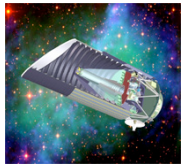


Concept for a JDEM Science Operations Center

Erik Gottschalk
Fermilab

Overview

We have developed a conceptual design for SNAP Science Operations that is generic enough to be applicable to JDEM. As planning for JDEM evolves we expect to be able to adapt our design to meet the requirements for a JDEM Science Operations Center.

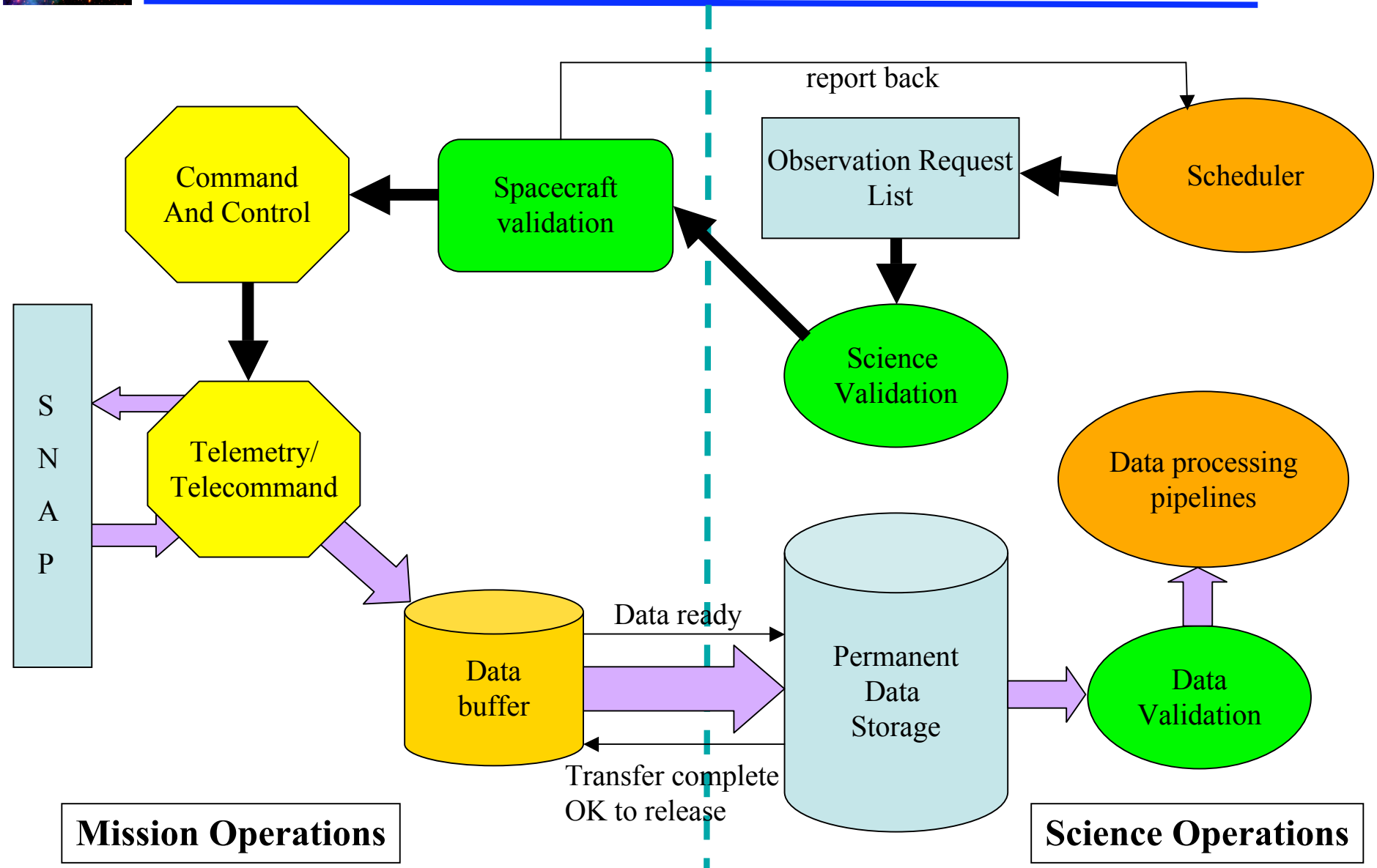
Overview:

- What is a Science Operations Center?
- Requirements for Science Operations
- Science Operations Center (systems view)
- Software infrastructure (deployments)
  - Analysis and Development Facility (ADF)
  - Science Operations Center (SOC)
  - Laptop Deployment (LAP)
- Work Breakdown Structure (WBS)
- Conclusion

What is a Science Operations Center?

- Provides computing, networking, and data management infrastructure for data processing pipelines, software development, and quality assurance (QA).
- Provides QA data analysis capabilities for scientists and engineers developing instruments for the mission.
- Interfaces with the Mission Operations Center (MOC); receives science and engineering data and generates observation requests (**supernova trigger**).
- Provides remote access to data and monitoring information, which is especially important during commissioning.
- Prepares science data products for collaborators doing science analyses and for the public archive.
- Provides a center for data operations with computing support for collaborators.

MOC/SOC Interface for SNAP



Software Workshops and Site Visits

- We held three workshops to develop requirements and then used these requirements to develop a conceptual design for SNAP Science Operations.
  - Science Operations Requirements Workshop at FNAL (July 23-25, 2008)
  - Science Operations Requirements Review at LBNL (August 21-22, 2008)
  - Software Design Workshop at LBNL (August 25-26, 2008)

- We extracted requirements from scenarios (e.g. daily data processing, science scheduling, etc.) that were developed during the first workshop at Fermilab.
- We completed the first version of the requirements document in September.
  - There are 18 subsections and 105 requirements in this document.
  - The requirements are somewhat generic, ie. not specific to SNAP.
  - Requirements for the interface to a NASA Mission Operations Center (MOC) were not fully developed since we did not have necessary information in August.
  - Since then we have visited the Fermi ISOC, six MOCs (Fermi, ACE, RXTE, MAP, EO-1, SDO), RXTE Science Ops Facility, and HST Alternate Ops Area.
  - We have met with a Network Systems Engineer at GSFC to discuss networking.
  - We have a meeting tomorrow (Nov. 5) at JPL with a NASA Telecommunications and Mission Systems Manager.

Science Operations Requirements

Requirements categories:

- Computing Services
- Production Running
- Supernova Triggering
- Calibration
- Reprocessing
- Control and Monitoring
- Data Monitoring
- Scheduling
- Resources for End-User Analyses
- Storage and Retrieval of Collected and Derived Data
- Support for Science Commissioning
- Collaborative Operations and Analysis Tools
- Release Management
- Development Management
- Execution Management
- Environment, Safety and Health
- Security
- Public Data Release

The requirements review at LBNL in August called out the need to define the interface between Science Operations and Science Analyses.

Science Operations Deployments

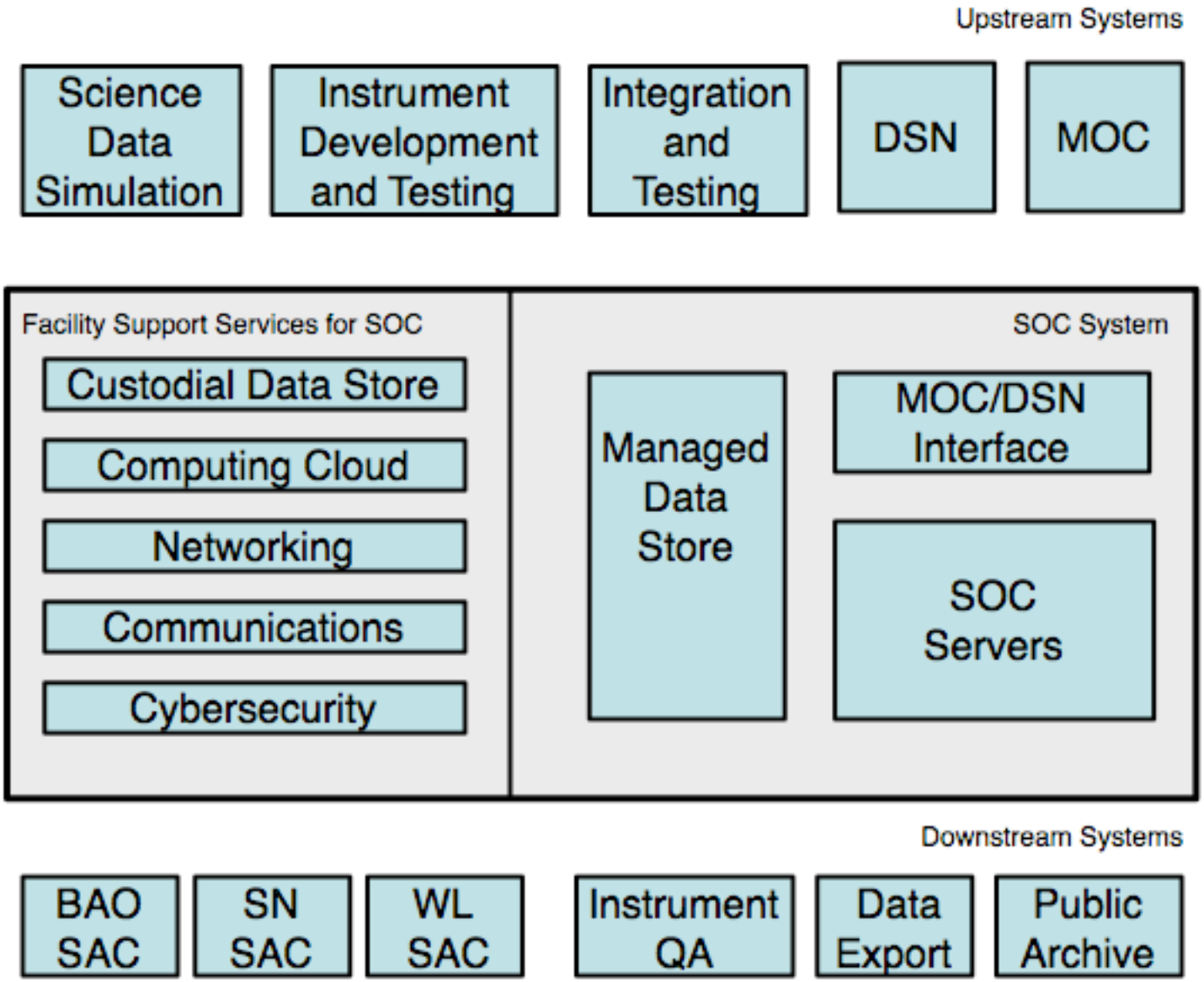
We have developed a conceptual design for Science Operations that involves **three deployments**. Each deployment provides **software infrastructure** to support the mission.

- Analysis and Development Facility (ADF)
  - Core software infrastructure for SOC and Science Analysis Centers (SACs)
  - Instrument QA
  - Software development platform
  - Workflow integration and testing
- Science Operations Center Software (SOCS)
  - Production workflow system (data processing pipelines)
  - Custodial data storage and central data management
  - Resource scheduling and science scheduling
  - Data import and export
  - DSN/MOC/SOC integration
- Laptop Deployment (LAP)
  - Enables software development, testing, QA and science analyses without a network connection

Glossary

- ADF - Analysis & Development Facility
- BAO - Baryon Acoustic Oscillations
- ITAR - International Traffic in Arms Regulations
- DRF - Data Reduction Framework
- DRM - Data Reduction Module
- DSN - Deep Space Network
- LEO - Launch and Early Orbit
- MOC - Mission Operations Center
- ORL - Observation Request List
- QAF - Quality Assurance Framework
- QAM - Quality Assurance Module
- SAC - Science Analysis Center
- SOC - Science Operations Center
- SN - Supernova
- WL - Weak Lensing

High-Level SOC Systems and External Systems



Software Systems

Data Reduction System

- Data Reduction Framework (DRF)
- Data Reduction Modules (DRM)
- Data Reduction Framework Sensors

Quality Assurance System

- Quality Assurance Framework (QAF)
- Quality Assurance Modules (QAM)
- Data Quality Monitoring (DQM)
- Mission Quality Monitoring (MQM)

Online System

- Production System (PS)
- Calibration Creation (CC)
- Supernova Trigger (ST)
- Observatory Scheduler (OS)
- MOC/DSN Interface Manager

Software Development

- Code and Release Manager (CODE)
- Development System (DEV)

Data Management System

- Data Manager/Central (DM/C)
- Data Manager/Local (DM/L)
- SOC Proxy/Server
- SOC Proxy/Client

User Interfaces

- Configuration Management (CONF)
- Global Resource Scheduler (GRS)
- SOC Manager (SOCM)
- Operations Display (OD)
- Remote Operations Display (ROD)

External Data Systems

- External Data Ingest Manager (EDIM)
- Data Exporter (DE)
- Public Archive Interface (PAI)

Integration and Test System

- Pipeline Integration Tester (PIT)

Software Systems (ADF-specific subsystems in green)

Data Reduction System

- **Data Reduction Framework (DRF)**
- **Data Reduction Modules (DRM)**
- **Data Reduction Framework Sensors**

Quality Assurance System

- **Quality Assurance Framework (QAF)**
- **Quality Assurance Modules (QAM)**
- **Data Quality Monitoring (DQM)**
- **Mission Quality Monitoring (MQM)**

Online System

- Production System (PS)
- Calibration Creation (CC)
- Supernova Trigger (ST)
- Observatory Scheduler (OS)
- MOC/DSN Interface Manager

Software Development

- **Code and Release Manager (CODE)**
- **Development System (DEV)**

Data Management System

- Data Manager/Central (DM/C)
- **Data Manager/Local (DM/L)**
- SOC Proxy/Server
- **SOC Proxy/Client**

User Interfaces

- **Configuration Management (CONF)**
- Global Resource Scheduler (GRS)
- SOC Manager (SOCM)
- **Operations Display (OD)**
- **Remote Operations Display (ROD)**

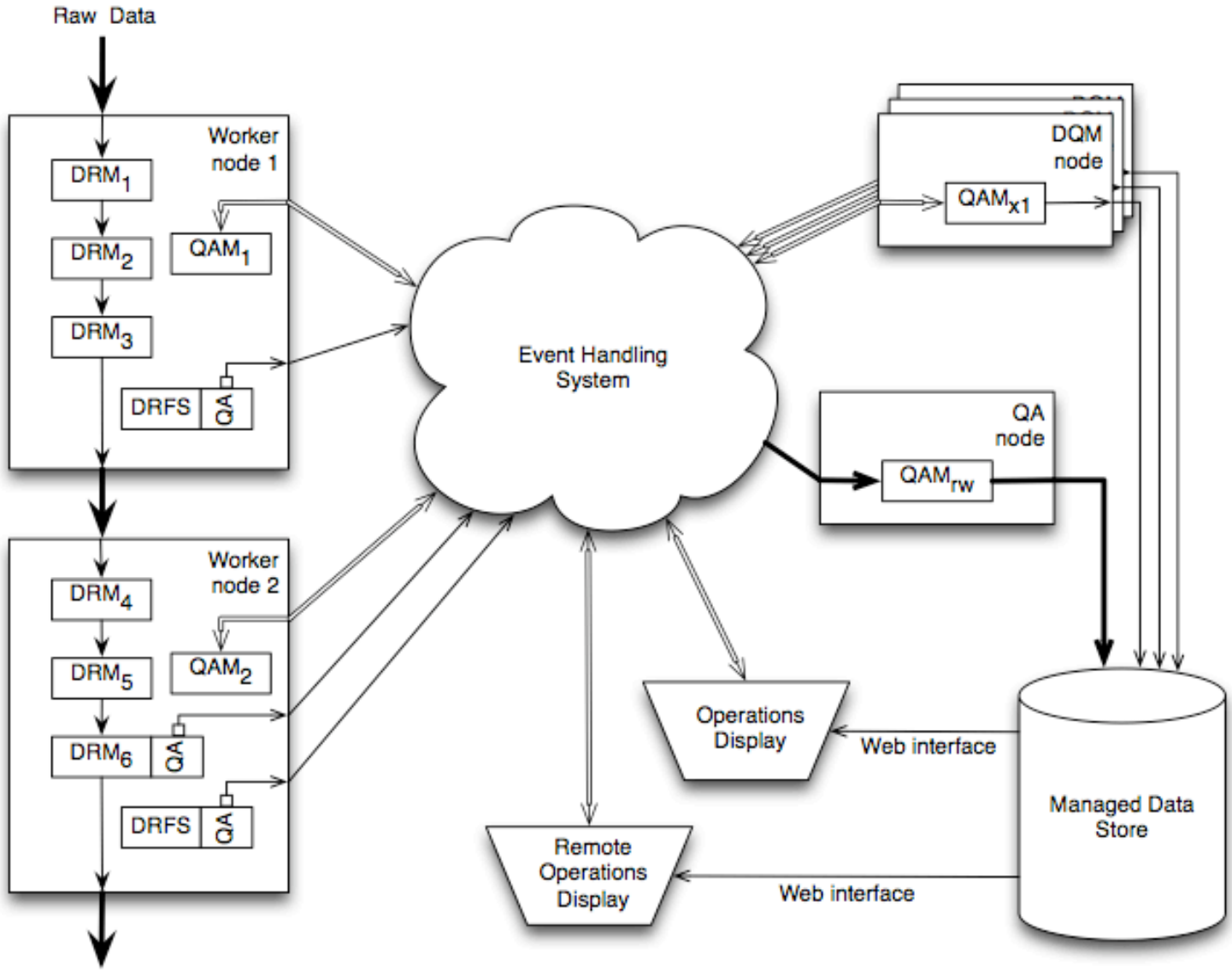
External Data Systems

- **External Data Ingest Manager (EDIM)**
- **Data Exporter (DE)**
- Public Archive Interface (PAI)

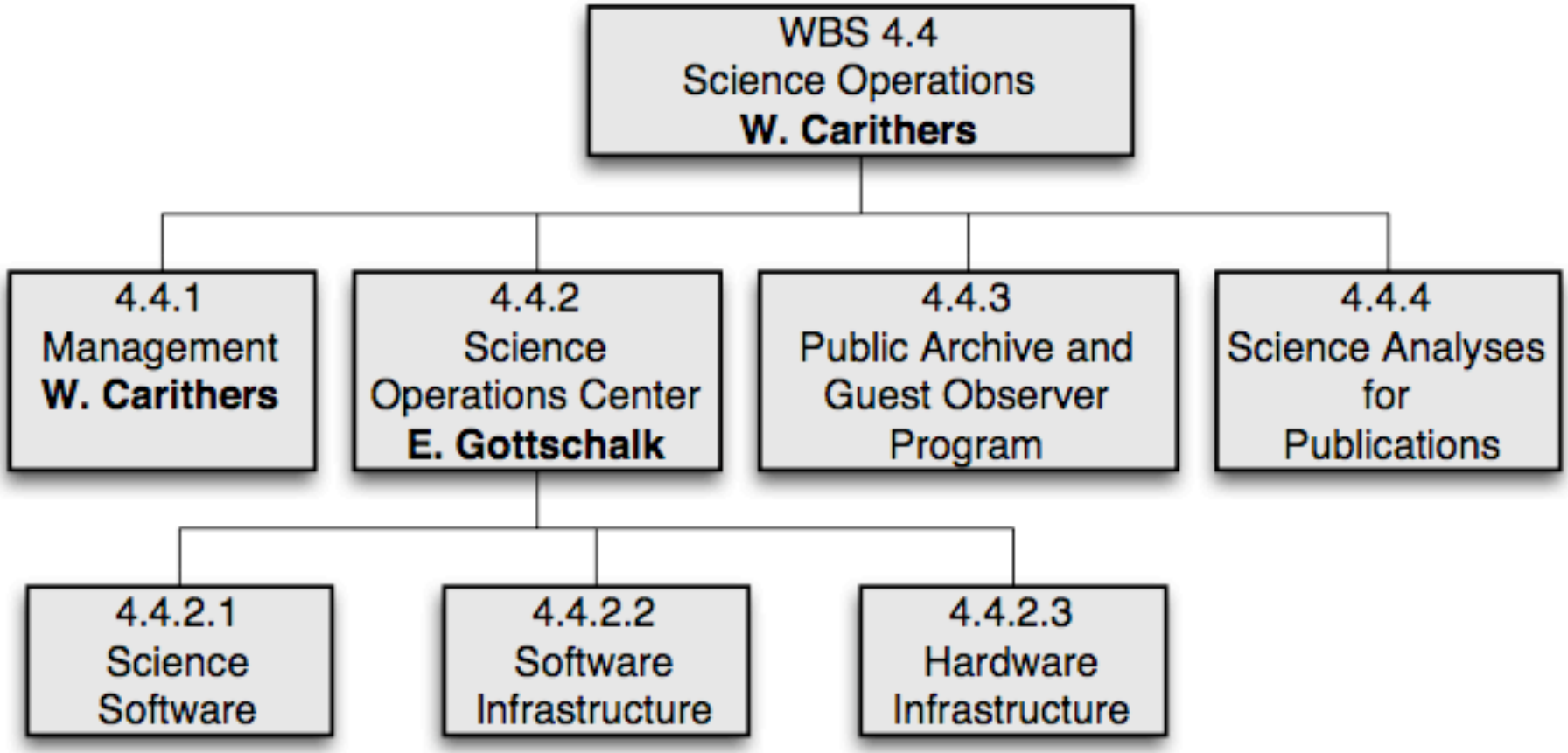
Integration and Test System

- **Pipeline Integration Tester (PIT)**

Core Infrastructure (Data Reduction & Quality Assurance)



SNAP Science Operations WBS

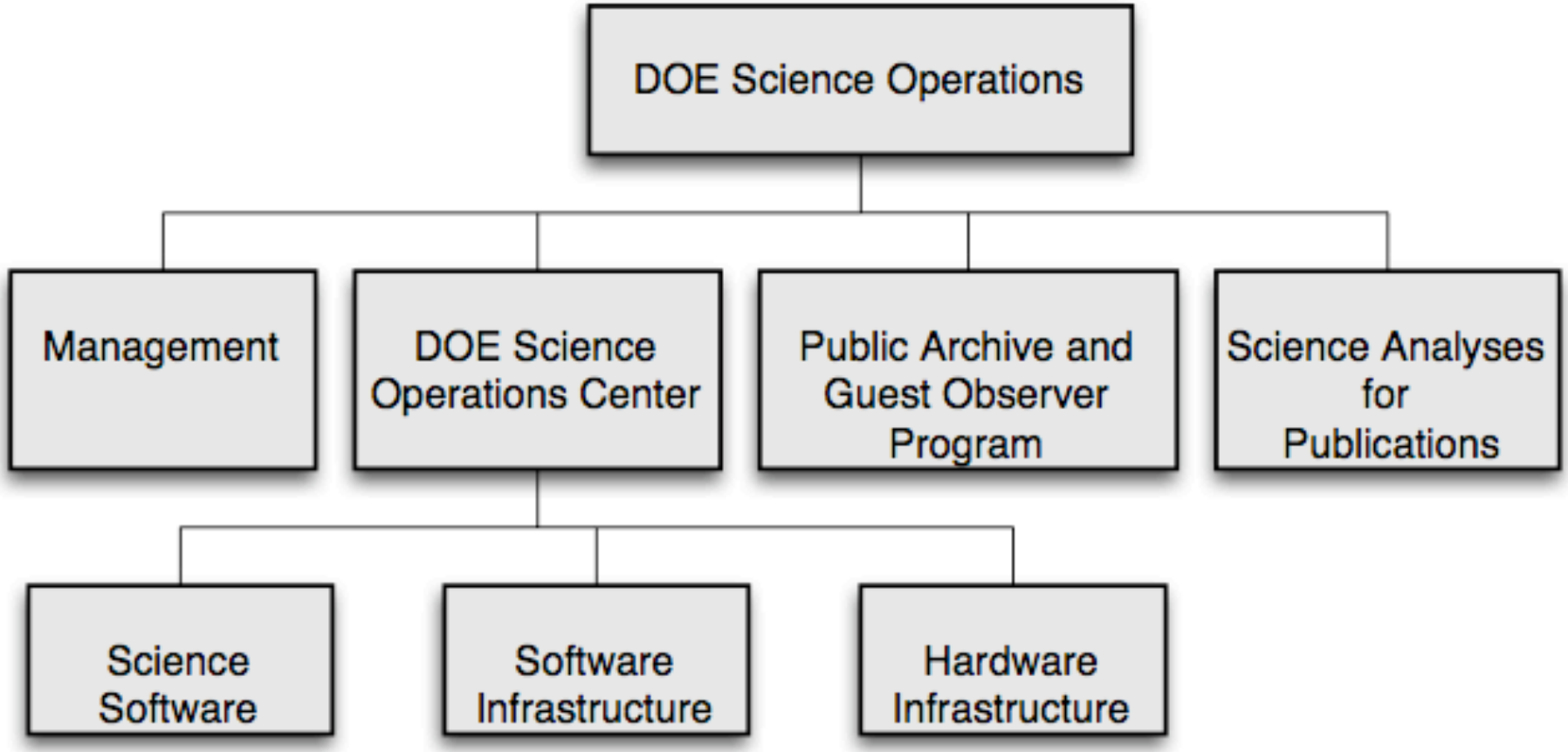


- Science algorithms
- Supernova trigger
- Scheduling algorithms

- Instrument QA
- Workflow system
- Data management
- Integration & testing
- DSN/MOC/SOC integration

- Computing
- Networking
- Mass storage
- Physical plant
- Communications

Notional JDEM DOE Science Operations WBS

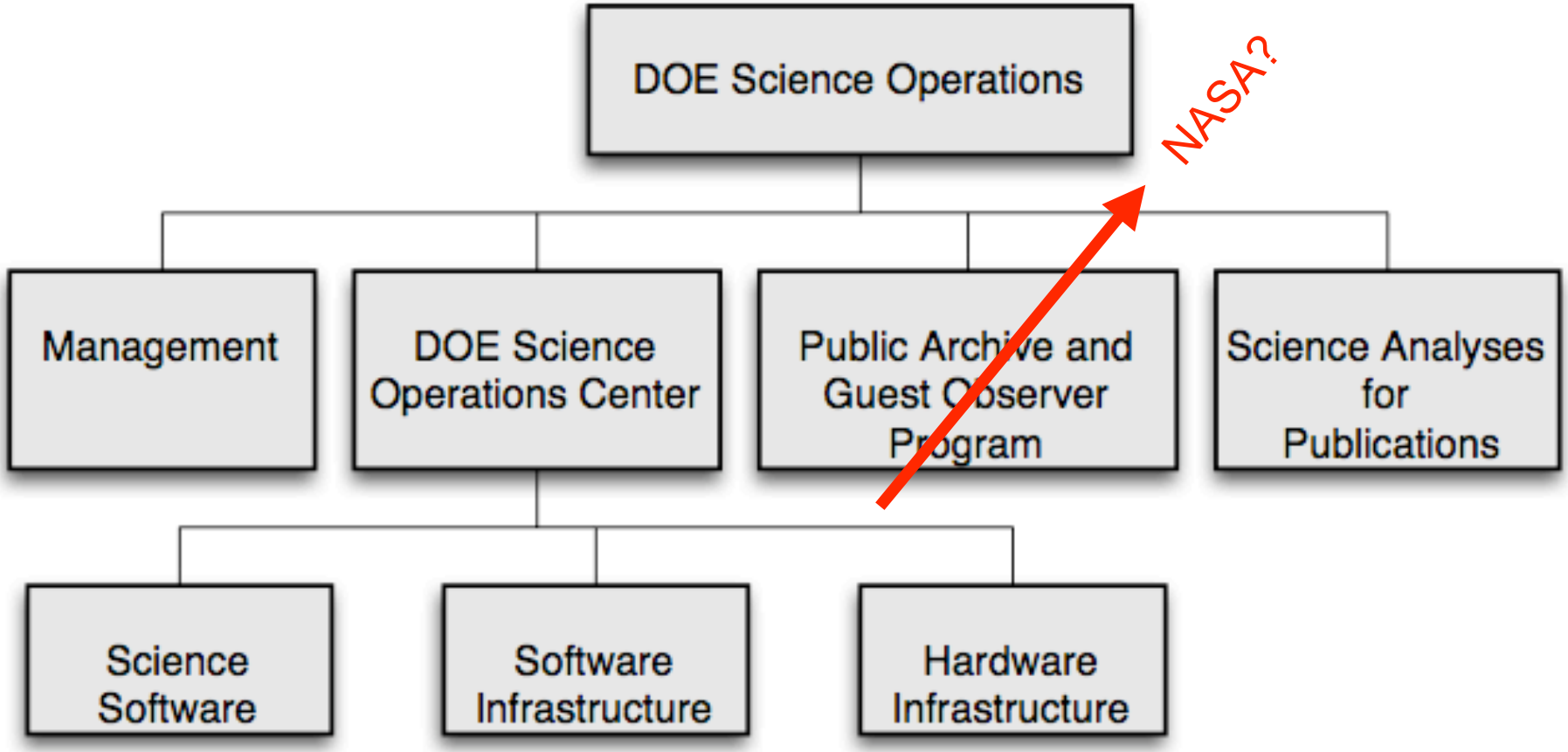


- Science algorithms
- Supernova trigger
- Scheduling algorithms

- Instrument QA
- Workflow system
- Data management
- Integration & testing
- DSN/MOC/SOC integration

- Computing
- Networking
- Mass storage
- Physical plant
- Communications

Notional JDEM DOE Science Operations WBS

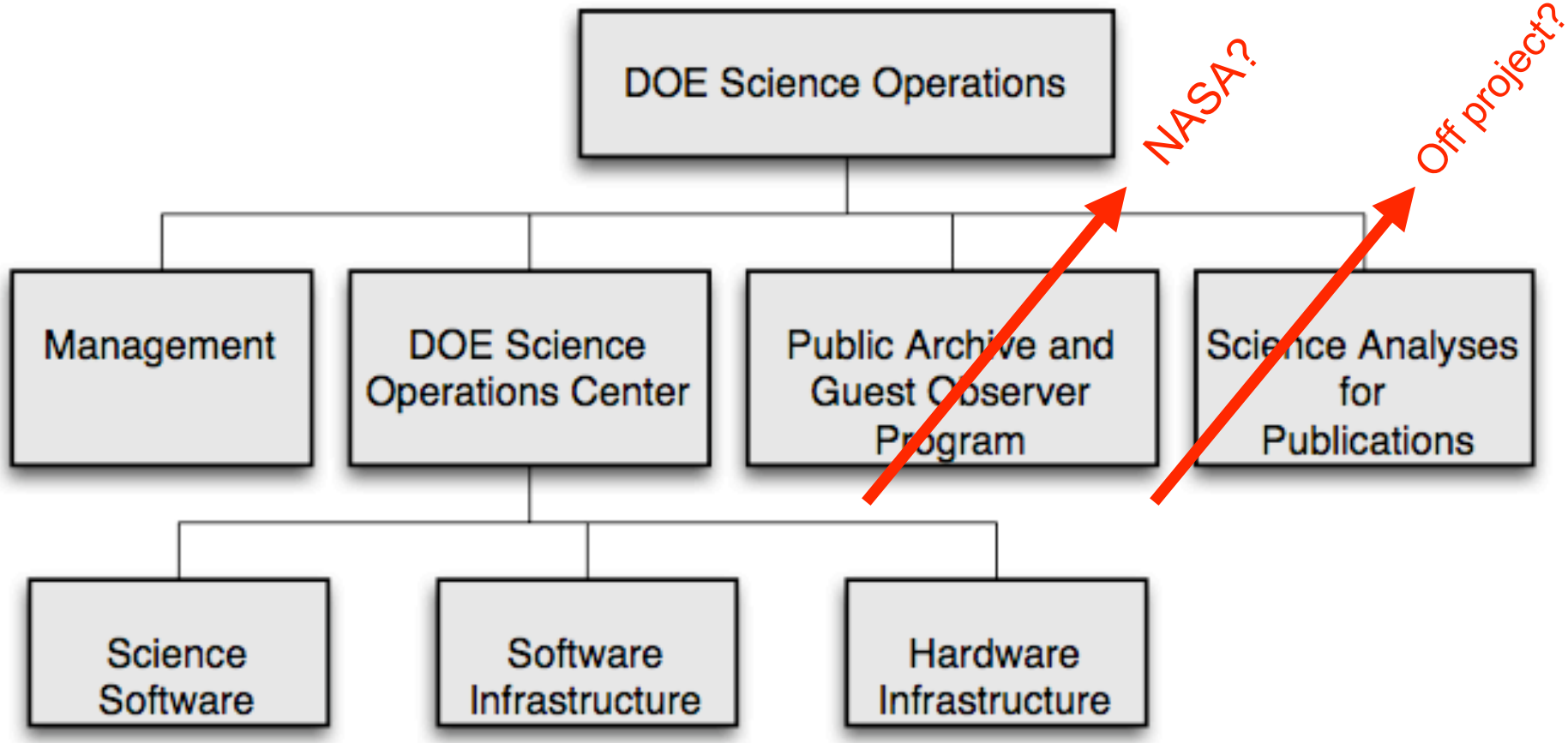


- Science algorithms
- Supernova trigger
- Scheduling algorithms

- Instrument QA
- Workflow system
- Data management
- Integration & testing
- DSN/MOC/SOC integration

- Computing
- Networking
- Mass storage
- Physical plant
- Communications

Notional JDEM DOE Science Operations WBS

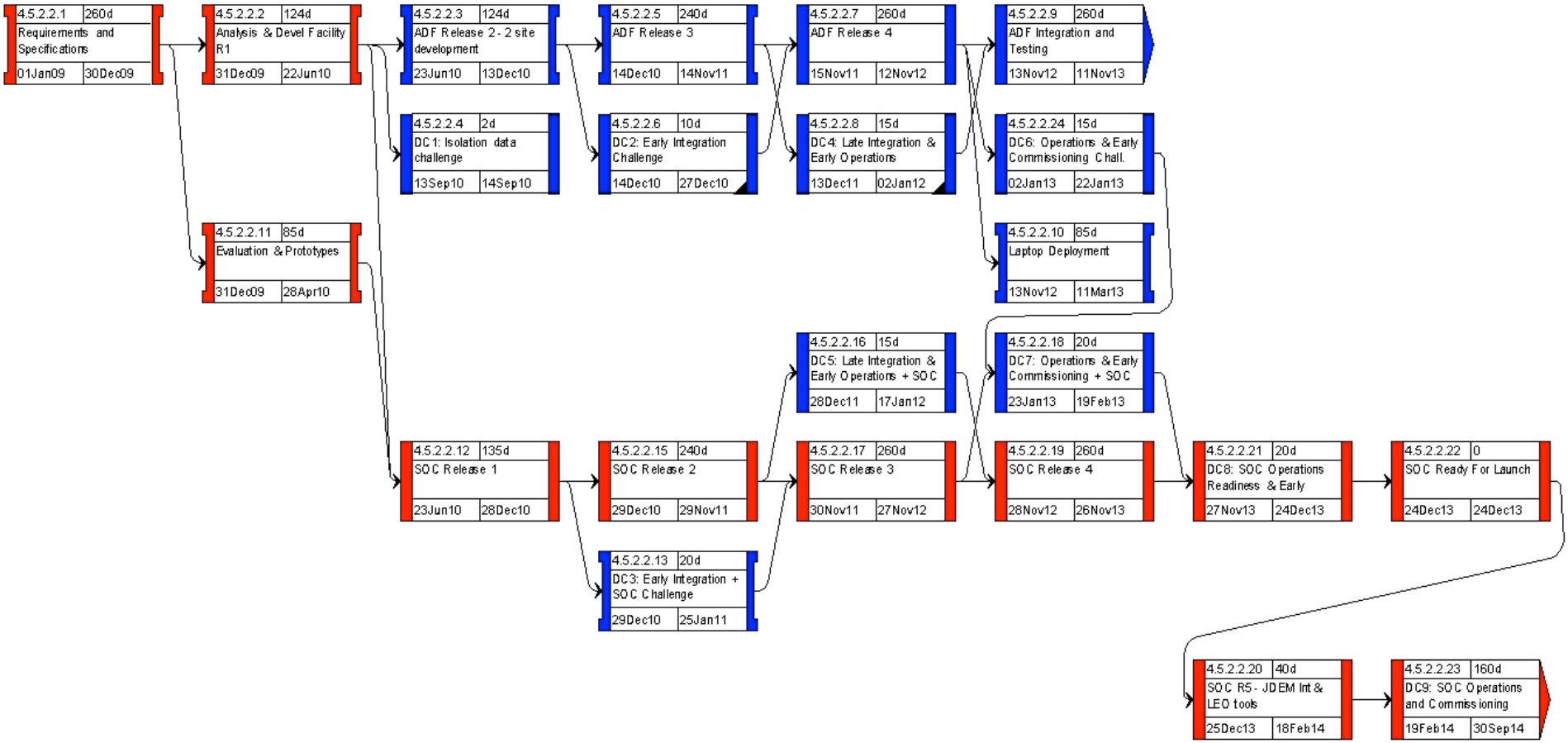


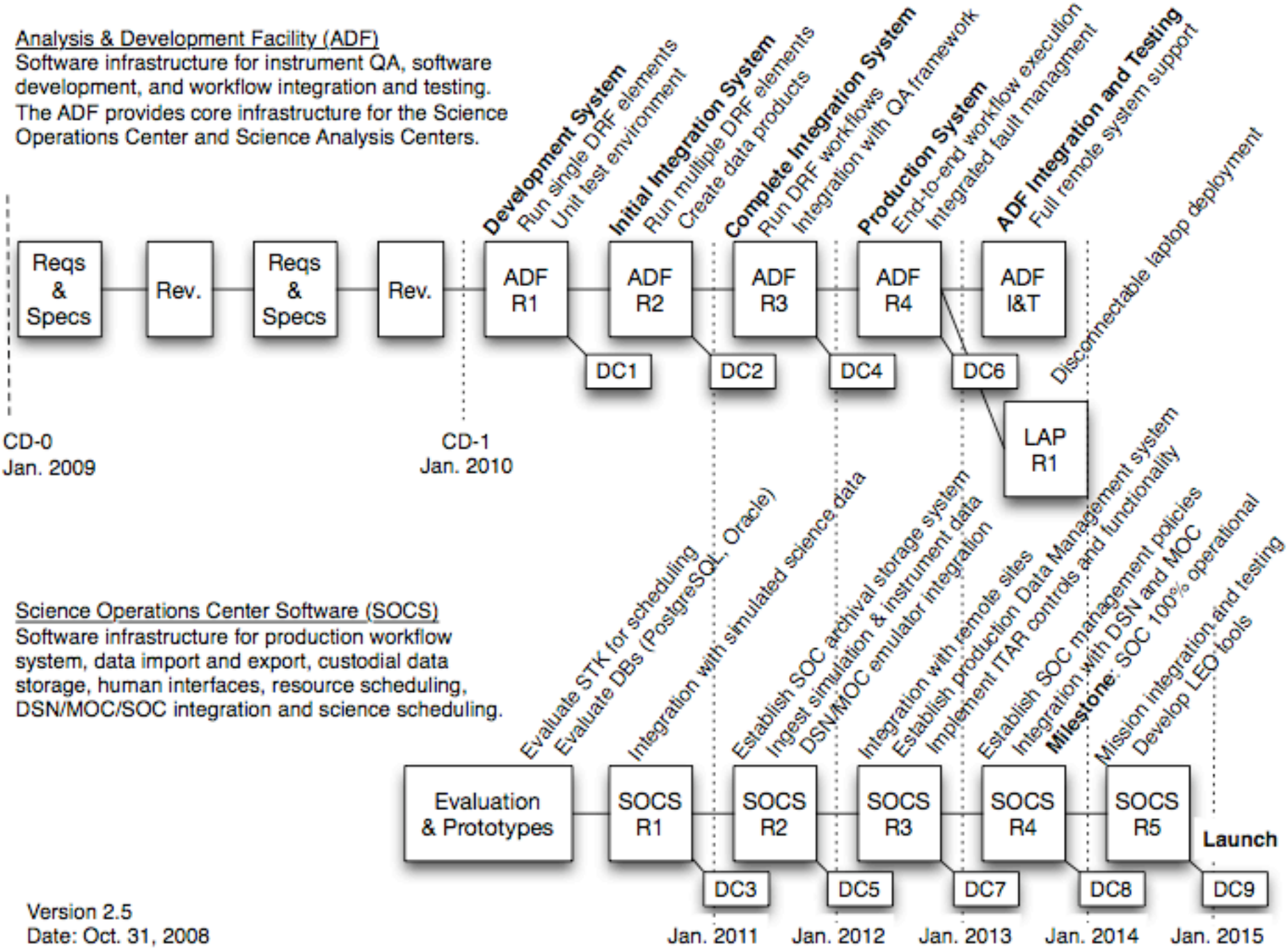
- Science algorithms
- Supernova trigger
- Scheduling algorithms

- Instrument QA
- Workflow system
- Data management
- Integration & testing
- DSN/MOC/SOC integration

- Computing
- Networking
- Mass storage
- Physical plant
- Communications

WBS Network View of Software Infrastructure

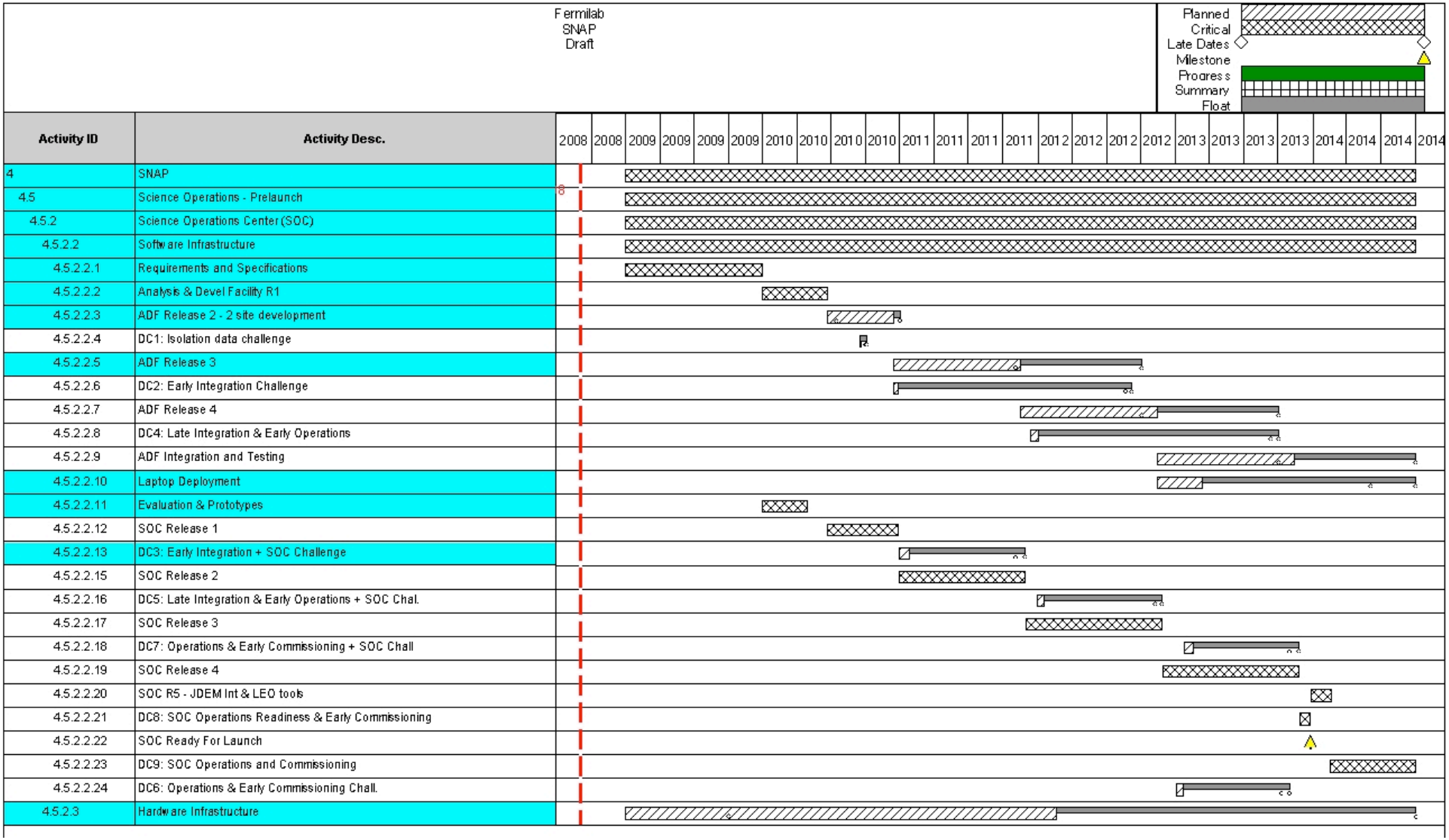



Analysis & Development Facility (ADF)
Software infrastructure for instrument QA, software development, and workflow integration and testing. The ADF provides core infrastructure for the Science Operations Center and Science Analysis Centers.
Development System
Run single DRF elements
Unit test environment
Initial Integration System
Run multiple DRF elements
Create data products
Complete Integration System
Run DRF workflows
Integration with QA framework
Production System
End-to-end workflow execution
Integrated fault managment
ADF Integration and Testing
Full remote system support
Disconnectable laptop deployment
Reqs & Specs
Rev.
Reqs & Specs
Rev.
ADF R1
ADF R2
ADF R3
ADF R4
ADF I&T
DC1
DC2
DC4
DC6
LAP R1
CD-0
Jan. 2009
CD-1
Jan. 2010
Science Operations Center Software (SOCS)
Software infrastructure for production workflow system, data import and export, custodial data storage, human interfaces, resource scheduling, DSN/MOC/SOC integration and science scheduling.
Evaluate STK for scheduling
Evaluate DBs (PostgreSQL, Oracle)
Integration with simulated science data
Establish SOC archival storage system
Ingest simulation & instrument data
DSN/MOC emulator integration
Integration with remote sites
Establish production Data Management system
Implement ITAR controls and functionality
Establish SOC management policies
Integration with DSN and MOC
Milestone: SOC 100% operational
Mission integration and testing
Develop LEO tools
Evaluation & Prototypes
SOCS R1
SOCS R2
SOCS R3
SOCS R4
SOCS R5
Launch
DC3
DC5
DC7
DC8
DC9
Jan. 2011
Jan. 2012
Jan. 2013
Jan. 2014
Jan. 2015
Version 2.5
Date: Oct. 31, 2008

Data Challenges

- DC1 - Unit Testing
- DC2 - Early Integration
- DC3 - Early Integration with SOC
- DC4 - Late Integration and Early Operations
- DC5 - Late Integration and Early Operations with SOC
- DC6 - Operations and Early Commissioning
  - Basic component testing, testing interconnections between systems, system load testing, DB load and scalability testing, network throughput, storage throughput, pipeline testing, provenance store testing, end-to-end testing, hardware and software monitor testing, simulated calibration, multiple workflow management, and fault injection testing.
- DC7 - Operations and Early Commissioning with SOC
- DC8 - SOC Operations Readiness and Early Commissioning
- DC9 - SOC Operations and Commissioning
  - Includes all of DC6, and…
  - DSN to SOC throughput testing, SOC to remote ADF testing, SN trigger testing, MOC integration testing, reprocessing, ITAR testing, ORL generation testing, commissioning studies, and operations center staffing.

Gantt Chart for Software Infrastructure



Conclusion

- We have developed a conceptual design for SNAP Science Operations that is generic enough to be applicable to JDEM.
- As planning for JDEM evolves we expect to be able to adapt our design to meet the requirements for a JDEM Science Operations Center.
- Our design includes three software deployments:

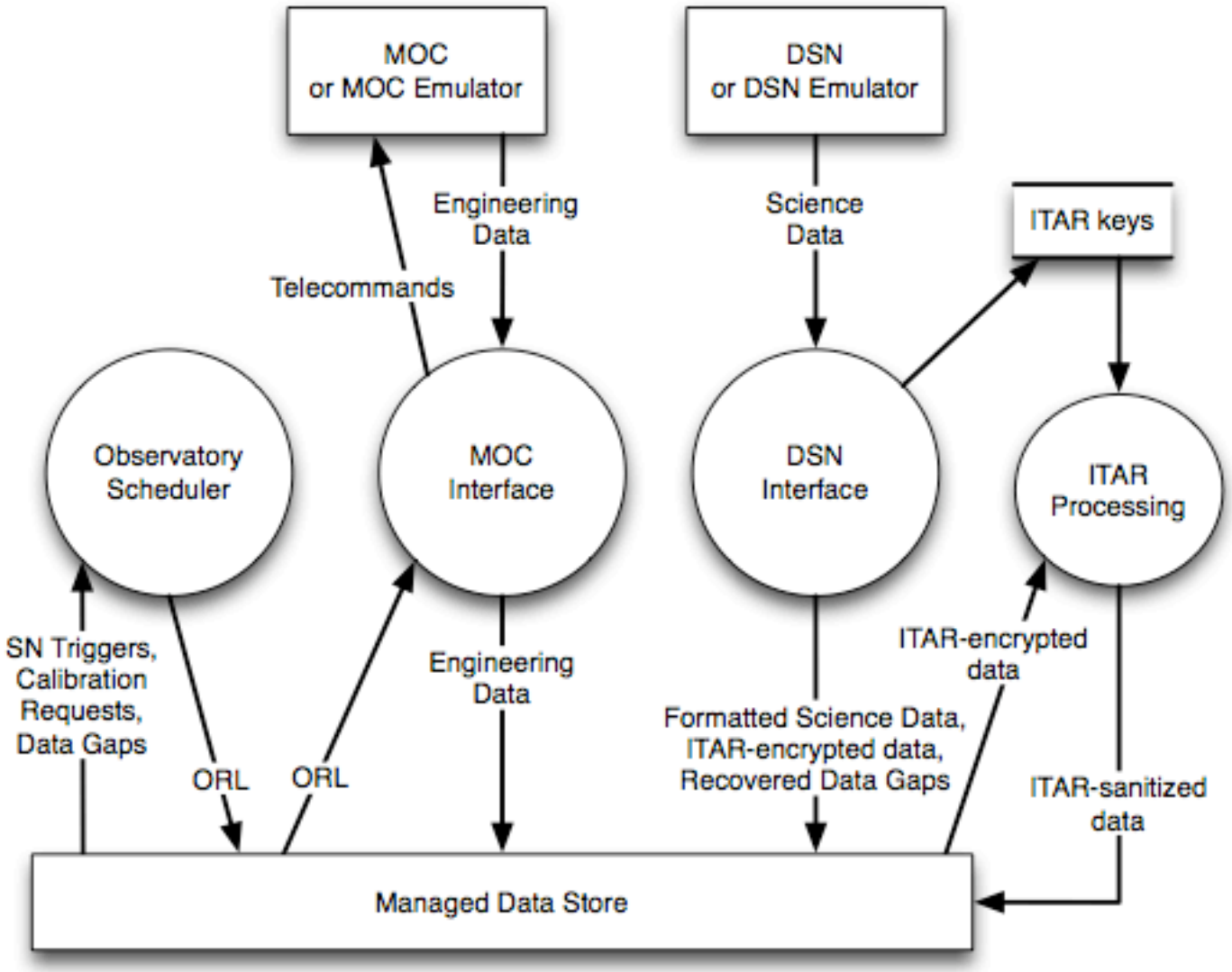
1. Analysis and Development Facility
   - Designed to support science software development
   - Provides support for instrument QA early in the schedule
   - Provides core infrastructure for the SOC and SACs
2. Science Operations Center Software
   - Production data processing pipelines
   - Integration with NASA's DSN and MOC
3. Laptop Deployment
   - Software development, instrument QA and science analysis

Additional Slides

Site Visits

- Gemini Project remote control room – Hilo, HI **(Sept. 20, 2005)**
- Hubble Space Telescope Operations Center at STScI – Baltimore, MD **(Oct. 25, 2005)**
- European Space Operations Centre (ESOC) – Darmstadt, Germany **(Dec. 7, 2005)**
- Fermi Instrument Science Operations Center (ISOC)– Menlo Park, CA **(Aug. 20, 2008)**
- Fermi Mission Operations Center (MOC) at GSFC – Greenbelt, MD **(Sept. 24, 2008)**
- Advanced Composition Explorer (ACE) MOC – Greenbelt, MD **(Sept. 26, 2008)**
- Rossi X-Ray Timing Explorer (RXTE) MOC – Greenbelt, MD **(Sept. 26, 2008)**
- Rossi X-Ray Timing Explorer Science Ops Facility – Greenbelt, MD **(Sept. 26, 2008)**
- Wilkinson Microwave Anisotropy Probe (WMAP) – Greenbelt, MD **(Sept. 26, 2008)**
- Earth Observing Mission 1 (EO-1) MOC – Greenbelt, MD **(Sept. 26, 2008)**
- Solar Dynamic Observer (SDO) MOC – Greenbelt, MD **(Sept. 26, 2008)**
- HST Servicing Mission 4 Alternate Ops Area (AOA) – Greenbelt, MD **(Sept. 26, 2008)**
- NASA Communication Area – Greenbelt, MD **(Sept. 26, 2008)**
- Jet Propulsion Laboratory (JPL) – Pasadena, CA **(Nov. 5, 2008)**
- Spitzer Science Center at IPAC – Pasadena, CA **(Nov. 7, 2008)**
- 2 Micron All Sky Survey (2MASS) at IPAC – Pasadena, CA **(Nov. 7, 2008)**

MOC and DSN Interfaces



Data Challenges 1 - 4

- DC1 - Unit Testing
  - Basic component testing (25%), testing interconnections between systems, system load testing (50%), DB load and scalability testing (50%), network throughput (25%), and storage throughput (25%).
- DC2 - Early Integration
  - Basic component testing (50%), testing interconnections between systems, system load testing (50%), DB load and scalability testing (100%), network throughput (50%), storage throughput (50%), pipeline testing (50%), and provenance store testing.
- DC3 - Early Integration with SOC
  - Basic component testing (50%), testing interconnections between systems, system load testing (50%), DB load and scalability testing (100%), network throughput (50%), storage throughput (50%), pipeline testing (50%), provenance store testing, and simulated science data (50%).
- DC4 - Late Integration and Early Operations
  - Basic component testing (75%), testing interconnections between systems, system load testing (75%), DB load and scalability testing (150%), network throughput (75%), storage throughput (75%), pipeline testing (75%), provenance store testing, initial end-to-end testing (50%), hardware and software monitoring testing, and simulated calibrations (25%).

Data Challenges 5 - 6

- DC5 - Late Integration and Early Operations with SOC
  - Basic component testing (75%), testing interconnections between systems, system load testing (75%), DB load and scalability testing (150%), network throughput (75%), storage throughput (75%), pipeline testing (75%), provenance store testing, initial end-to-end testing (50%), hardware and software monitoring testing, simulated calibrations (25%), DSN to SOC throughput testing, SOC to remote ADF testing, SN trigger testing (25%), and emulated MOC testing.
- DC6 - Operations and Early Commissioning
  - Basic component testing (100%), testing interconnections between systems, system load testing (100%), DB load and scalability testing (200%), network throughput (100%), storage throughput (100%), pipeline testing (100%), provenance store testing, end-to-end testing (75%), hardware and software monitor testing, simulated calibrations (50%), multiple workflow management, and fault injection testing.

Data Challenges 7 - 8

- DC7 - Operations and Early Commissioning with SOC
  - Basic component testing (100%), testing interconnections between systems, system load testing (100%), DB load and scalability testing (200%), network throughput (100%), storage throughput (100%), pipeline testing (100%), provenance store testing, end-to-end testing (75%), hardware and software monitor testing, simulated calibrations (50%), multiple workflow management, fault injection testing, DSN to SOC throughput testing, SOC to remote ADF testing, SN trigger testing (50%), emulated MOC testing, reprocessing (50%), ITAR testing, ORL generation testing, and operations center staffing.
- DC8 - SOC Operations Readiness and Early Commissioning
  - Basic component testing (100%), testing interconnections between systems, system load testing (100%), DB load and scalability testing (200%), network throughput (100%), storage throughput (100%), pipeline testing (100%), provenance store testing, end-to-end testing (100%), hardware and software monitor testing, simulated calibrations (100%), multiple workflow management, fault injection testing, DSN to SOC throughput testing, SOC to remote ADF testing, SN trigger testing (100%), emulated MOC testing, reprocessing (100%), ITAR testing, ORL generation testing, operations center staffing, and mock commissioning studies.

Data Challenge 9

- DC9 - SOC Operations and Commissioning
  - Basic component testing (100%), testing interconnections between systems, system load testing (100%), DB load and scalability testing (200%), network throughput (100%), storage throughput (100%), pipeline testing (100%), provenance store testing, end-to-end testing (100%), hardware and software monitor testing, simulated calibrations (100%), multiple workflow management, fault injection testing, DSN to SOC throughput testing, SOC to remote ADF testing, SN trigger testing (100%), MOC integration testing, reprocessing (100%), ITAR testing, ORL generation testing, operations center staffing, and commissioning studies.