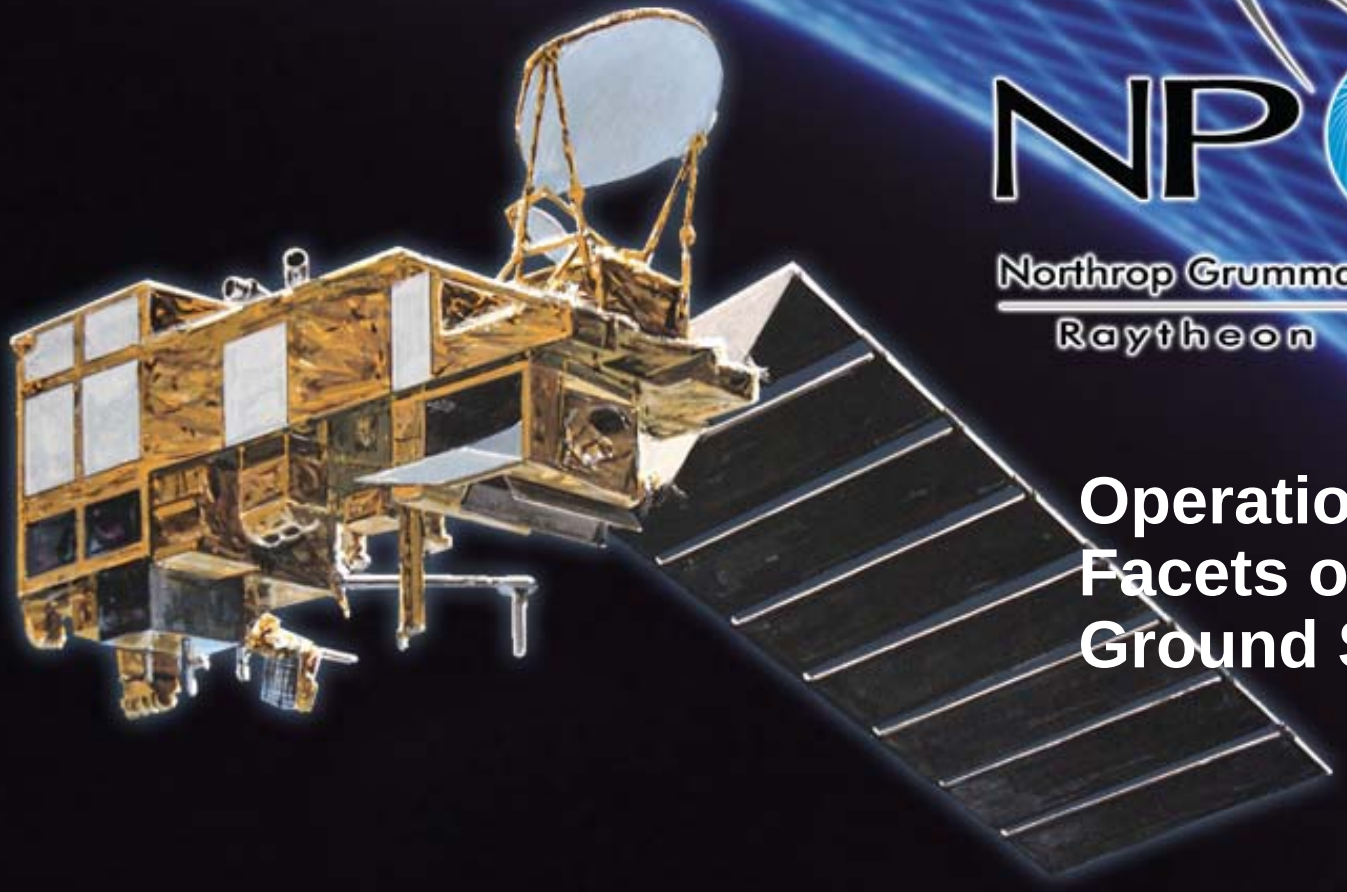


NPOESS

Northrop Grumman
Raytheon

DOC • DoD
NASA

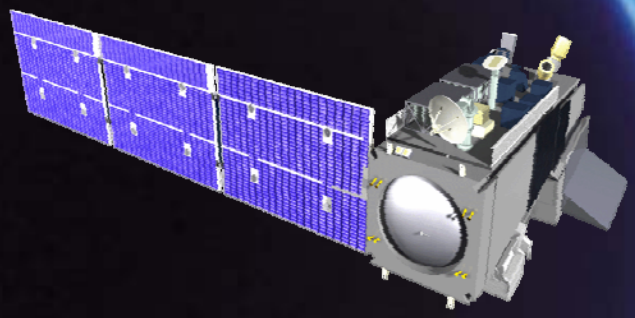
# Operationally Responsive Facets of the NPOESS Ground System

## National Polar-Orbiting Operational Environmental Satellite System (NPOESS)

Keith Reinke
Pete Phillips
Joe Mulligan

# Agenda

- NPOESS Mission and Architecture
- Ground System Maturity
- Software Reuse
- Improved Data Latency
- Increased Bandwidth for Antarctica
- Processing Architecture Benefits
- Industry Standard Output Format

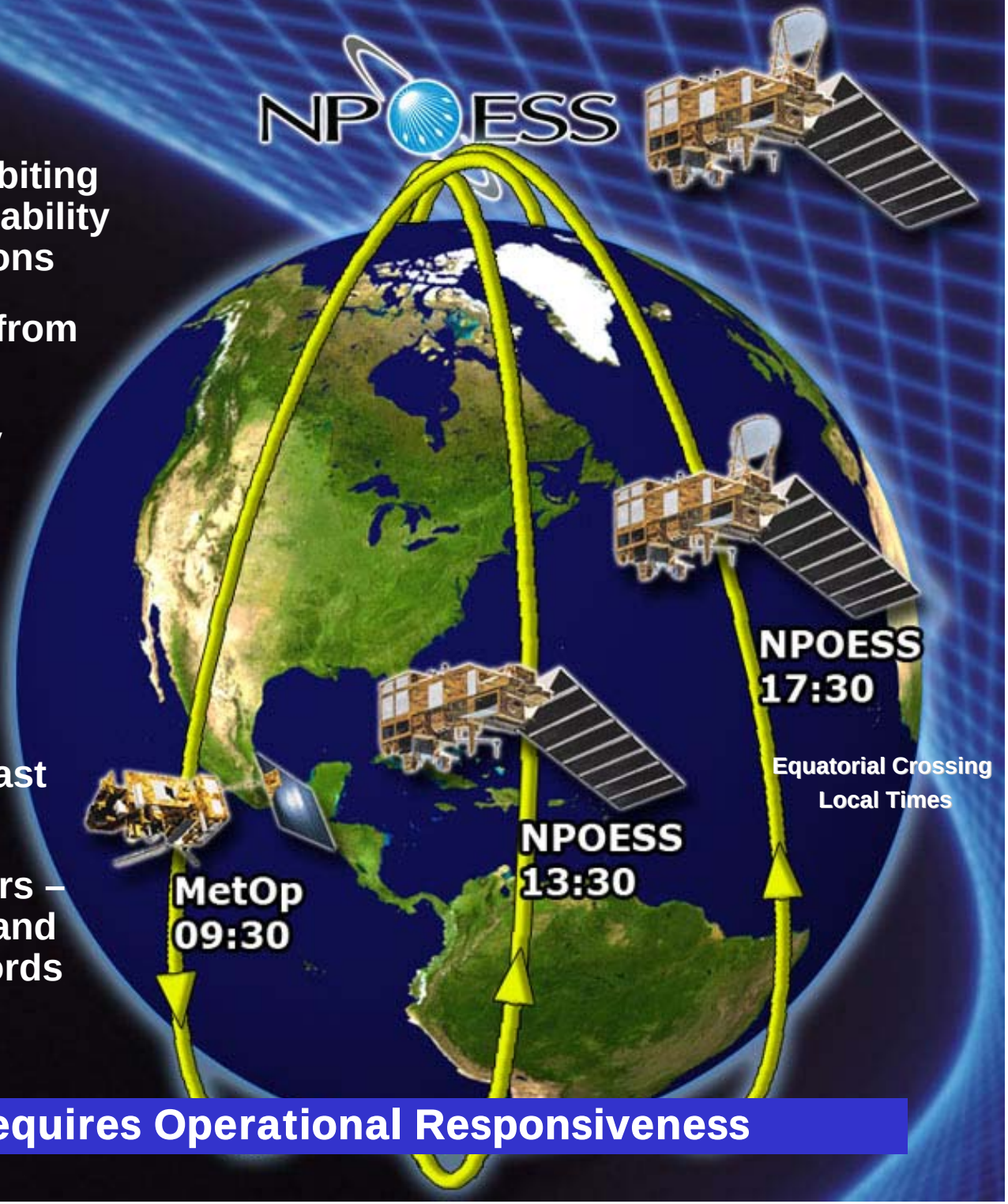


# Mission

- National, operational, polar-orbiting environmental monitoring capability for defense and civil applications
- Incorporates new technology from NASA programs
- Includes NPOESS Preparatory Project risk reduction mission
- International cooperation with European MetOp satellite

# Benefits

- Critical input to weather forecast models
- Science-quality data to all users – including research scientists and continuity of climate data records




**Broad Mission Requires Operational Responsiveness**

# NPOESS Architecture

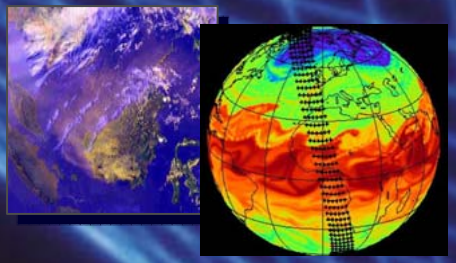
TDRSS GPS TDRSS

Space Segment

NPP 1330 1730 1330 Residuals NPOESS Satellites

A-DCS

SARSAT



C3 Segment

Svalbard Primary T&C NPP SMD

White Sands Complex LEO&A Backup T&C

SAFETY NET™

15 Globally Distributed Receptor Sites Interconnected by Commercial Fiber

Field Terminal Segment

HRD Field Terminal

LRD Field Terminal

Offline Support

LTA SDS

NAVO FNMOC AFWA NESDIS

Data Del Process Infra Data Mgt Ingest

Data Del Process Infra Data Mgt Ingest

Data Del Process Infra Data Mgt Ingest

Data Del DQM Process Infra Data Mgt Ingest

Interface Data Processing Segment

One full set resides in each of the 4 Centrals

Launch Support Segment

Aurora MMC Contingency Operations Team

MMC at Suitland Flight Operations Team

- Enterprise Management
- Mission Management
- Satellite Operations
- Data Monitoring & Recovery

NPOESS Stored Mission Data

Command and Telemetry

NPP Stored Mission Data

Data Handling Nodes reside at each Central

# Ground System Maturity

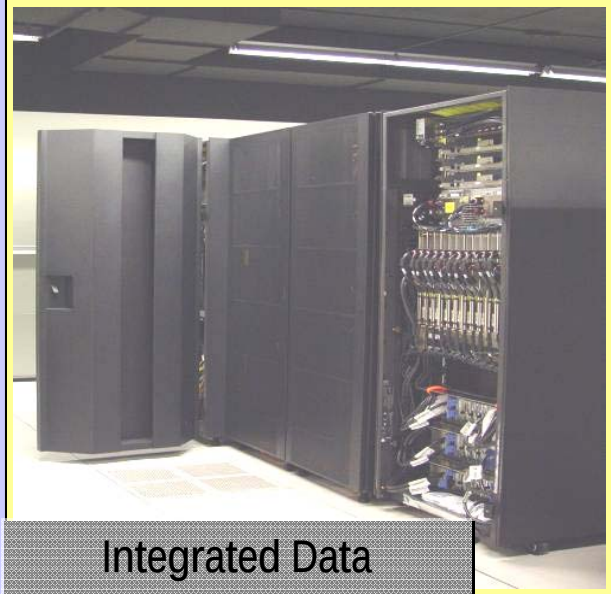
## Command and Control System

- NOAA Satellite Operations Facility (NSOF) populated
- Command, Control and Communications Segment (C3S) installed and acceptance tested at 4 sites
- NPP Flight Vehicle Simulator installed at NSOF

## Svalbard Ground Station


- NPP Svalbard Antenna Modifications Completed
- Communications services to NSOF established
- End to End compatibility checkouts conducted
- WindSat data relay operational

## Integrated Data Processing System



- Build 1.4 completed qualification testing
- Final NPP Software Build 1.5 in development
- NSOF Installation in progress
- Acceptance Test at sites in Summer 2008

**Ground Segment on schedule and on path to meeting all goals**

# Software Reuse


- **NPOESS Phase 1 (NPP) Command and Control Software reuse was very high percentage of total delivered SLOC (Source Lines of Code) for program**

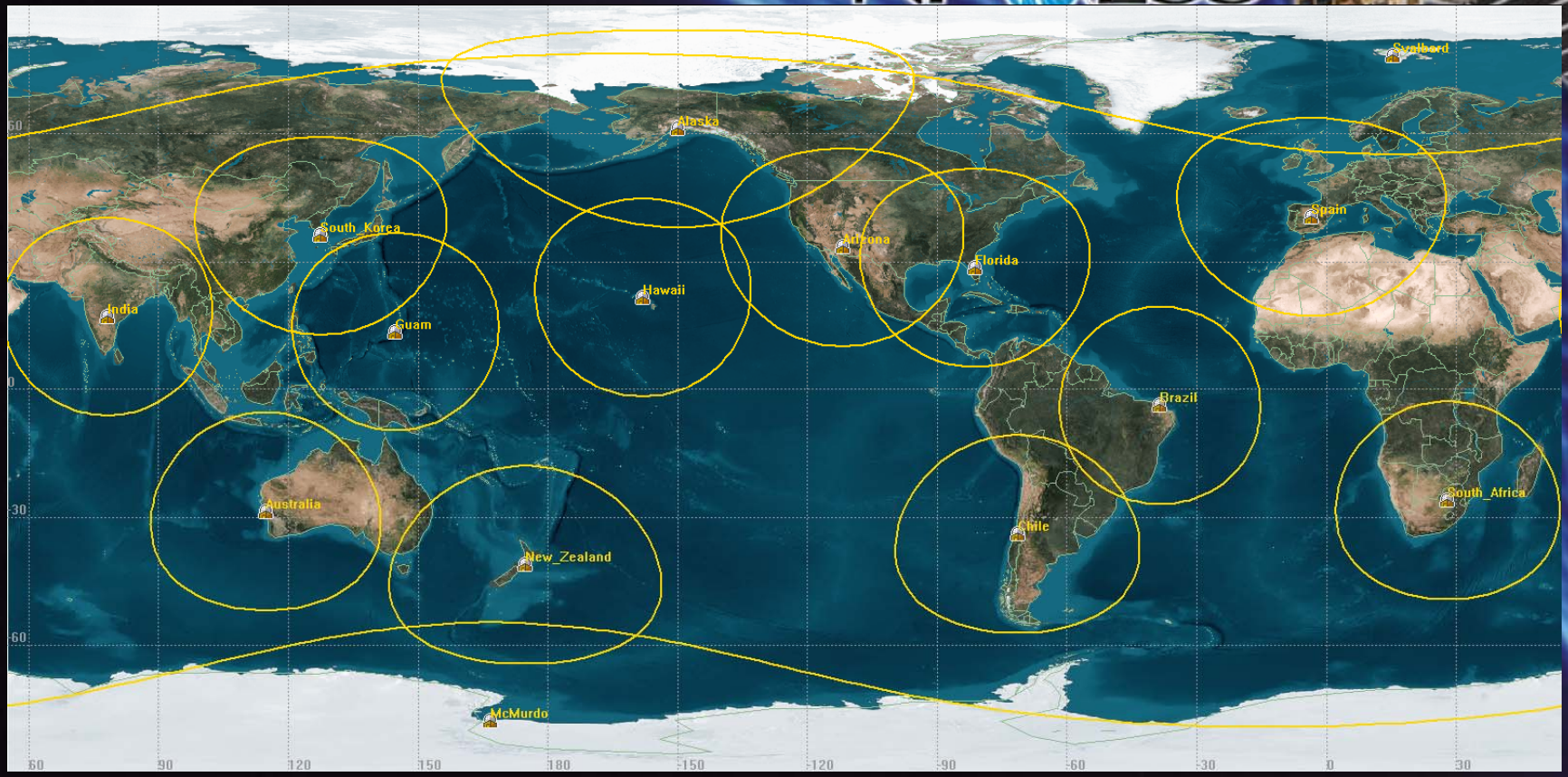
| | New SLOC | Reuse SLOC | Total SLOC | Reuse % |
|---|---|---|---|---|
| C3S | 291,872 | 1,698,784 | 1,990,656 | 85% |

- **The NPOESS Phase 1 software reuse came from many other successful Commercial, Civil, DoD and Government Missions/Programs**
  - Reduced risks, schedule, and costs by not having to “reinvent the wheel”
  - Core command and control components highly mature, feature rich
  - Software reuse was a key component in early delivery of C3S

- **Raytheon IIS has increased the reuse percentage on each successive program**
  - Software is designed for reuse
  - Factors for re-design, re-code and re-test account for reusability of SW
  - Re-test is always required for reused SW

**C3S Early Deployment Enabled by High Software Reuse**

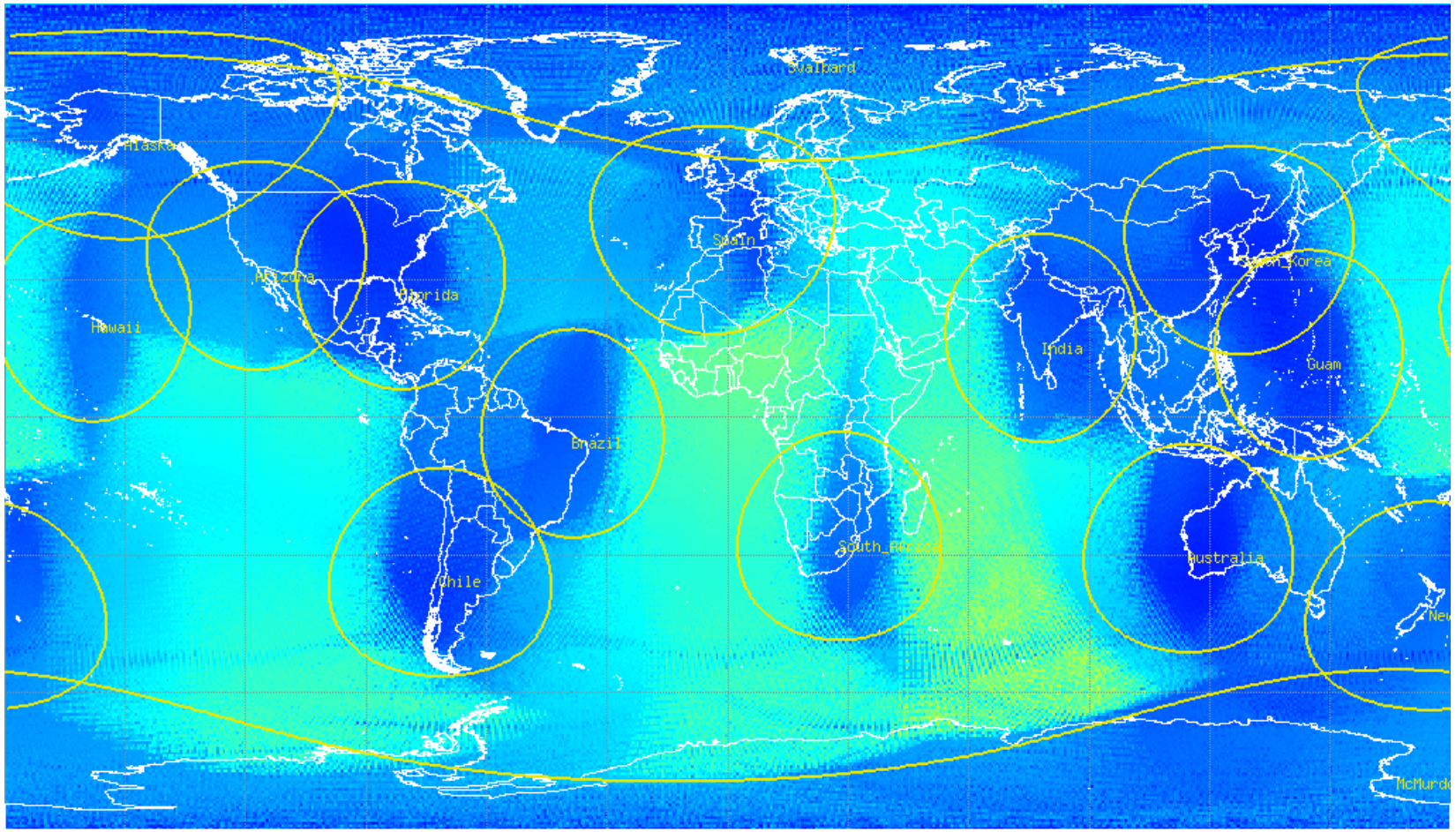
# Worldwide Receptor Sites Reduce Latency




- 15 global receptors provide multiple data delivery path, high availability
- Unmanned receptors centrally controlled by Mission Management Center
- Extremely robust; meets system performance with 6 simultaneous receptor failures
- Leverages high bandwidth commercial fiber, cost effective delivery
- On track to attain Landing Rights in host countries

**Reduces Data Latency from Hours to Minutes**

# NPOESS Latency Profile




**Locations Optimized For Minimum Latency**

# NPOESS Data Parameter Comparison


DMSP/POES
NPP
NPOESS

## DATA LATENCY – Delivery Of Data To Users

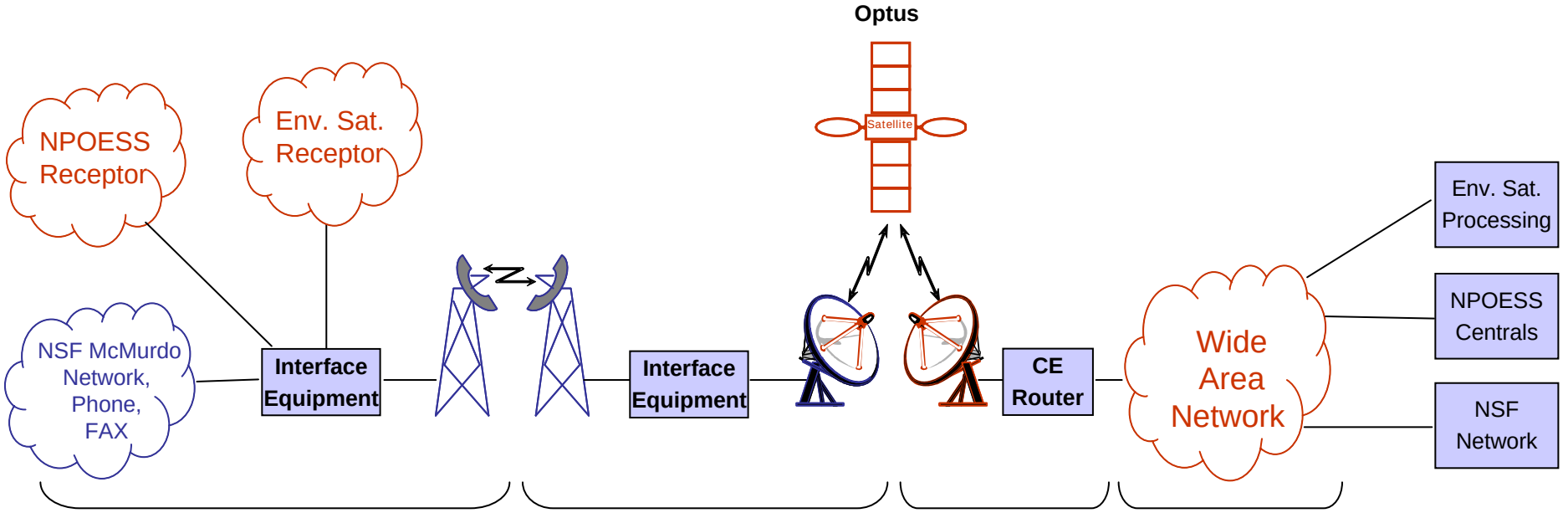

## KEY DATA PARAMETERS

| Mission | Observed Data Rate | Data Volume | Downlink Frequencies | Spectral Capability | Vertical Resolution |
|---|---|---|---|---|---|
| Heritage | 1.5 Mbps | 6.3 GB/Day | VHF, L-, S-Band | 5 bands | 40 bands |
| NPOESS | 20 Mbps | 5.4 TB/Day | S-, X-, Ka-Band | 22 bands | 1300 bands |

**NPOESS improves robustness, accuracy, and timeliness of delivery of essential weather and climate data**

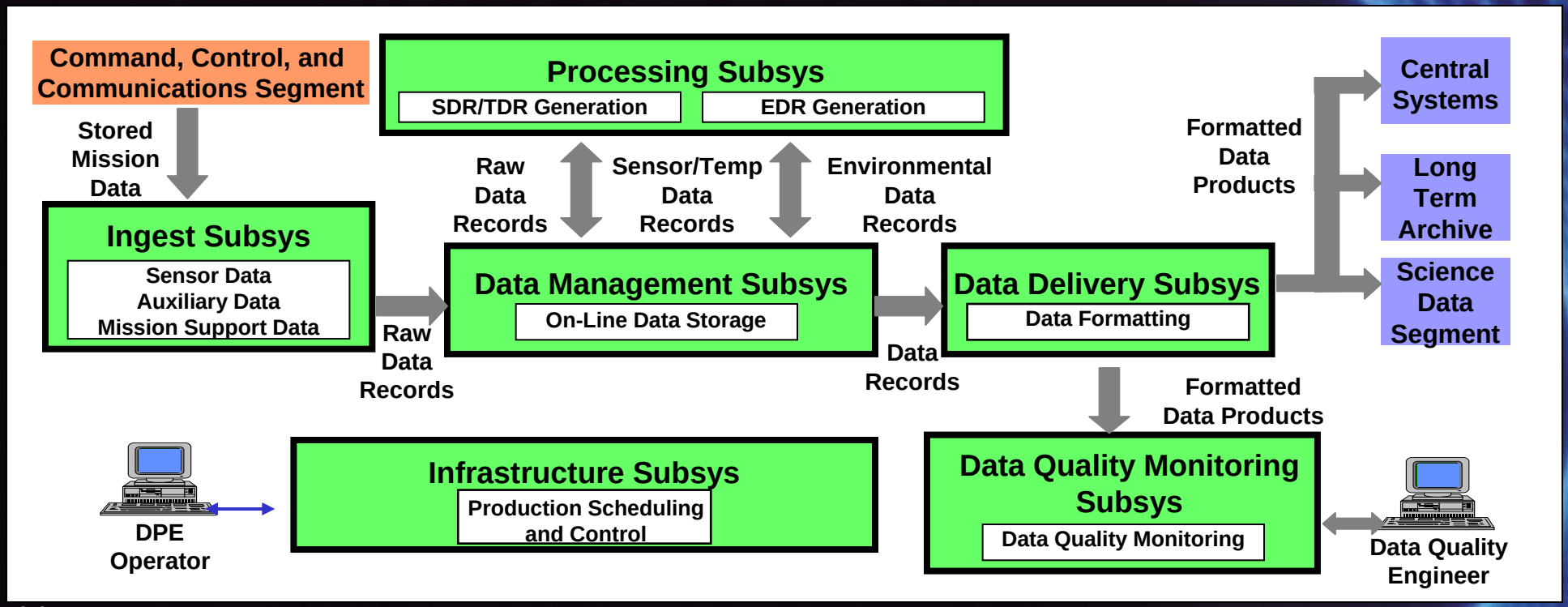
# Increased Bandwidth for Antarctica

- **NPOESS SATCOM deployed in 2007 in Antarctica**
  - Risk Reduction for NPOESS Antarctic Receptor
  - Increased Bandwidth by a factor of 3 for National Science Foundation Users at McMurdo Station
  - Provides opportunity to downlink other Environmental Satellite Programs through Antarctica and reduce latency – i.e. METOP, DMSP



# Data Processing Architecture


- Data Processing System must process large volumes of data with low latency
- Processing algorithms are used to turn raw sensor readings into calibrated data records
- Processing algorithms architected into Input-Processing-Output (I-P-O) format



# I-P-O Benefits


- **Processing algorithm initiated after all required inputs are present**
  - Simplifies graceful degradation
  - Input quality checks performed up-front
  - Prevents occupation of CPUs by active processes waiting for additional input
- **Modularization and isolation of algorithm simplifies algorithm updates**
- **Standardized output processing**
- **Increased maintainability**
  - Rapid isolation of error
  - Simplified logic, error handling, and recovery

# Output Formats Utilize Industry Standard


- **NPOESS writes all externally-distributed products in Hierarchical Data Format 5 (HDF5)**
- **HDF5 is a self-describing format designed for storing scientific data**
  - It provides a structure for organizing objects and optimizes the storage of multidimensional arrays of data elements
  - The HDF5 libraries are open source and run on multiple platforms
- **All NPOESS products are organized within HDF5 in a consistent manner (e.g. use the same group structure)**
  - Familiarity with one product provides familiarity with all NPOESS products
  - Approach allows for extensible temporal dimension
    - Simply extending dataset dimension permits storage of additional granules
- **A separate XML Product Profile documents product fields**
  - Each product is described by a Product Profile
    - All profiles use the same type and XML schema definition
  - Profiles contain data types, descriptions, units, dimensions, scaling information, etc.
  - Product profiles can be viewed in a web browser through the use of a style sheet
- **Flexibility in product sizing enabled through separation of geolocation information**
  - Placed in separate product group or separate file (initial requestor controlled)

# Synopsis


- **NPOESS Ground Segment has many facets that provide operational responsiveness to benefit user communities**
  - Command and Control Software reuse enabled early deployment, high initial maturity
  - Improved latency makes environmental data more valuable to operational users
  - Increased Antarctic communications bandwidth provides benefit to Antarctica Scientists and environmental satellite community
  - Data Processing architecture provides mechanism to readily update environmental algorithms
  - Data Processing output data follows industry standard HDF5 standard, simplifying creation of value-added products by users

**NPOESS Ground Segment is Operationally Responsive**