L0/L1b algorithms completed

- Science & Operationalization phase for ABI L2+ products for Product Set 1 completed: Imagery (KPPs), Clouds, Aerosols, Soundings

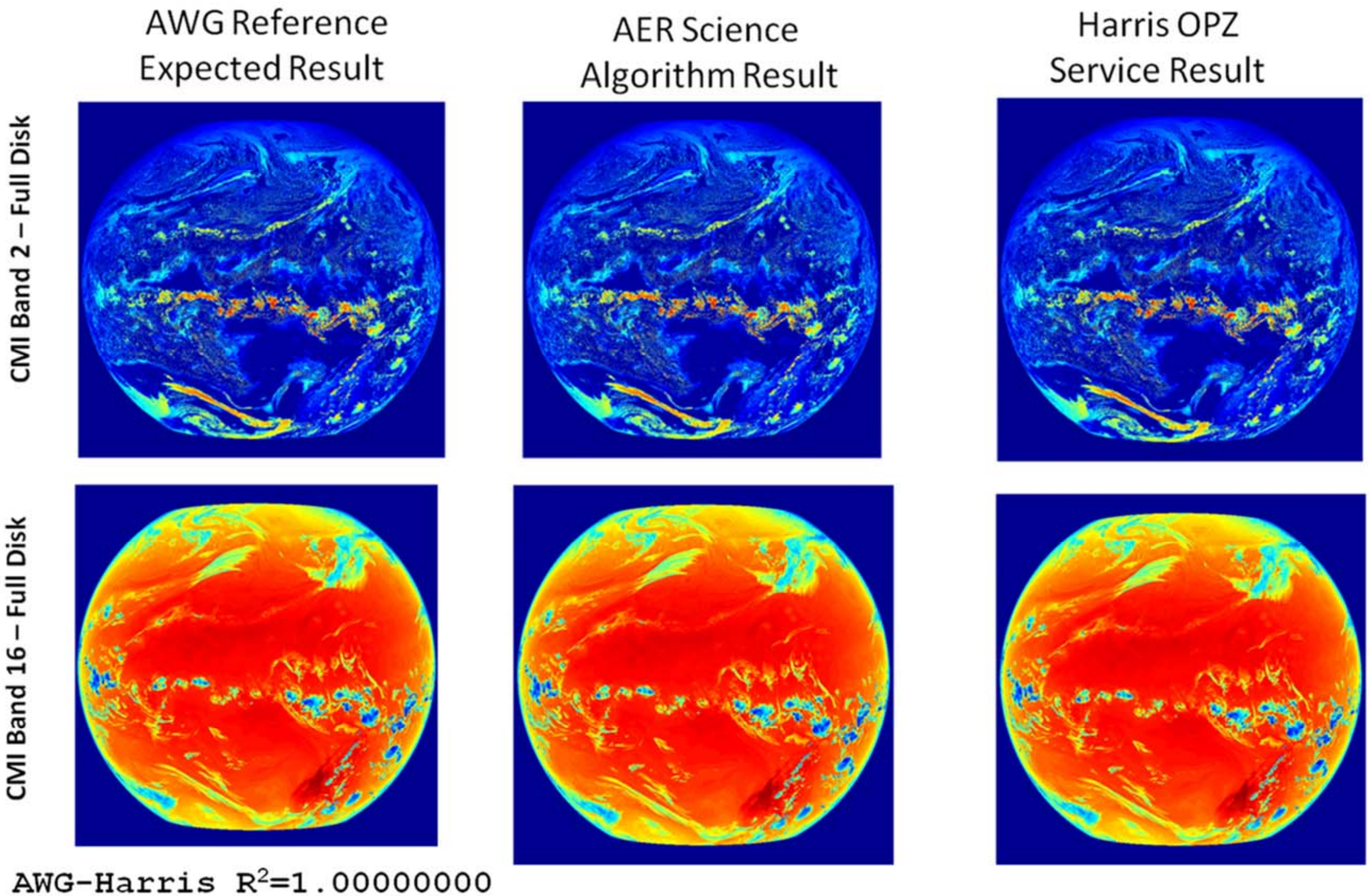
- Integration of Product Generation & Product Distribution is completed for ABI L1b (Radiances) and L2+ for product set 1 (Imagery, Clouds, Aerosols, and Soundings).

- Integration of Mission Management, Product Generation and Product Distribution to be completed by mid 2014

Science Phase Test Result: Full Disk ABI 16 Band Outputs From Simulated Data

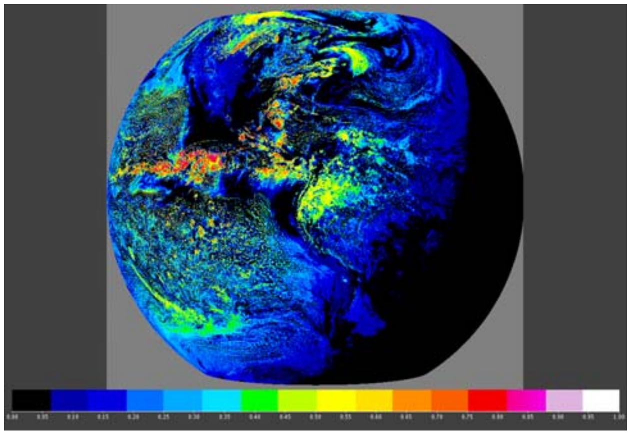


Reproducing Science in to an Operational System is a Key Requirement!!

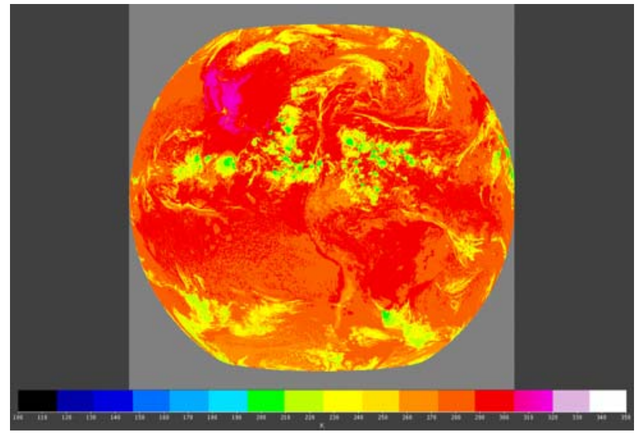


Results from PG-PD Integration

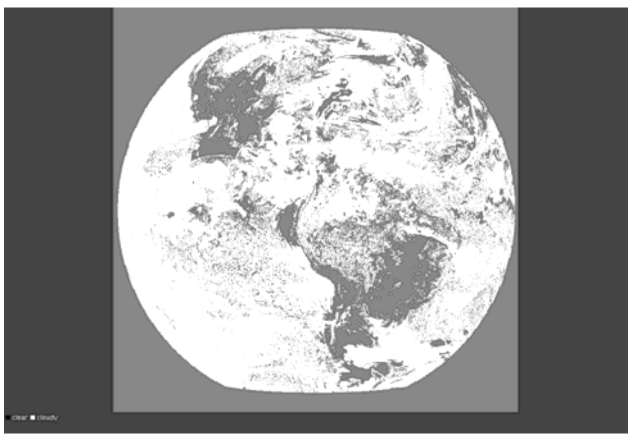
Reflectance



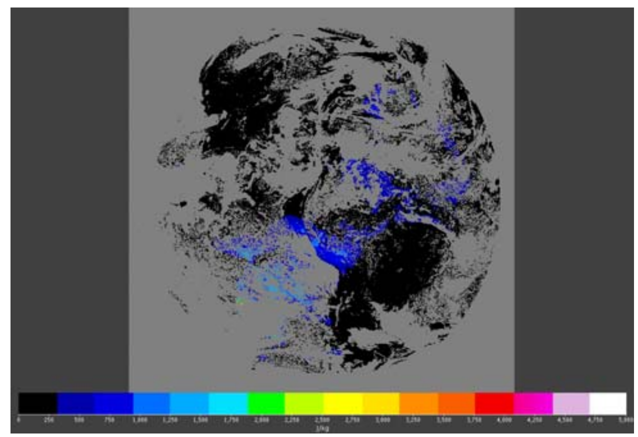
Brightness Temperature



Cloud Mask



Convective Available Potential Energy



Lots of Data Processing, Need a Lot of 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 KPP
  - < 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

Summary

- Latency, Latency, Latency
- Flexibility, Scalability, Expandability, and Availability
- Robustness with automated failover
- Design addresses major architecture challenges
  - 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
- Early result indicates that the design is meeting or exceeding performance specification.