HMI – AIA Joint Science Operations Center
"Peer" Overview, 17 March 2005

10 AM HEPL Conference Room, Stanford

Overview of JSOC Parts (Phil, 5 min.)

JSOC Operations, Part 1 (Jerry and LM team, 100 min.)

Lunch break, Continue at 1 PM

JSOC Operations, Part 2 (Jerry and LM team, 40 min.)

SU Development Plan (Phil, 10 min)

Data Capture System (Jim, 20 min.)

JSOC Pipeline and HMI Science Analysis System Infrastructure (90 min.)

AIA Science Analysis System Infrastructure (Neal, John) (30 min)

HMI – AIA Joint Science Operations Center
"Peer" Overview, 17 March 2005

Overview of JSOC

Philip Scherrer

pscherrer@solar.stanford.edu

650-723-1504

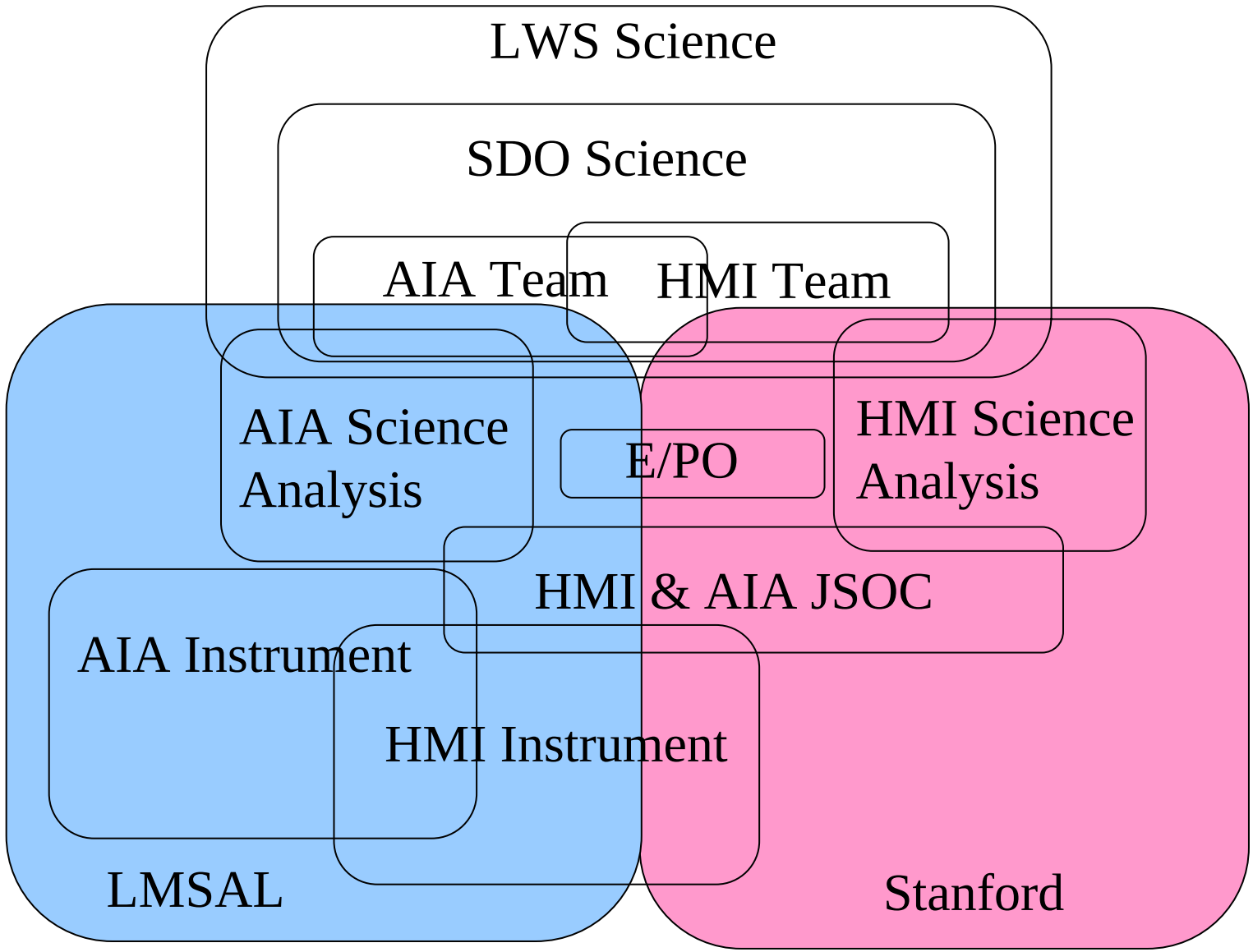
Scope of JSOC, **NOT** science analysis, etc.
Parts of JSOC and roles, SU & LMSAL
- Operations
- Data Processing

Heritage
Scope of this review.

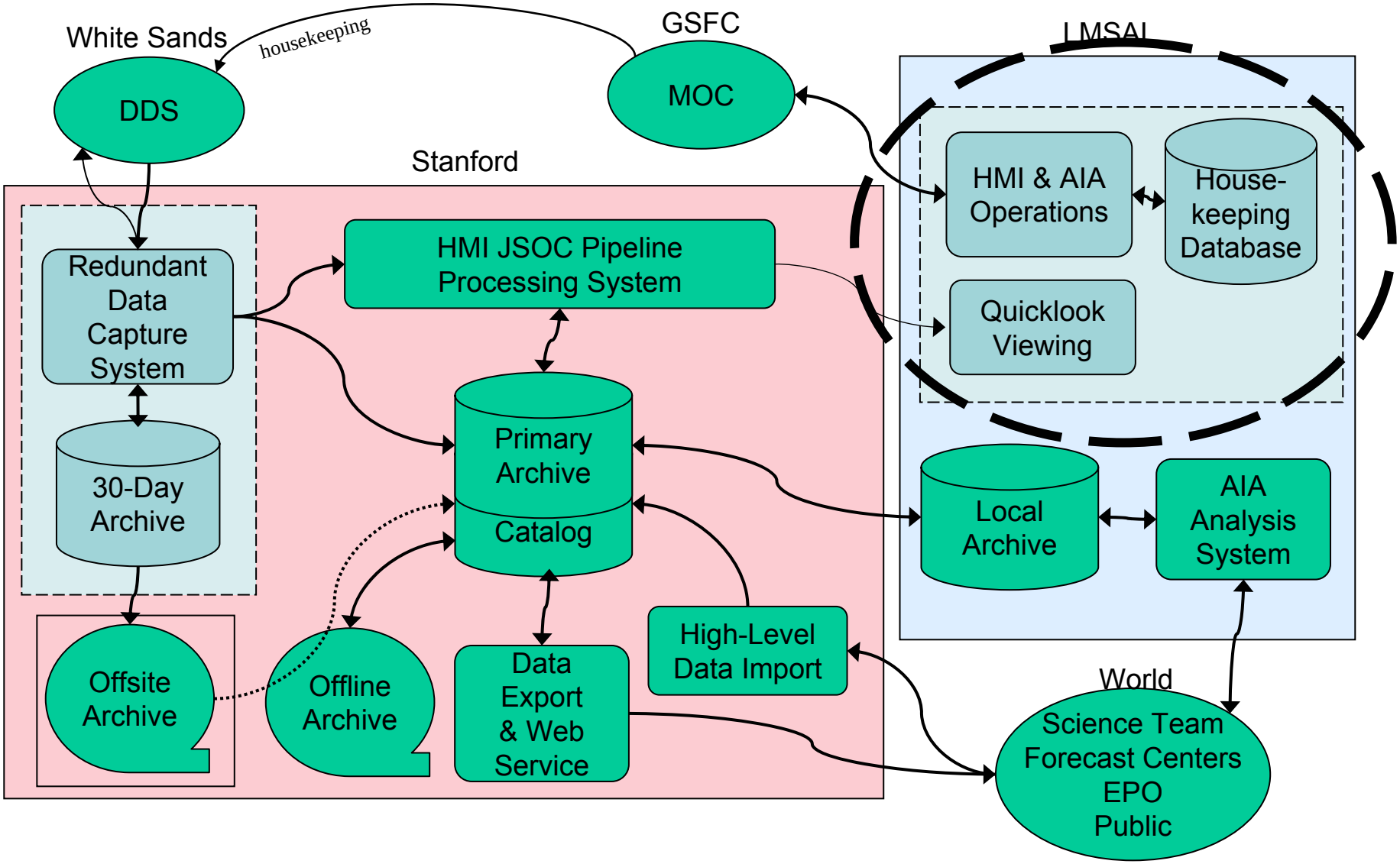
JSOC SDP Scope

- **The HMI/AIA Joint SOC consists of two parts:**
  - Science Data Processing – at Stanford and LMSAL
  - Science Instrument Operations – at LMSAL
- **JSOC SDP includes:**
  - HMI and AIA Telemetry Data capture (from DDS) and archive
  - HMI and AIA Level-0 processing and archive
  - HMI processing through to level-2 with archiving of end products
  - AIA processing through level-1a with online archive at Stanford
  - AIA level-2 processing at LMSAL
  - Data export of the above and other HMI and AIA products as needed
- **JSOC SDP does not include tasks such as:**
  - Science analysis beyond level-2 products
  - HMI and AIA EPO
  - HMI & AIA Co-I science support

HMI & AIA Institutional Roles



HMI & AIA JSOC Architecture



JERRY

HMI & AIA JSOC Operations
Health Monitoring and Control

J. Drake, LMSAL

R. Chevalier, LMSAL

R. Bush, Stanford University

J. Lemen, LMSAL

JSOC Peer Review on 17 March 2005

HMI/AIA Operations Agenda (1)

- **Requirements Overview** — **J. Drake**
- **Changes From Previous Reviews** — **J. Drake**
- **System Architecture** — **R. Chevalier**
  - Hardware
  - Network Configuration
  - Software: LMSAL EGSE
    - Automatic Notification System
- **Methodology** — **J. Drake**
  - Configuration Management and Control
  - Development & Test Plans and Schedule
    - End-to-end testing
  - Documentation
  - Sustaining/maintenance plans
  - Security: Physical and IT
- **Operations Teams** — **J. Drake**
  - Personnel: Team structure, responsibilities, training (5 min)

HMI/AIA Operations Agenda (2)

- **MOC Interface** — **J. Drake**
  - Loads
  - Coordinated activities
    - GT & ISS Calibration (HMI)
    - Roll Calibration (HMI & AIA)
    - Flat Field Calibration (HMI & AIA)
  - Utilities
  - Orbit timeline
- **Operations for HMI** — **R. Chevalier**
  - Early mission
  - Routine
  - Periodic, including instrument calibrations
  - Anomalous conditions
- **Operations for AIA** — **J. Lemen**
  - Early mission
  - Routine
  - Periodic, including instrument calibrations
  - Anomalous conditions

HMI/AIA JSOC Requirements (1 of 2)

- **Monitor health and safety of instrument on orbit**
- **Control instrument on-orbit**
- **Source of detailed requirements: 464-GS-ICD-0001, MOC-SOC ICD**
- **High level summary:**
  - Socket connection from SOC to MOC
    - SOC is client
  - Three ports used
    - Commands
    - Real-time telemetry
    - Recorded telemetry (from Solid State Recorder)
  - Communications protocol in Sect. 3.1.2
  - Formats contained in Sect. 4 as follows:
    - 4.1.2 Communication Protocol Messages
    - 4.2 Commanding Data Specification
    - 4.3 Housekeeping Telemetry Data Specification

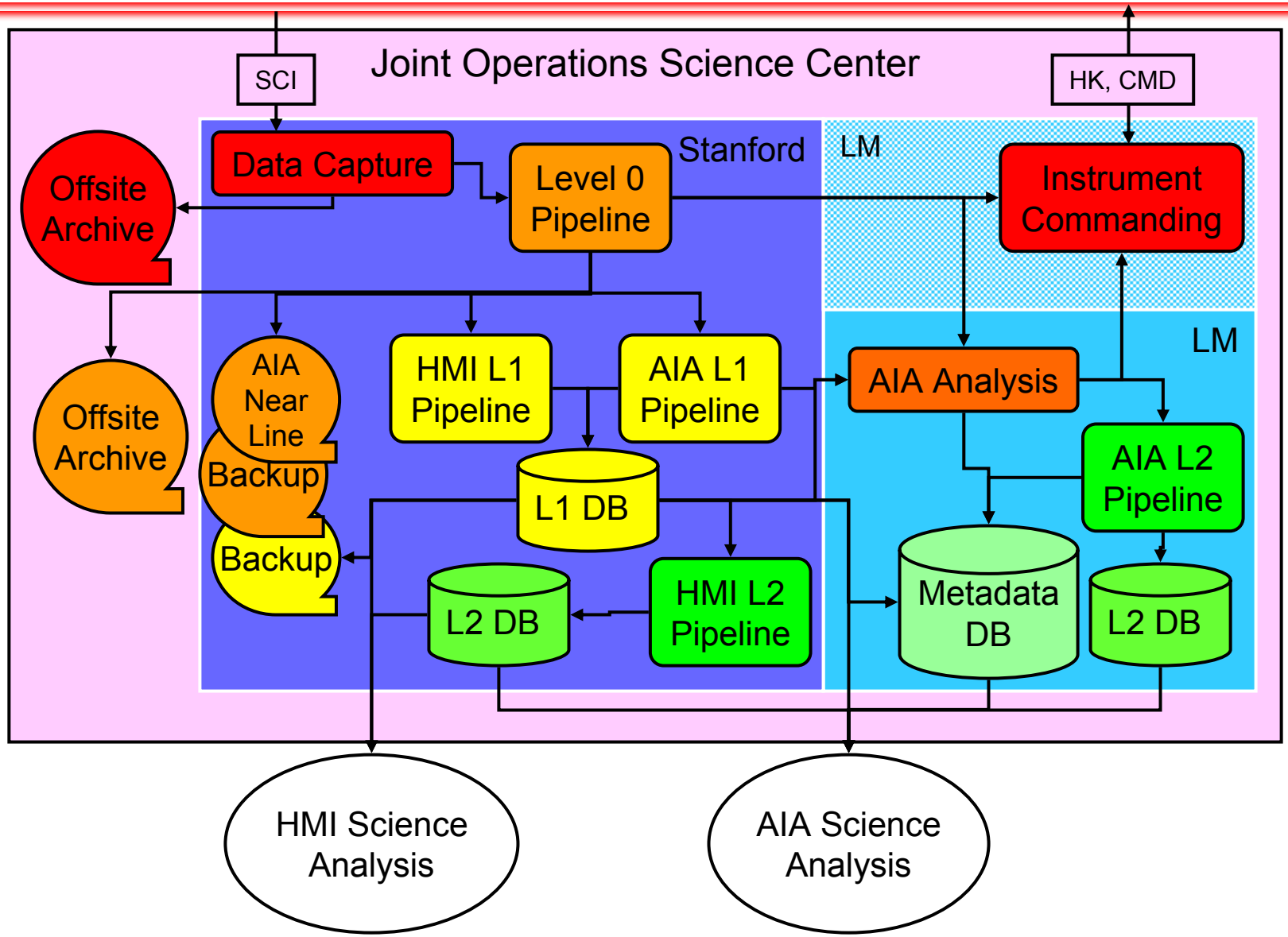
HMI/AIA JSOC Requirements (2 of 2)

- **Additional MOC-SOC requirements sources:**
  - 464-HMI-ICD-0002, Spacecraft to HMI Interface Control Document
  - 464-AIA-ICD-0011, Spacecraft to AIA Interface Control Document
  - 464-SYS-REQ-0004, Mission Requirements Document
  - 464-GS-REQ-0005, Detailed Mission Requirements (DMR) for SDO Mission
  - NPR 2810, NASA Security Procedures and Guidelines
  - 464-GS-PLAN-0041, SDO Flight Operations Plan (FOP)
  - 464-GS-PLAN-0042, SDO Database Format Control Document
  - 464-GS-LEGL-0040, Operations Agreement (OA) between the SDO MOC and the HMI SOC
  - 464-GS-LEGL-0041, Operations Agreement (OA) between the SDO MOC and the AIA SOC
  - 464-GS-PLAN-0010, Operations Concept Document

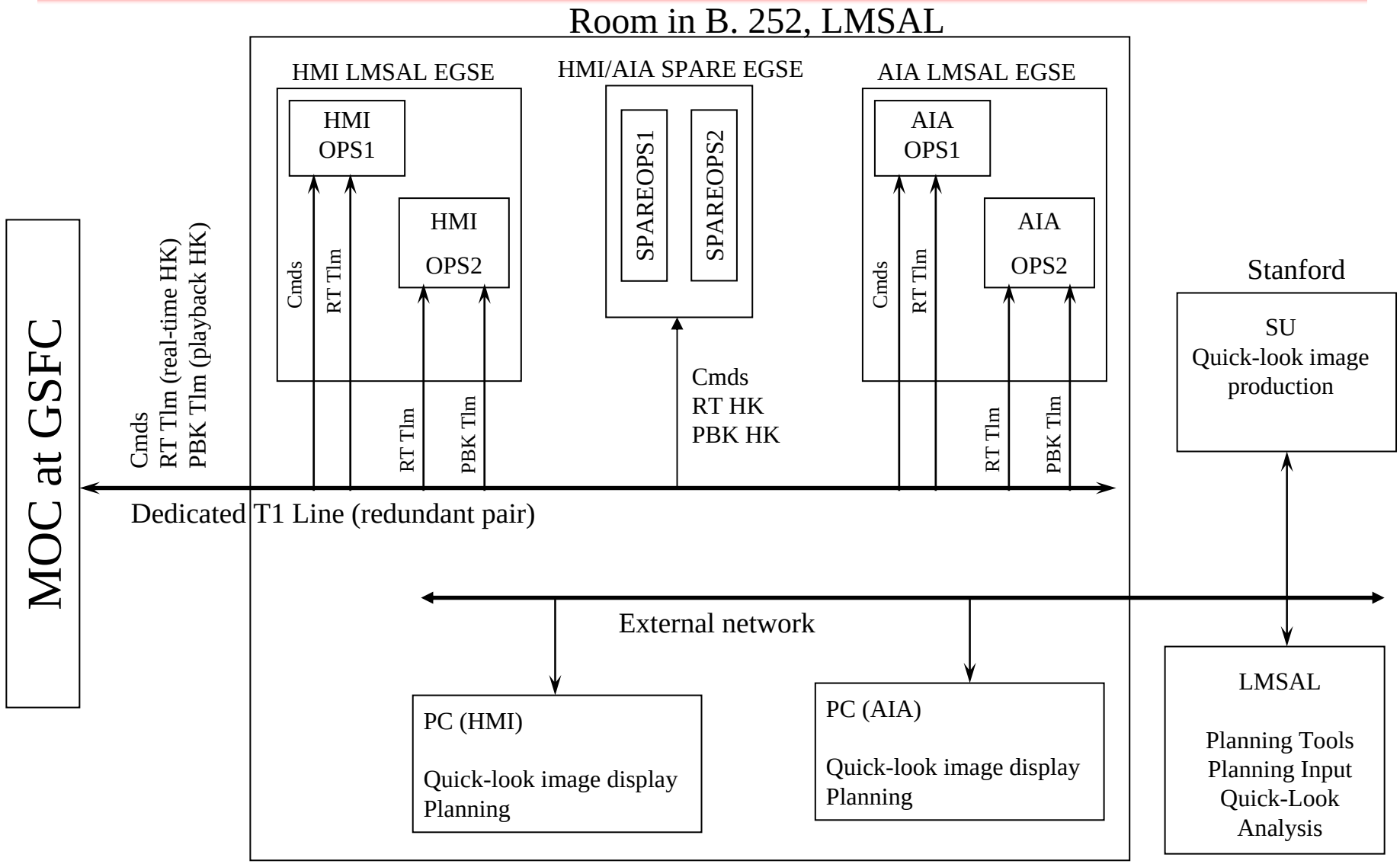
Changes From Previous Reviews

- **Previous presentations (reviews)**
  - Mission Operations Peer Review 2004-02-05 HMI00560
  - SDO Ground Systems PDR
    - Instrument Operations Concept 2004-04-21 HMI00643
    - Telemetry & Control Design 2004-04-22 HMI00644
  - HMI/AIA SOC Design Walkthrough 2004-09-09
    - EGSE Limit Checking
    - Automated Notification System
  - HMI CDR 2004-11-15 AIA01037
  - AIA CDR 2005-02-16, 17 HMI00928
- **No changes to report (other than continued lower-level detailed development)**

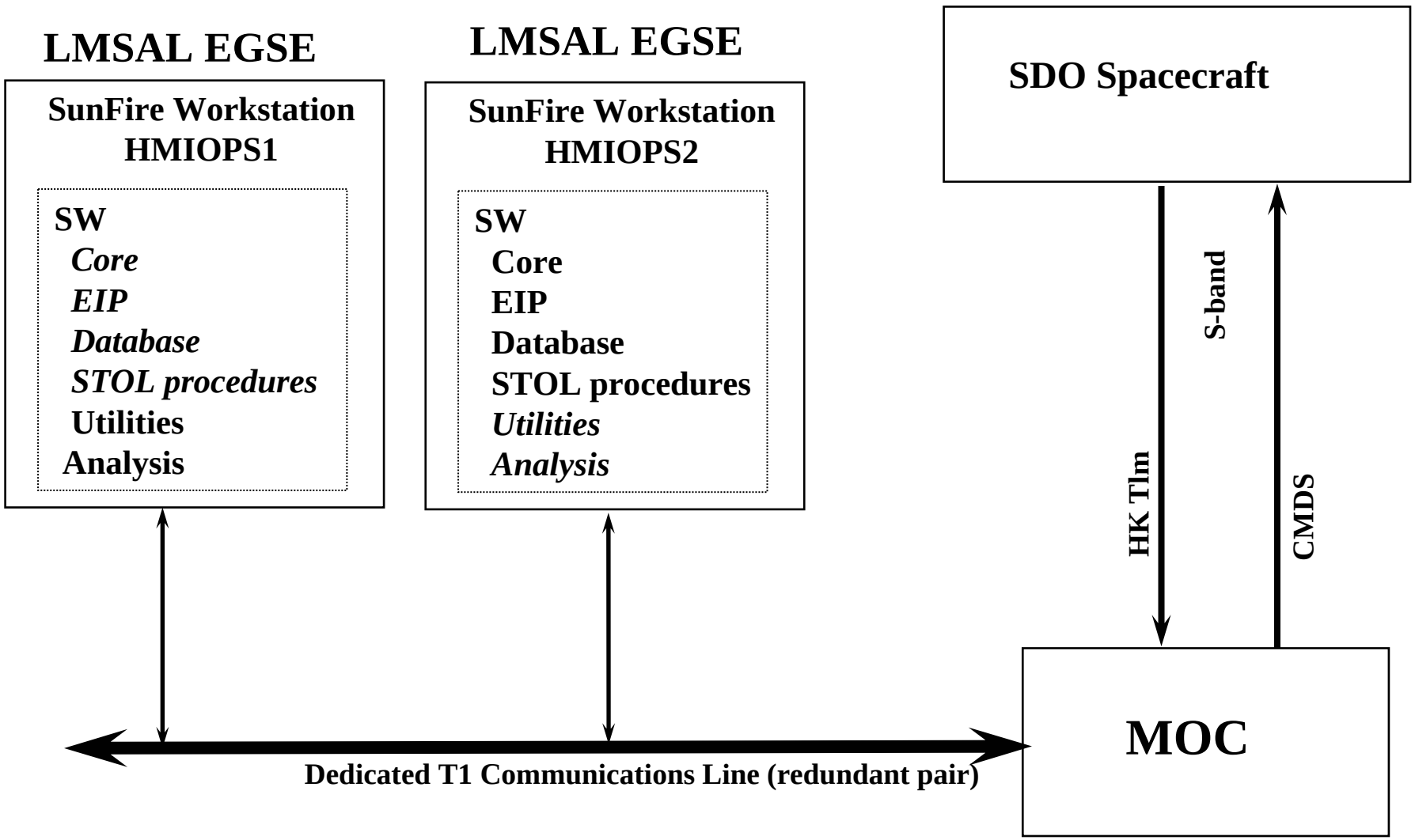
HMI/AIA JSOC Architecture



HMI/AIA Operations HW Architecture



HMI/AIA LMSAL EGSE Configuration



HMI/AIA JSOC Hardware Configuration Items

- **Two Sun workstations running Solaris for HMI and two for AIA**
- **Both connect through sockets to the MOC (or a Spacecraft Simulator or Real-Time Node)**
  - Socket interface implemented
    - LMSAL EGSE
    - Spacecraft Simulator (SSIM) used for instrument development
    - Real-Time Node (1553 interface to instrument used at LMSAL as surrogate for SSIM)
  - One Sun provides real-time instrument command and telemetry functionality
    - Command socket to MOC
    - Real-time telemetry socket from MOC
  - The other Sun workstation is for
    - Quick-look analysis of housekeeping data
    - Backup for the primary MOC connection
    - Real-time telemetry socket from MOC
    - Playback telemetry socket from MOC
    - Level-0 24 hour HK telemetry
  - Both Suns configured identically (as much as possible)

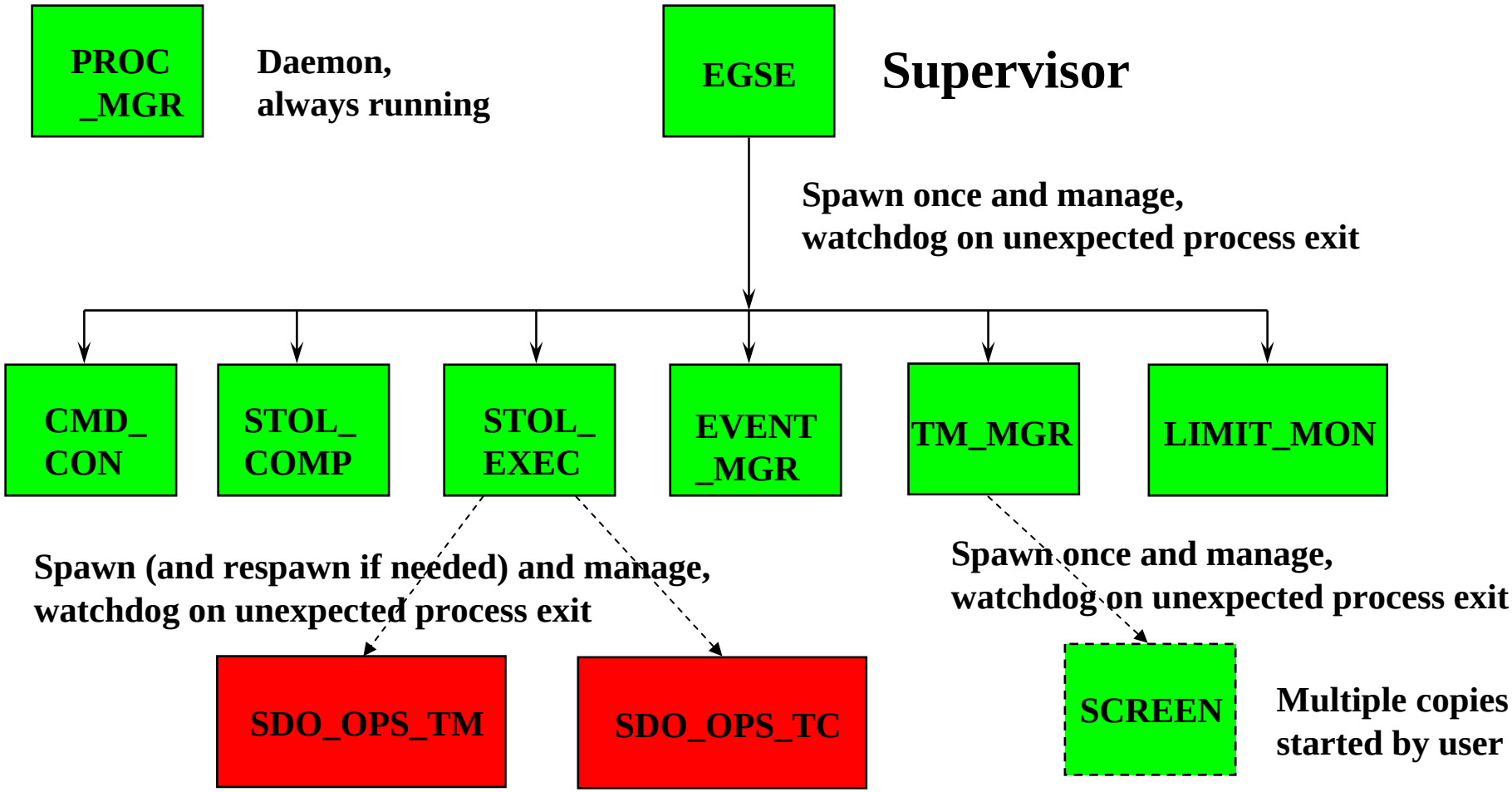
MOC-SOC Socket Connections

- **HK Telemetry sockets (3 per instrument)**
  - HMI
    - LMSAL EGSE 1 (hmiops1)
    - LMSAL EGSE 2 (hmiops2)
    - Stanford
  - AIA
    - LMSAL EGSE 1 (aiaops1)
    - LMSAL EGSE 2 (aiaops2)
    - Stanford
- **Command socket (1 per instrument)**
  - HMI LMSAL EGSE
  - AIA LMSAL EGSE

HMI/AIA JSOC LMSAL EGSE Software

- **Core code**
  - Command processor
  - Telemetry processor
    - Screen displays
  - Event handling
    - Logging
    - Screen displays
  - Limit checking
  - STOL processor
    - STOL (Special Test and Operations Language)
- **Experiment Interface Program (EIP)**
  - Unique to each program at LMSAL
  - Contains socket communications protocol
  - Instrument-specific command information from database used here
  - Will add functionality to contact (by page or phone) personnel in case of a limit exceedance (from the Limit Check module) or certain events as identifed by the Event module
    - Tiered calling protocol
    - Everyone on list called soon (within 30 minutes) if no response to pages or phone call drags out

Process Management



Run-time Database Creation

ASCII Database File

EGSE parameters,

Telemetry Decomutation Table,

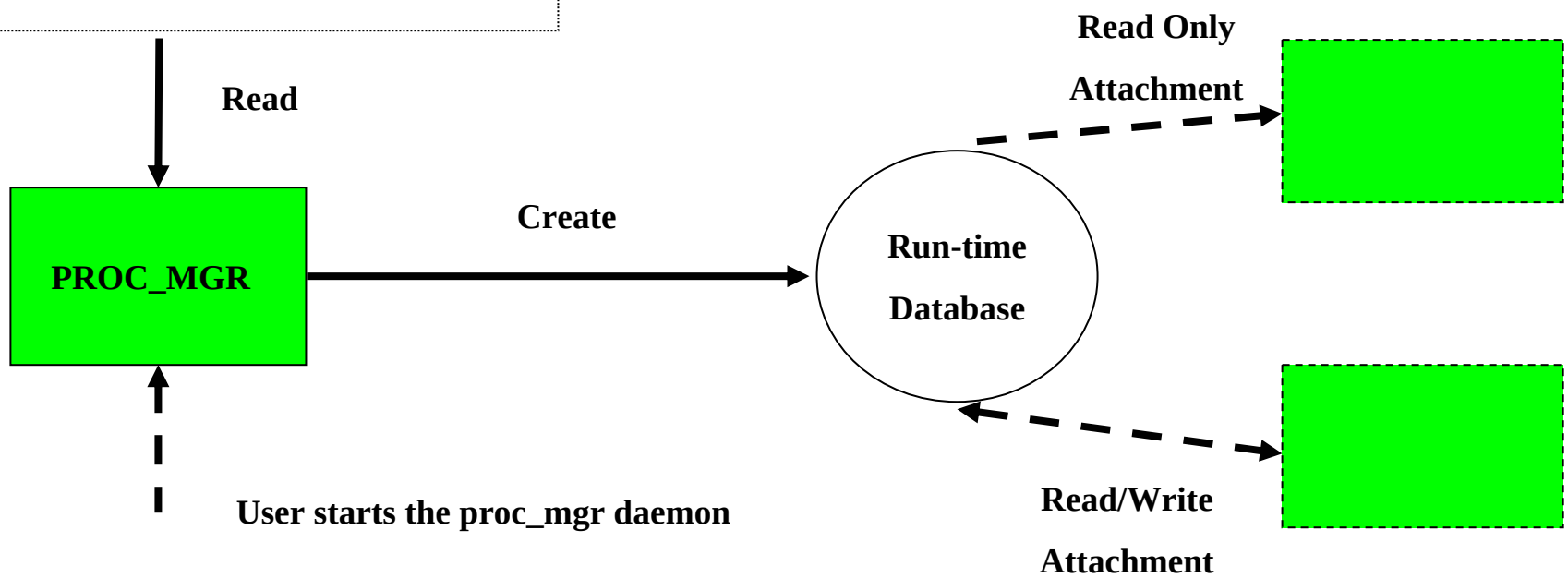
Analog Polynomial Conversion Table

Digital to String Conversion Table

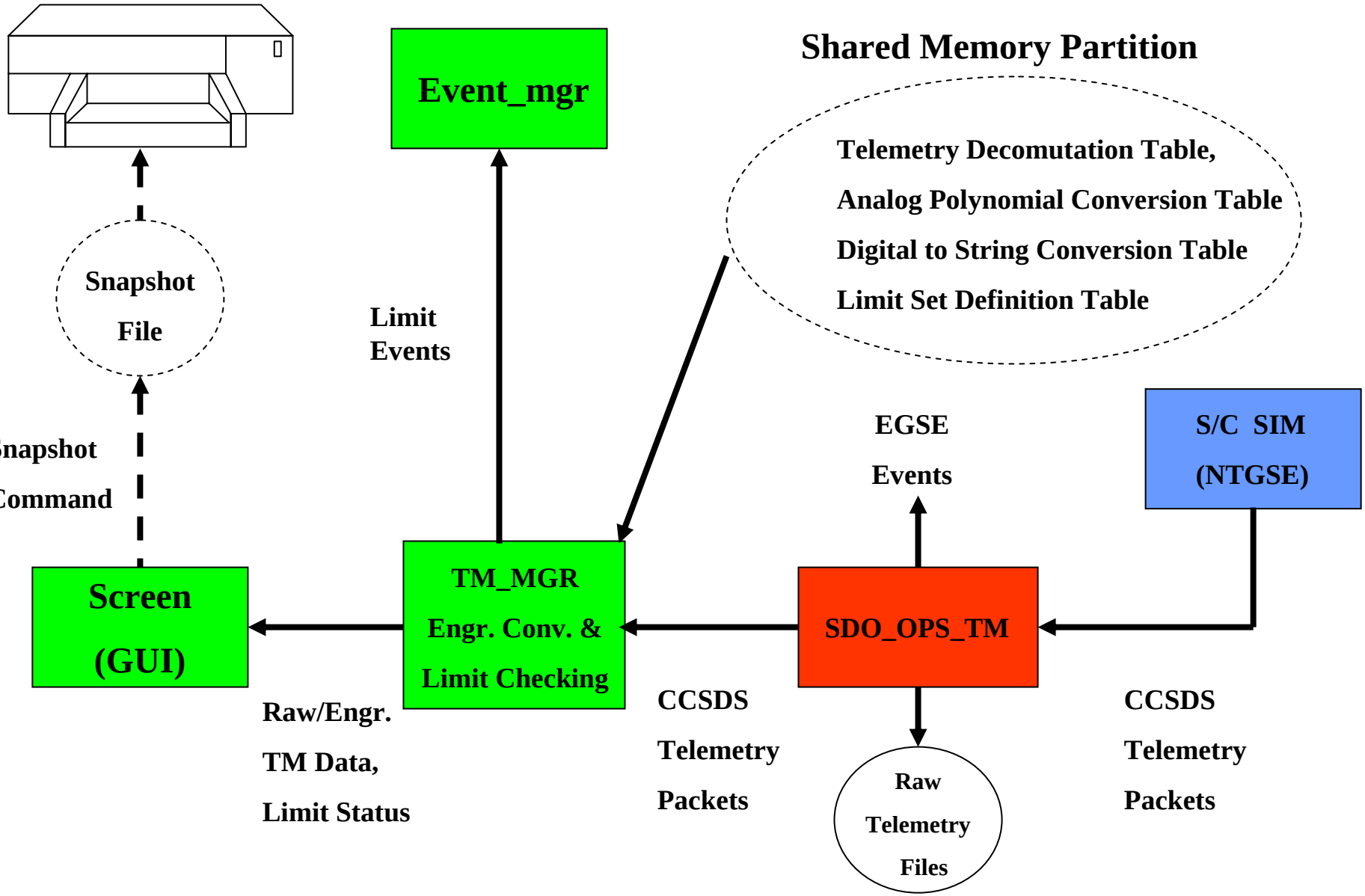
Limit Set Definition Table

Telecommand Definition Table

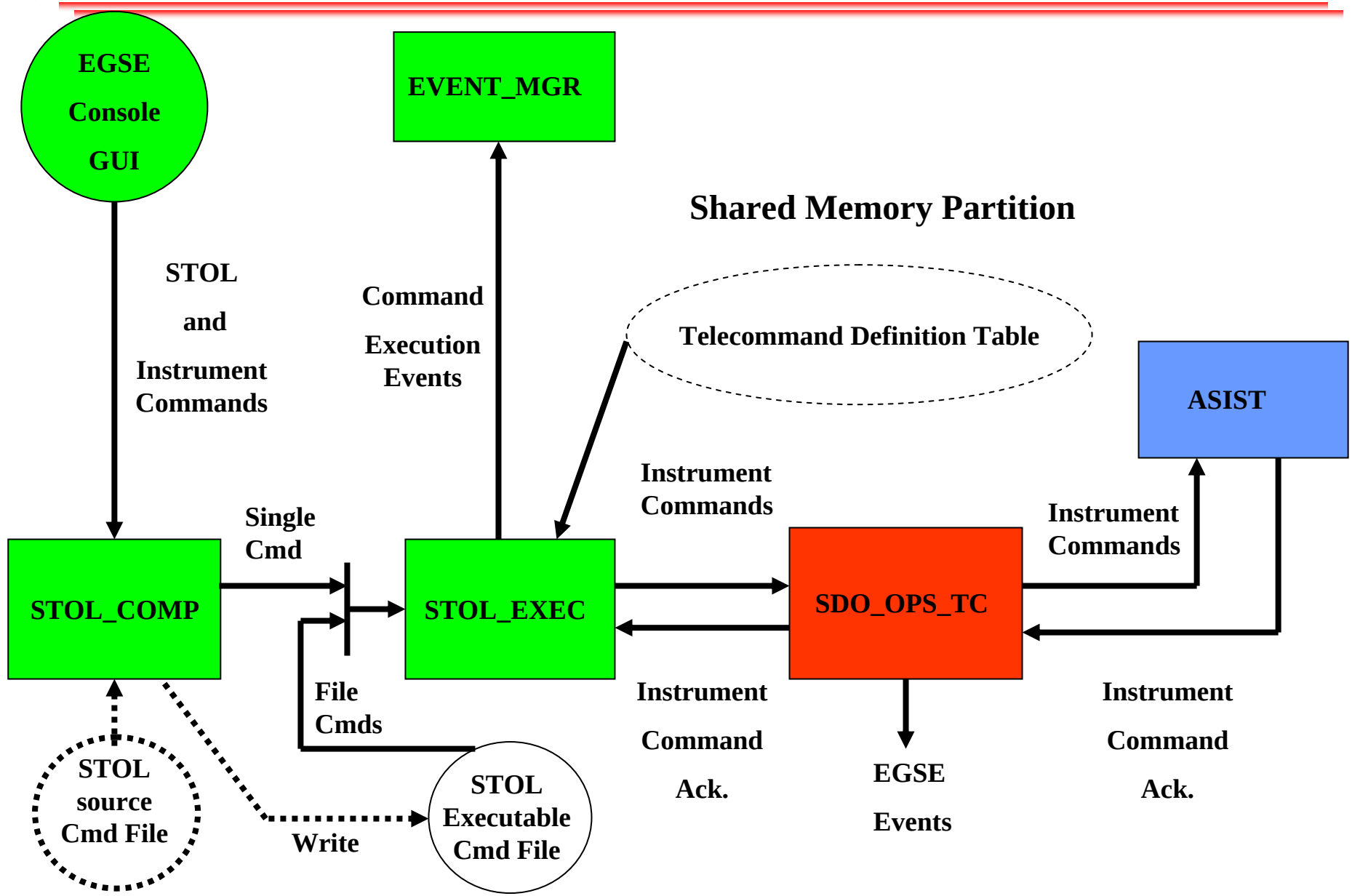
Each process shall be attached with either read-only or read/write access as appropriate for the process



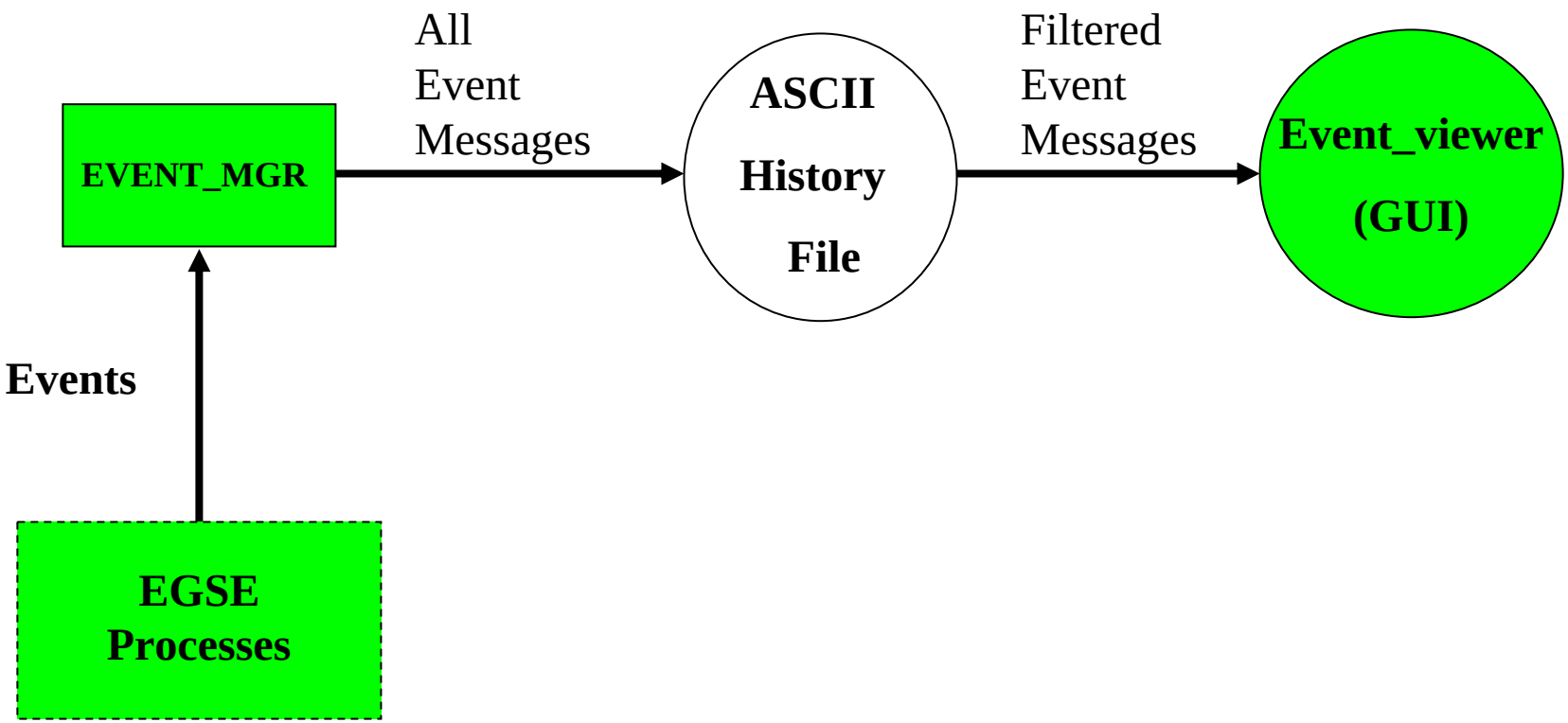
Telemetry Subsystem Data Flow



Telecommand Subsystem Data Flow



Event Handling



EGSE Event Types

- DB_REL_VER - Release Version of Run-time database in use
- ERROR - Error messages from EGSE processes and EIPs
- WARNING - Warning messages from EGSE processes and EIPs
- INFO - Informational messages from EGSE processes and EIPs
- APP_REG - Startup notification for an EGSE application (screen)
- APP_EXIT - Exit notification for an EGSE application (screen)
- CMD_ECHO - Echo of a STOL or Instrument command
- CMD_EXEC - Execution notification for a STOL or Instrument command
- APP_EVENT - Informational message from an EGSE application (screen)
- CMD_PERF - Notification of the start of execution of a STOL procedure
- CMD_TCM - Execution message for a binary instrument command from an EIP
- CMD_TCB - Execution details for a binary instrument command from an EIP
- CMD_EIP - Echo of a command sent to an EIP
- LIM_TRIP - Notification of an out of limit or back within limit condition
- PROCESS_REG - Version of an EGSE process or EIP reported during process startup

LMSAL EGSE Telemetry Limit System Paging

- Each HMI and AIA telemetry mnemonic can be limit monitored
- Possible limit system states (per mnemonic) are:
  - **alarm high (same as) red high**
  - **report_high yellow high**
  - **normal**
  - **report_low yellow low**
  - **alarm_low red low**
- The limit state triggers when a database specified number of consecutive packets exceeding the limit are received
- Design details to be completed:
  - Which mnemonics are monitored
  - What limits are used for each mnemonic
  - Are messages specific to the mnemonic/limit or general?
  - How does the pagee acknowledge receipt of notification from the LMSAL EGSE?

Limit Alarm Notification and LMSAL Pager System

- Limit Alarm Notification
  - **List based automated notification using the LMSAL pager system**
  - **Person at the top of the list is paged first**
  - **FOT at the MOC will be notified that an alarm was tripped and who was paged**
  - **HMI/AIA person notified acknowledges receipt of the message within 10 minutes (settable) else the top two people on the list are notified**
  - **If no response, then either the top three on the list are notified or the entire list is notified**
- LMSAL Pager System
  - **Lockheed Martin will provide text capable pagers leased from Metrocall**
  - **Sending of text message will be automated in the LMSAL EGSE**
  - **Receipt of acknowledgment from person paged will be automated**
  - **Email message sent to <10 digit pager #>@page.metrocall.com**
- Web-accessible Status Page
  - **Health page for everyone to be aware that something has happened**

HMI/AIA JSOC Operations Software Configuration Items (1 of 3)

- **LMSAL EGSE**
  - Core code
  - EIP (Experiment Interface Process)
- **Flight Software**
  - SUROM
  - KERNEL (OS plus basic cmd & tlm architecture)
  - HMI FSW
  - AIA FSW
- **Ground Tools**
  - Binary load generation tools convert object modules or tables into binary upload format
    - Kernel loads into SUROM
    - Object modules (*.o) load into Kernel
    - Scripts (*.scr) load into FSW
    - Tables (*.tbl) load into FSW
  - Database tools control command and telemetry database (see next slide)
- **Software Simulator**
  - Needed to check out observing sequences before use on-orbit

HMI/AIA JSOC Operations Software Configuration Items (2 of 3)

- **Command & Telemetry Database**
  - Database Tools (programs)
    - CmdList
    - TlmList
    - RetList
      - Error return codes
    - ADList
      - Table for analog data acquisition control
  - Database Files
    - MASTER Master database file from which all others are generated
    - SUROM Start-Up ROM (SUROM) header files
    - Kernel Kernel header files
    - HMI HMI FSW header files
    - AIA AIA FSW header files
    - GSE Files
      - LMSAL EGSE
      - RTN (Real-Time Node, 1553 spacecraft interface used in place of SSIM)
      - ASIST
    - DOCS (html files documenting the commands and telemetry)

HMI/AIA JSOC Operations Software Configuration Items (3 of 3)

- **Planning Tools**
  - Web tools from MOC
- **Analysis Tools**
  - IDL programs
    - Inventory of existing IDL programs being prepared
    - Will catalog, control and make available to HMI & AIA as necessary
  - Trending programs
    - Will use those developed for, and used in, instrument and spacecraft level testing
- **Documented in User's Guides**

Configuration Management & Control

- **Flight Software**
  - Managed by HMI and/or AIA CCB respectively
  - Controlled in CVS (Concurrent Version System)
- **LMSAL EGSE**
  - Managed by HMI and/or AIA CCB and LMSAL departmental CCB respectively
  - Controlled in SCCS (Source Code Control System)
- **Ground Tools**
  - Managed by HMI and/or AIA CCB respectively
  - Controlled in CVS
- **Database**
  - Managed by HMI and/or AIA CCB respectively
  - Controlled in CVS
  - Version number in telemetry
- **Tables**
  - Managed by HMI and/or AIA CCB respectively
  - Controlled in CVS
  - Keep track of flight software configuration
  - Directory dumps of RAM and EEPROM provide verification of currently loaded software

HMI/AIA JSOC LMSAL EGSE Heritage

- **Initially used on MDI and still in use for orbital operations**
- **Adopted for TRACE and still in use for orbital operations**
  - Suggest visit to SOHO and TRACE EOFs at GSFC (Bldg. 14)
- **Upgraded version currently used on Solar-B FPP and SXI**
  - FPP is in instrument I&T; SXI is at Observatory I&T
- **Used on both HMI & AIA with the following differences due to command and telemetry mnemonics**
  - Databases
  - STOL procedures
  - Displays
- **Software has evolved over more than a a decade as an LMSAL resource**

HMI/AIA JSOC Implementation Plan

- **Implementation plan**
  - Purchase three pairs of Sun workstations at the appropriate time in the future
  - Install current version of LMSAL EGSE and databases
  - Acceptance Test
- **Procurement strategy**
  - Standard LMSAL procurement process
  - No special items or procurements needed
- **Test Approach**
  - Run LMSAL EGSE Acceptance Test procedure
  - Update Acceptance Test Procedure if new functionality added or additional unknown problems discovered and fixed
  - Run with Spacecraft Simulator (SSIM) provided by SDO Project
  - Run with spacecraft I&T system (interfaces are to be identical to the maximum extent practical)
- **Deliverables**
  - Sun workstations
  - All necessary software
  - Documentation (LMSAL EGSE User's Guide)
- **Maintenance Support (both pre- and post-launch)**
  - All software maintenance support provided by departmental staff
  - Hardware support under warranty or contract

Development & Test Plans and Schedule

- **HMI and AIA LMSAL EGSE installed**
  - Used for hardware and software testing to maximum extent possible
  - Uses socket interface with Ground System
  - HMI and AIA LMSAL EGSE same except for
    - Command and telemetry database files (different mnemonics)
    - Instrument specific display pages
- **HMI & AIA Mission planning software**
  - Prototypes for I/F testing with GS Mar, 2006
- **AIA data analysis software**
  - Prototypes for I/F testing with GS Mar, 2006
- **Purchase computers for JSOC Jan, 2006**
- **Install LMSAL EGSE Feb, 2006**
- **Interface test with GS Mar, 2006**
- **Test in I&T and with MOC as called for in SDO Ground System schedule**

Documentation

- **LMSAL EGSE User's Guide** **DEP0304**
- **LMSAL EGSE SDO Experiment Interface User's Guide** **HMI01131**
- **HMI Flight Software User's Guide** **2H00782**
- **AIA Flight Software User's Guide** **2T00175**
- **User's Guide for each ground tool**

Sustaining/Maintenance Plans

- **Maintenance Support (both pre- and post-launch)**
  - All software maintenance support provided by departmental staff
  - Hardware support under warranty or contract
  - LMSAL EGSE is maintained long-term already due to multi-mission usage
  - Flight software and ground tools
    - Documented
    - Developers available for maintenance if necessary

Security: Physical and IT

- **Operations equipment in room in B. 252**
  - B. 252 is card-key controlled
  - Room containing SDO Operations cypher-lock controlled (if necessary)
- **Computers used for commanding (2)**
  - Only one socket per instrument for commanding
  - Only network connection is to dedicated line with MOC (“air-gapped”)
- **Each user must have an individual account**
- **Operations computers must be:**
  - Access controlled (proper password length)
  - Logging
  - Assigned System Administrators
- **Requirements on all personnel using systems connected to the SDO network for commanding**
  - National Agency Check (NAC) Takes 7 – 12 months to complete
- **Requirements on all personnel using systems connected to the NASA networks**
  - Annual NASA security training required (1 –2 hours)
- **Requirements currently under review and expected to change during summer 2005**
- **NASA security to visit LMSAL and Stanford in the next few months to review the HMI and AIA security**

Operations Teams: Personnel

- **Team Structure & Responsibilities**
  - Three people minimum will monitor instrument operations
    - One (engineer) responsible for health & safety monitoring for both instruments
      - Will check trend and health displays
      - Will make daily contact with the FOT (5 days per week)
    - One (scientist) responsible for science operations for HMI
      - Will participate in longer term science planning
      - Will generate and send commands or will request commands to be sent by the engineer
      - Will monitor Instrument performance
      - Will confirm proper science data collected
    - One (scientist) responsible for science operations for AIA
      - Will identify regions of increased activity and communicate with science team concerning any observing changes needed
      - Will participate in longer term science planning
      - Will generate and send commands or will request commands to be sent by the engineer
      - Will monitor Instrument performance
      - Will confirm proper science data collected
- **Training**
  - Personnel will be from the development team
    - Engineers will have experience with testing the instrument at the instrument and spacecraft levels
    - Scientists will have been involved in the instrument definition, development and testing
    - Participation in NASA testing, both spacecraft level and MOC simulations, will be part of the training
- **Certification**
  - No formal certification program will be used
  - Program management will identify those individuals who will have the mission operations responsibilities

MOC Interface: Loads (1 of 3)

- **Types**
  - VxWorks kernel (available now, used for SUROM only, make_gse_kernel)
  - Names are name.major.minor.extension
    - Name is 22 alpha-numeric (case-insensitive)or underscore
    - Must begin with a letter
    - Major and minor are the CVS Ids
    - Extensions listed below
  - Scripts (.scr)
    - One uncompressed or several compressed (gz)
  - Object files (.o)
    - Always loaded from ground compressed
    - Uncompressed and linked on-board
  - Tables (.tbl)
    - Tables of like kind compressed on ground, loaded into EEPROM (if required)

MOC Interface: Loads (2 of 3)

- **Frequency**
  - Kernel and object files are not expected to be reloaded
    - Can be reloaded if a change is necessary
  - Scripts and tables
    - Changed infrequently (maybe one per week as needed for science observations)
- **Tools**
  - One program for each type
  - Runs on Unix workstation (EGSE)
  - Produces a STOL procedure (.src) and multiple binary files (bfile) if needed
    - Binary files are maximum of 100 commands each
    - STOL procedure consists of an upload header plus
      - Each binary file is uplinked and checked for successful upload
      - If command accept counter and block counter shows successful uplink, continue with next file (if not at end)
      - If not, binary file is retried one time
      - If successful, continue with next bfile
      - If not, STOL procedure terminated
      - Partial upload is removed on receipt of a new upload header command or an abort command
- **Load Verification**
  - Command counters and checksums used in upload process
  - Can dump loads also to verify contents on ground (if necessary or desired)

MOC Interface: Loads (3 of 3)

- **Worst case upload - Kernel**
  - 236 bytes in one upload_data command
  - One bfile of 100 commands is ~23K bytes
  - Kernel will be ~ 128K bytes
  - Kernel load needs about 6 bfiles
  - At 1 command/sec, one bfile load will take ~2 minutes
  - For 6 bfiles, total upload time is ~12 minutes

MOC Interface: Coordinated Activities

- **GT Calibration (AIA)**
  - One integrated ATS containing all commands
    - Spacecraft maneuvers
    - AIA commands
    - HMI commands
    - EVE commands
- **ISS Calibration (HMI & AIA)**
  - No coordination required
  - Internal to HMI & AIA
- **Roll Calibration (HMI & AIA)**
- **Flat Field Calibration (HMI & AIA)**

MOC Interface: Utilities, Orbit Timeline

- **Utilities**
  - Binary file to STOL procedure
  - Tables to STOL procedure
- **Orbit Timeline**
  - Not needed except for gross planning
  - Use the one provided by FOT

HMI Operations: Early Mission

- **Early Operations Support**
  - Science and engineering team members will be located at both the MOC and the HMI/AIA JSOC from launch through instrument commissioning.
- **Launch and Early Operations**
  - The instruments will be powered off for launch.
  - The survival heaters will be powered on as soon as practical after launch.
  - The CCD decontamination heaters will be powered on immediately after the spacecraft is power positive.
- **Orbit Circularization Period**
  - The instruments will be powered on as soon as practical after GTO insertion.
  - The CCD decontamination heaters will continue to be operated for several weeks.
  - Functional checkout of selected subsystems, including processor, heaters and mechanisms will begin as soon as commanding and telemetry resources are available.
  - The front doors will remain closed until SDO is “on station”.

HMI Operations: Checkout & Commissioning

- **Checkout and Initial Commissioning**
  - Complete the checkouts that are possible with closed doors.
  - Tune the temperature control systems after SDO achieves the final geosynchronous orbit.
  - Tune the guide telescopes (GT) and commission their ability to be the observatory fine sun sensor.
  - Open doors and retune thermal control systems, pointing systems, etc.
- **Commissioning and Calibration**
  - Detailed measurements of the instruments' performance will be made using calibration sequences developed during ground testing, including:
    - Instrument transmission and focus characteristics
    - Optical distortion, field curvature and astigmatism
    - Image data compression tests
    - Image stabilization calibrations
    - HMI filter wavelength and uniformity
    - Temperature dependence of various parameters
  - Testing of observing sequences to finalize the "Prime Sequence" of HMI and both the Synoptic Sequence and High-Activity Sequence of AIA

HMI Operations: Routine

- **Engineer daily checks – HMI and AIA (5 days/week)**
  - Health and safety of instrument
  - All auto-generated files (trending)
  - Contact FOT to verify status is as expected
  - Generates command lists, scripts or STOL procedures as necessary
  - Verify sufficient space for the next day or weekend exists to store telemetry data
  - Review the operations plan for the next day or the weekend
- **Scientist daily checks - HMI and AIA (5 days/week)**
  - Instrument performance
    - Auto-generated plots
    - Any special analysis needed
- **Scientist daily operations updates – AIA (5 days/week)**
  - Solar activity level
  - Operations plan to see what other observations (ground, space or SDO) may be occurring
  - Is responsible to notify the science team when activity becomes interesting and an observing change should be considered

HMI Operations: Anomalous Conditions

- **Notify immediately**
  - FOT
  - Program management
- **Place instrument in safe mode**
- **Document the emergency**
- **Call for whatever additional support is required**
- **Plan for recovery/troubleshooting**

HMI Periodic Operations

- **Periodic Calibrations - HMI**
  - The on-orbit calibration support will be similar to that implemented with the MDI instrument.
  - Transmission Monitoring: A daily set of images will be taken in HMI "calibration mode" to monitor instrument transmission and CCD performance. This sequence will run for one to two minutes, and will be scheduled as part of the nominal observing timeline.
  - Trending: Approximately every two weeks, a performance monitoring sequence will be run for about one hour to measure the instrument focus, filter and polarization characteristics. This sequence will be scheduled as part of the observing timeline, but could also be initiated by ground command.
- **Annealing (aperiodic)**

HMI & AIA Periodic Events

Event	Freq (times/yr)	HMI	AIA	Type of commanding	# of cmds
GT Calibration	12	X*	X	Coordinate through use of ATS, simultaneous	~250 AIA cmds
Flat Field Cal	2	X	X	Coordinate through use of ATS, simultaneous	~100/instrument
Roll Cal	2	X	X	Coordinate through use of ATS, simultaneous	~50/instrument
ISS PZT Offset & Strain Gauge Calibration	12		X	Internal to HMI & AIA but done simultaneously	~250 AIA cmds
Annealing	As needed (infrequent)	X	X	Internal to instruments, done independently	~10/instrument

*HMI ISS tests

AIA Operations: Early Mission

- **Early Operations Support**
  - Science and engineering team members will be located at both the MOC and the HMI/AIA JSOC from launch through instrument commissioning.
- **Launch and Early Operations**
  - The instruments will be powered off for launch.
  - The survival heaters will be powered on as soon as practical after launch.
  - The CCD decontamination heaters will be powered on immediately after the spacecraft is power positive.
- **Orbit Circularization Period**
  - The instruments will be powered on as soon as practical after GTO insertion.
  - The CCD decontamination heaters will continue to be operated for several weeks.
  - Functional checkout of selected subsystems, including processor, heaters and mechanisms will begin as soon as commanding and telemetry resources are available.
  - The front doors will remain closed until SDO is “on station”.

AIA Operations: Checkout & Commissioning

- **Checkout and Initial Commissioning**
  - Complete the checkouts that are possible with closed doors.
  - Tune the temperature control systems after SDO achieves the final geosynchronous orbit.
  - Tune the guide telescopes (GT) and commission their ability to be the observatory fine sun sensor.
  - Open doors and retune thermal control systems, pointing systems, etc.
- **Commissioning and Calibration**
  - Detailed measurements of the instruments' performance will be made using calibration sequences developed during ground testing, including:
    - Focus, field curvature and astigmatism
    - Image data compression tests
    - Guide telescope and image stabilization calibrations
    - Temperature dependence of various parameters
    - Coalignment of all AIA wavelengths
  - Testing of observing sequences to finalize the Synoptic Sequence and High-Activity Sequence of AIA

AIA Operations: Routine

- **Engineer daily checks – HMI and AIA (5 days/week)**
  - Health and safety of instrument
  - All auto-generated files (trending)
  - Contact FOT to verify status is as expected
  - Generates command lists, scripts or STOL procedures as necessary
  - Verify sufficient space for the next day or weekend exists to store telemetry data
  - Review the operations plan for the next day or the weekend
- **Scientist daily checks - HMI and AIA (5 days/week)**
  - Instrument performance
    - Auto-generated plots
    - Any special analysis needed
- **Scientist daily operations updates – AIA (5 days/week)**
  - Solar activity level
  - Operations plan to see what other observations (ground, space or SDO) may be occurring
  - Is responsible to notify the science team when activity becomes interesting and an observing change should be considered

AIA Operations: Periodic

- **Periodic Calibrations - AIA**
  - Approximately monthly, a performance monitoring sequence will be run for about one hour to measure the instrument focus, dark count, filter health, CCD noise and other characteristics. This sequence will be scheduled as part of the observing timeline, but could also be initiated by ground command.
  - Guide telescope and image stabilization system (PZT) calibrations will be done every 1-3 months, including both AIA internal tests and spacecraft offset maneuvers described below.
  - Occasionally, calibration frames will be taken ~hourly over a full orbit (1 day) to measure the periodic orbital and thermal variations
  - Every few days, a set of images will be taken to monitor the health of the filters in each AIA telescope
- **Annealing (aperiodic)**

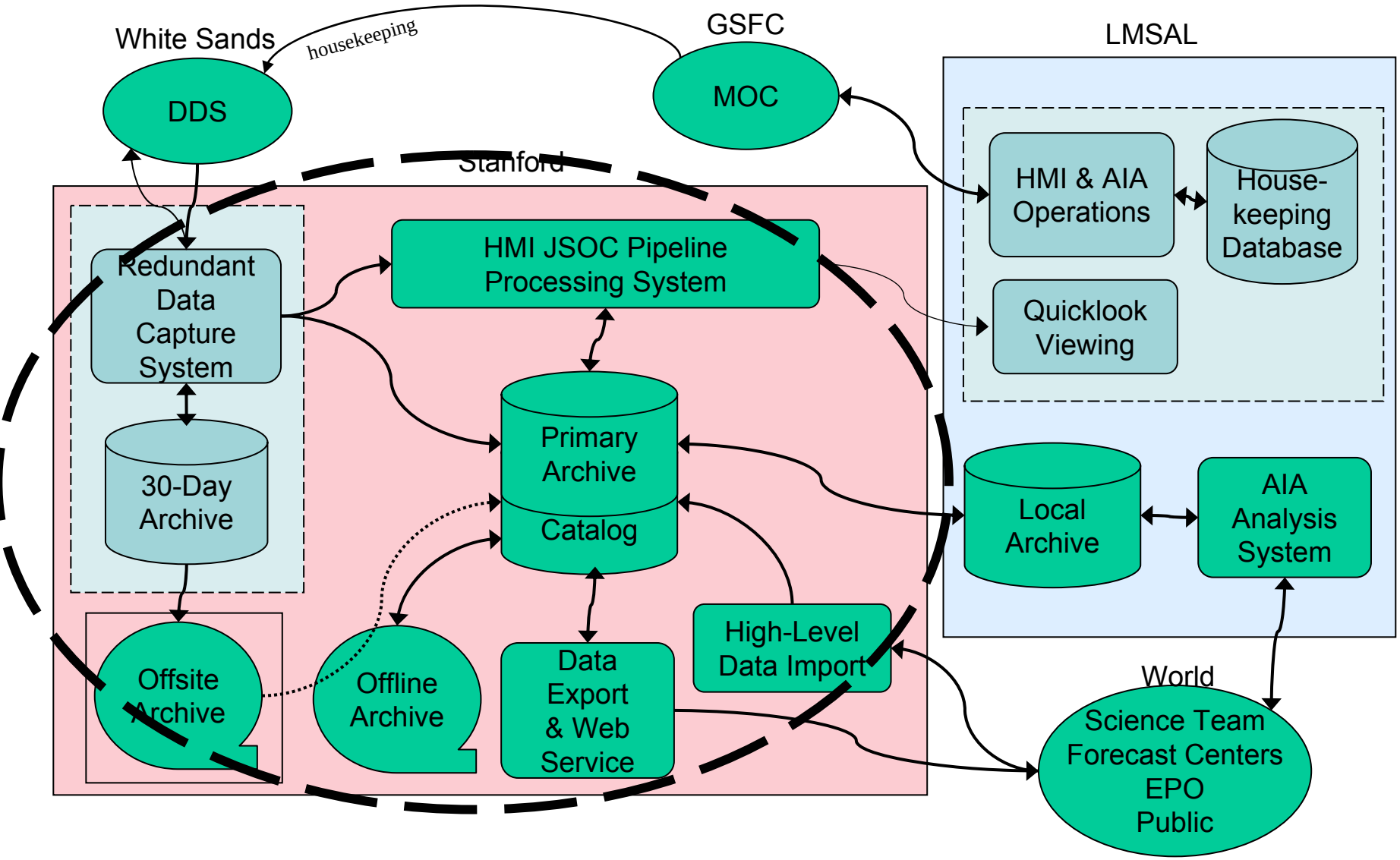
HMI & AIA Periodic Events

Event	Freq (times/yr)	HMI	AIA	Type of commanding	# of cmds
GT Calibration	12	X*	X	Coordinate through use of ATS, simultaneous	~250 AIA cmds
Flat Field Cal	2	X	X	Coordinate through use of ATS, simultaneous	~100/instrument
Roll Cal	2	X	X	Coordinate through use of ATS, simultaneous	~50/instrument
ISS PZT Offset & Strain Gauge Calibration	12		X	Internal to HMI & AIA but done simultaneously	~250 AIA cmds
Annealing	As needed (infrequent)	X	X	Internal to instruments, done independently	~10/instrument

*HMI ISS tests

Phil

HMI & AIA JSOC Architecture



JSOC 17 March 2005 "Peer" Review

Stanford SDP Development Plan

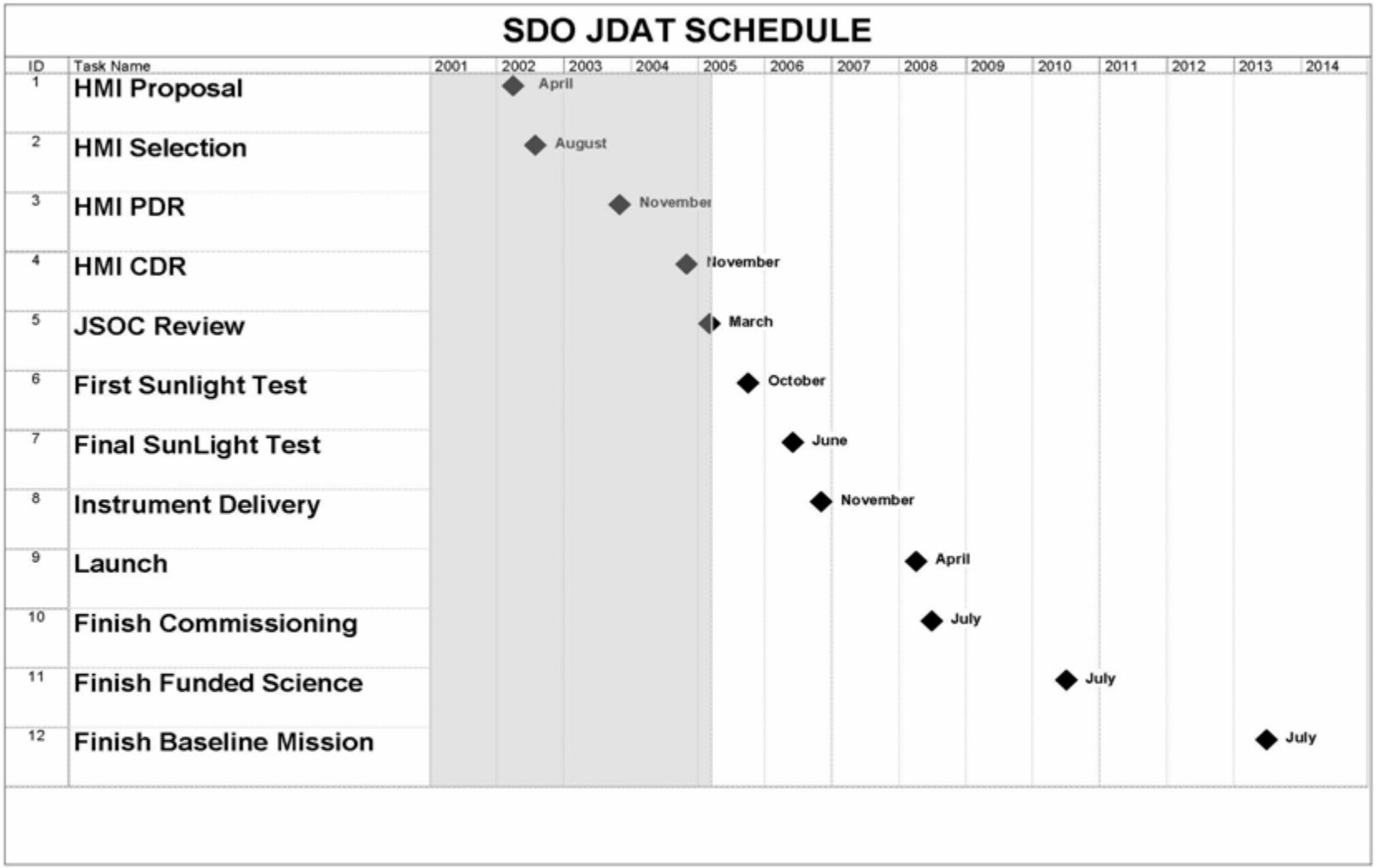
Philip Scherrer

pscherrer@solar.stanford.edu

650-723-1504

- Schedule and effort levels and development sequence
- Staffing Organization Chart for JSOC system
- ***IT security plan, Configuration management and change control***
- Future SU HMI & JSOC Facility

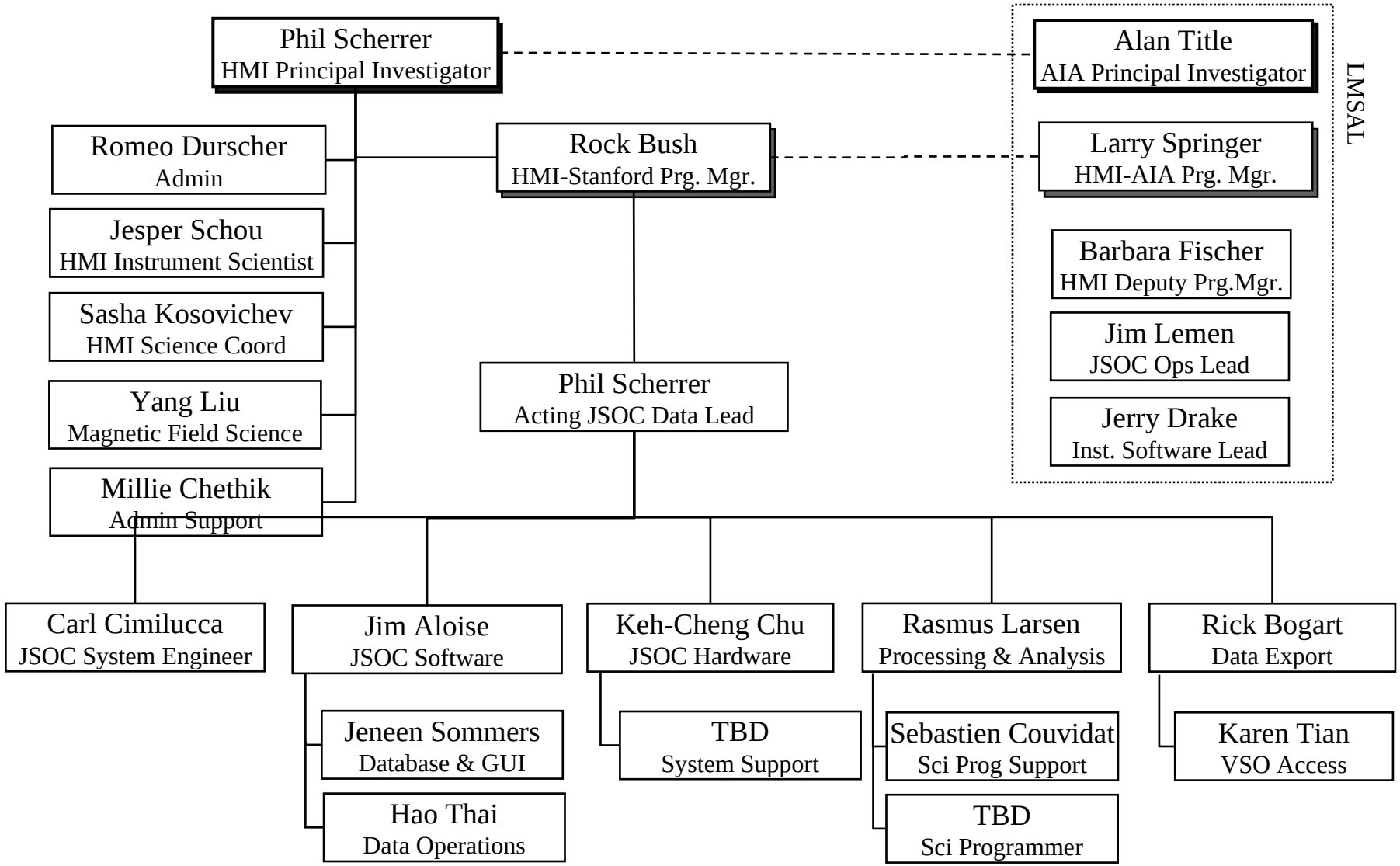
JDAT Overview Schedule



Development & Test Plans and Schedule

- **HMI and AIA Data EGSE installed**
  - Prototype for I/F testing with GS — Mar, 2005 onward
  - Version 2 to support flight inst. — June 2005
- **JSOC Capture System**
  - Purchase computers — Summer 2006
  - Support DDS testing — Fall 2006
  - Final system installed — Spring 2007
- **JSOC SDP Infrastructure, SUMS, DRMS, PUI**
  - Prototype testing of core system — June 2005
  - Fully functional — Dec, 2005
- **Purchase computers for JSOC** — Jan, 2007
- **Infrastructure Operational** — April, 2007
- **Data Product Modules** — Jan, 2008
- **Test in I&T and with DDS,MOC as called for in SDO Ground System schedule**

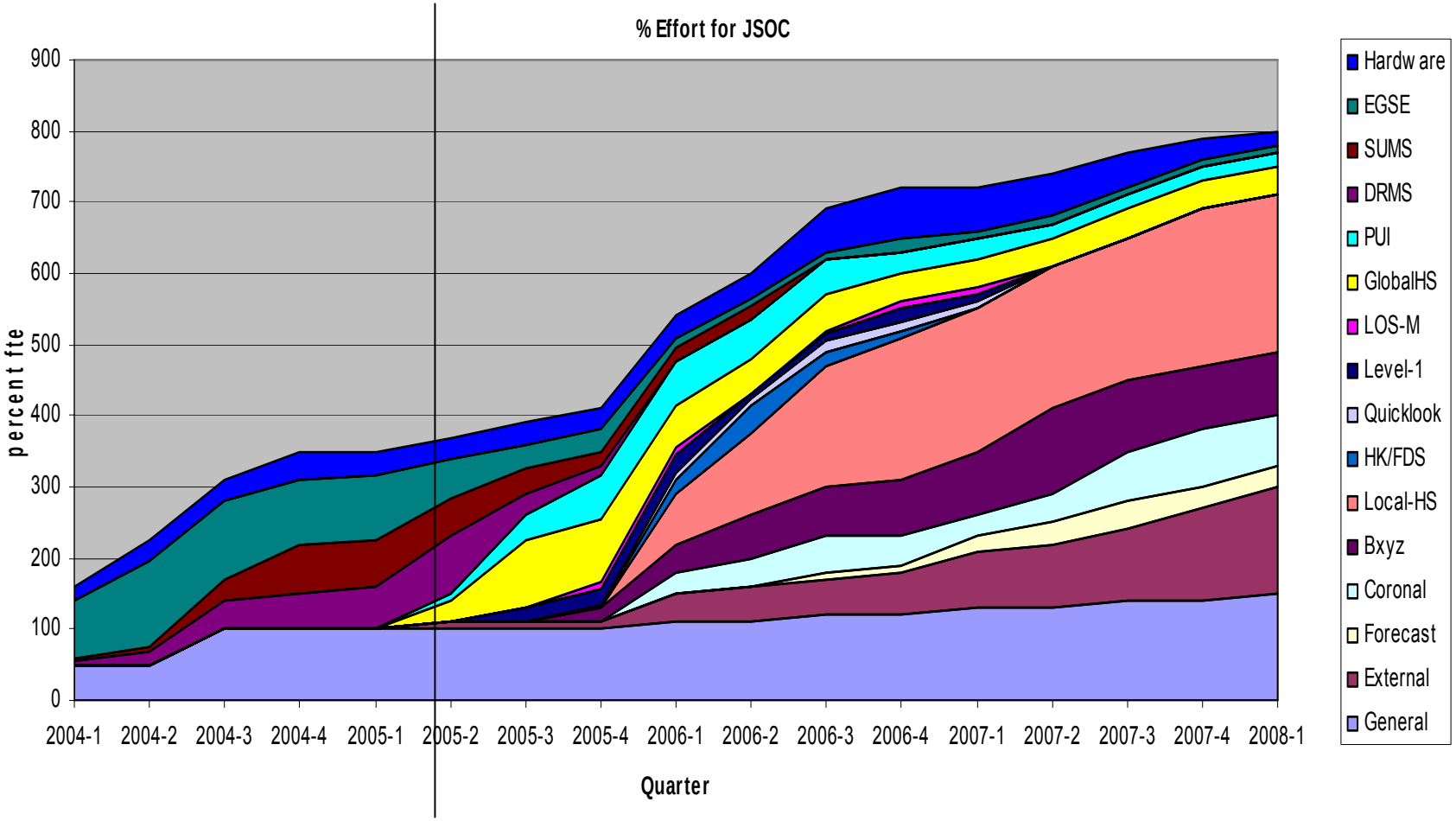
SDO/HMI – Stanford Personnel



Stanford JSOC Effort Level Budget

HMI AIA SOC Pre-Launch	FY2004	FY2005	FY2006	FY2007	FY2008
	5/1/04 - 9/30/04	10/1/04 - 09/30/05	10/1/05 - 09/30/06	10/1/06 - 09/30/07	10/1/07 - 5/30/08
Salaries (FTE rate)					
WBS 1.1 Program Management	1.36	1.80	1.80	1.80	1.80
WBS 1.2 Science Development	0.76	0.83	2.55	3.45	3.15
WBS 1.3 Instrument Development	1.40	1.08	0.53	0.15	0.10
WBS 1.4 Integration and Test Support	0.00	0.83	1.71	2.13	2.10
WBS 1.5 Ground Data System Development	1.31	1.94	3.05	4.18	4.45
WBS 1.6 SU Pre-Launch Science OPS & Data	0.52	1.16	1.91	2.91	3.15
WBS 1.7 JSOC Management	0.08	0.20	0.20	0.20	0.20
WBS 1.8 JSOC Development	0.22	0.53	0.93	0.88	0.88
WBS 1.9 JSOC Science Data Preperation	0.00	0.30	0.40	0.40	0.40
WBS 4.3 AIA Education and Public Outreach	0.08	0.20	0.30	0.30	0.30
Stanford Total	5.74	8.85	13.38	16.39	16.53
JSOC Total	**1.83**	**3.36**	**5.89**	**7.96**	**8.48**

JSOC Effort Plan by SubTask



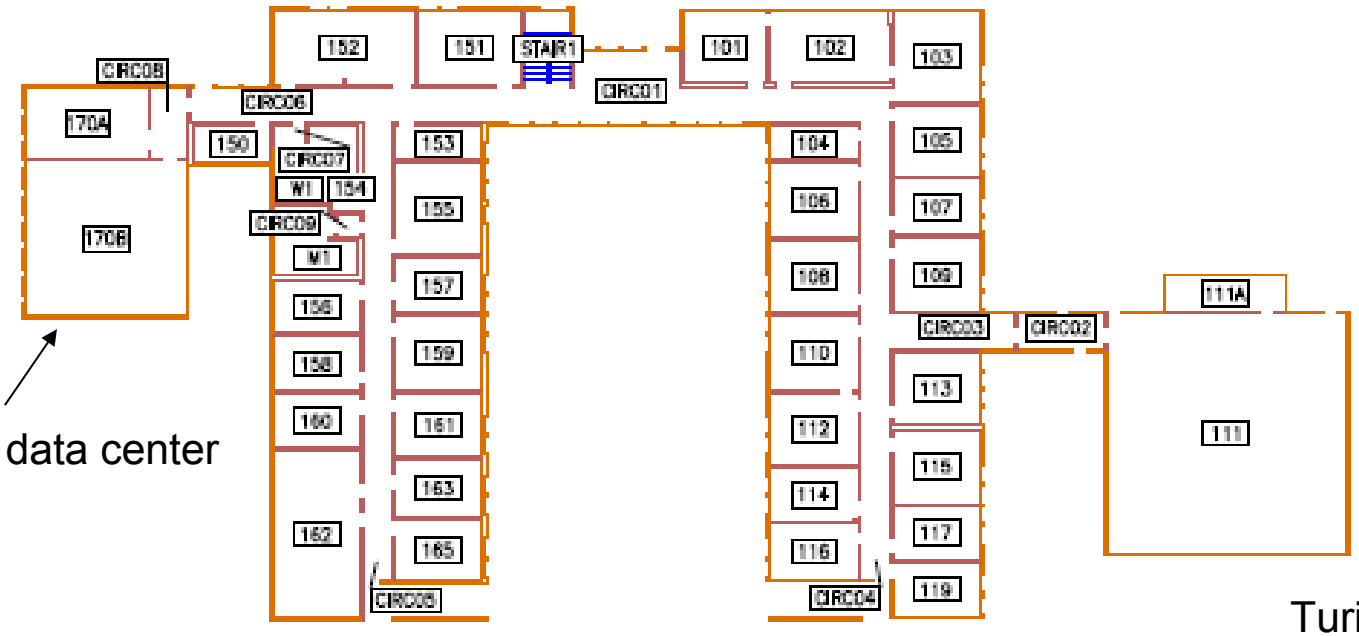
Configuration Management & Control

- **Capture System**
  - Managed by JSOC CCB
  - Controlled in CVS
- **SUMS, DRMS, PUI, etc. Infrastructure**
  - Managed by JSOC CCB after launch
  - Controlled in CVS
- **PUI Processing Tables**
  - Managed by HMI and/or AIA Instrument Scientist
  - Controlled in CVS
- **Level 0,1 Pipeline Modules**
  - Managed by HMI and/or AIA Instrument Scientist
  - Controlled in CVS
- **Science Analysis Pipeline Modules**
  - Managed by program author
  - Controlled in CVS

Security: Physical and IT

- **Stanford JSOC facility location TBD, need date Jan 2007**
- **Capture System in isolated room**
  - Room access limited to essential personnel
  - Firewall to Pipeline system
  - Computer access limited to essential personnel
- **Pipeline computers**
  - Room access limited to JSOC personnel
  - password protected
  - Firewalls to outside

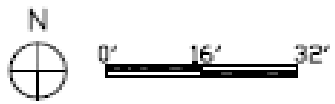
Likely new location for Solar Observatories Group



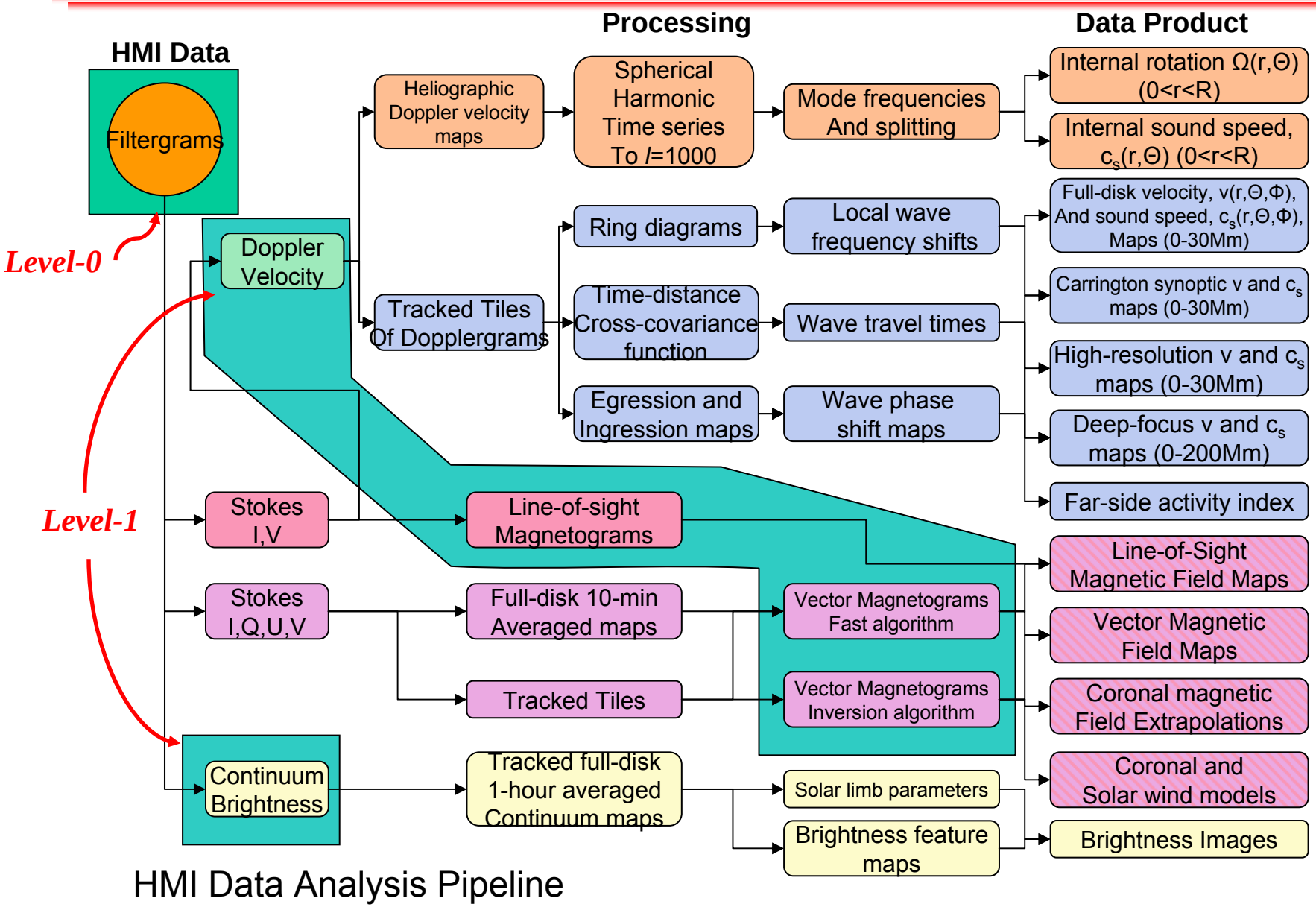
Possible data center

Turing Auditorium

Possible location for Stanford Solar Group – Polya Hall, first floor. The second floor is also available. The combined building is c. 13000 nasf. We need about 7000.

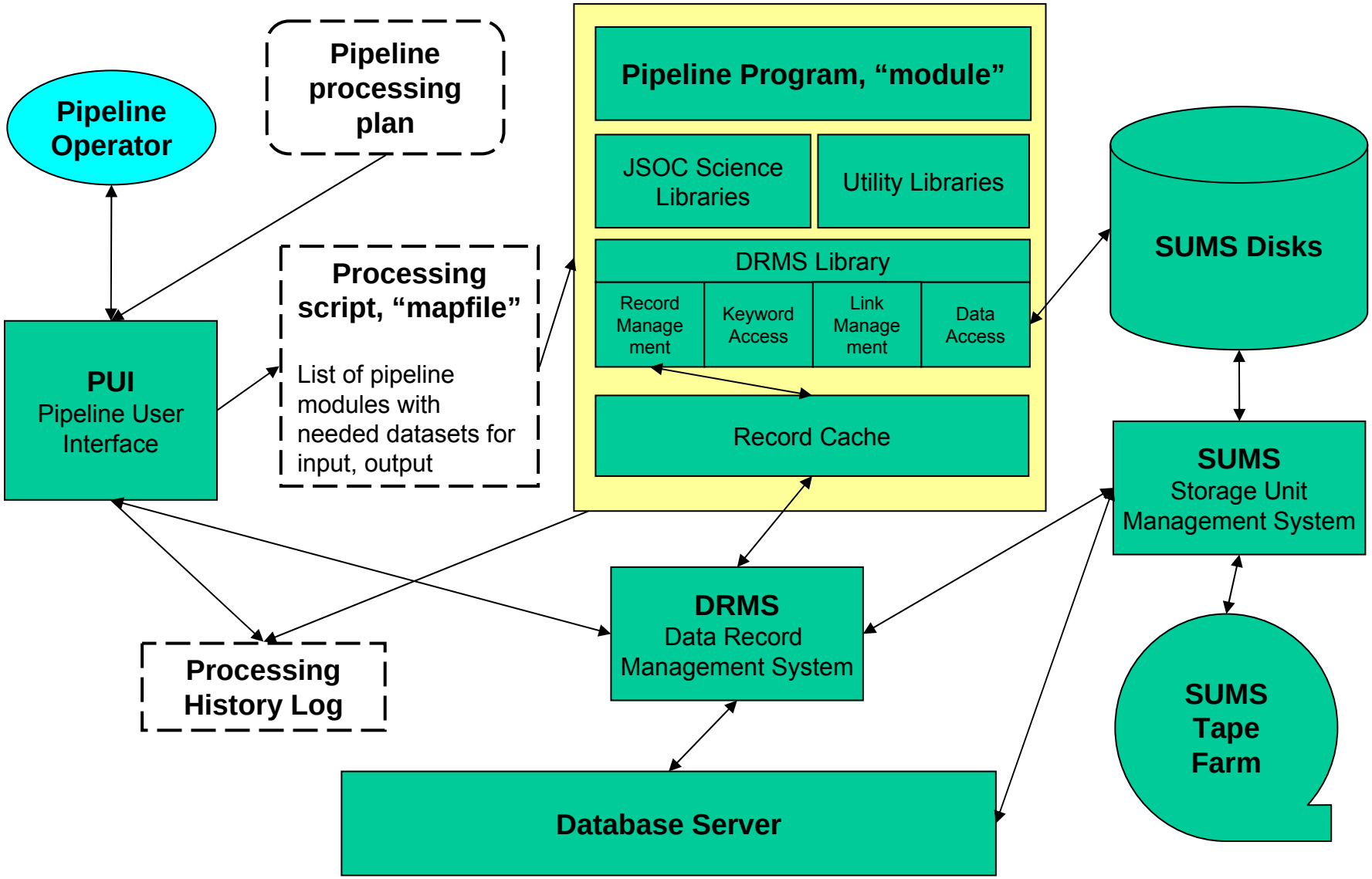


HMI - SOC Pipeline

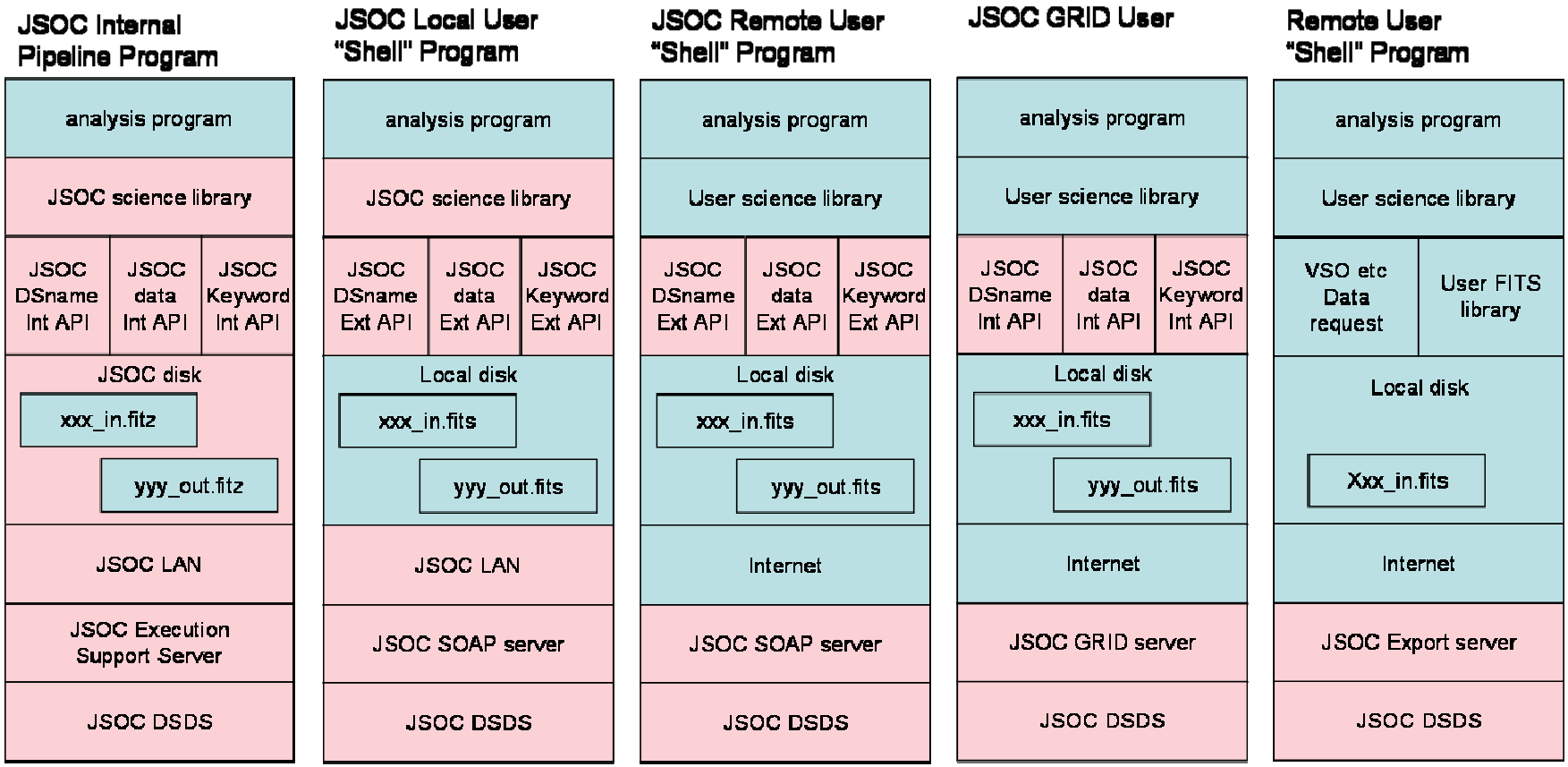


HMI Data Analysis Pipeline

JSOC Pipeline Processing System Components

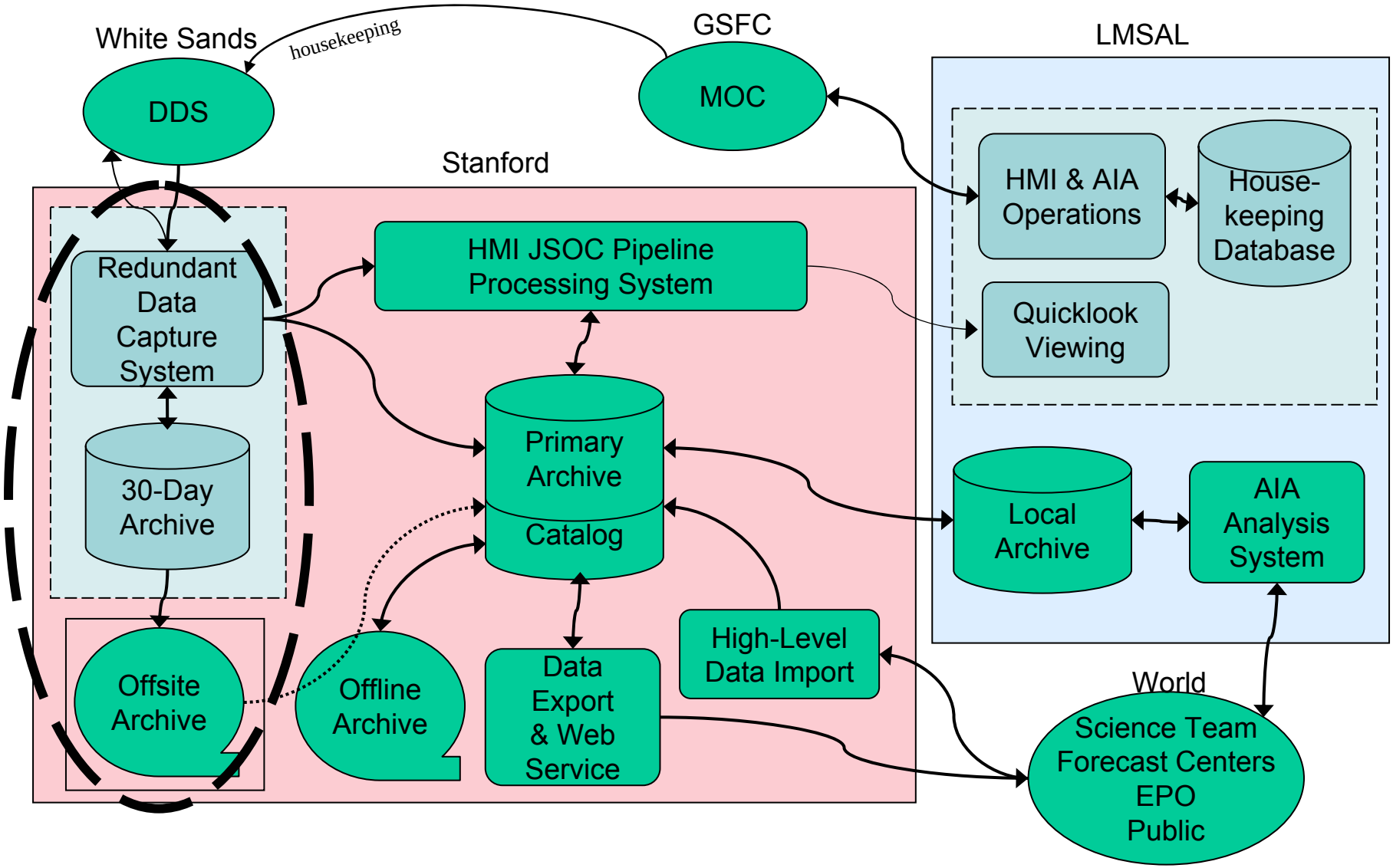


Five Kinds of Users



Jim

HMI & AIA JSOC Architecture



JSOC

Data Capture Front End

DMR – JSOC Requirements

- **8000.2.4 Science Data Processing, Archiving and Distribution**

- **Each SOC shall provide the necessary facility, software, hardware and staff to receive, process, archive and distribute the science data generated by its instruments.**

- **Implementation is a Joint SOC (JSOC) for HMI and AIA**

My Documents\DMR_SOC_Req.ppt

JDAT Data Capture Driving Requirements

Telemetry Input from DDS

(JDAT_000100) Data Capture(DC) interface to DDS

JDAT shall use the interface detailed in the DDS/SOC ICD. [DSI S1.1 S1.2]

(JDAT_000200) Data Capture IT Security

JDAT telemetry input machine shall be on a secure networking conforming to the JDAT IT Security Document. [DSI S5.4]

(JDAT_000300) Data Capture receives telemetry files from DDS

JDAT shall receive a fixed length of approximately one minute of telemetry data in tlm files from the DDS. The DDS pushes tlm files to JDAT. [DSI S3.1.2:1 S5.3 T5-1]

(JDAT_001700) Data Capture receives quality and accounting files from DDS

DDS shall send the qac files to the JDAT. This file contains validation data or quality and accounting information on corresponding tlm file. JDAT shall use information to validate tlm file. [DSI S4.1.3]

JDAT Data Capture Driving Requirements (Cont.)

Telemetry Input from DDS

(JDAT_003000) Data Capture requests error files from DDS

DDS creates error files that contain VCDU that were flagged by the Spacecraft as being corrupted. JDAT shall request to the DDS to receive error files.[DSI S3.1.2.1:5]

(JDAT_003700) Data Capture shall receive dsf files

JDAT shall receive every hour on the hour dsf (data status file) files from DDS. [DSI S3.1.2.1:8 S3.1.2.3:8]

(JDAT_004300) Data Capture shall create and update asf files.

JDAT shall create every hour before the half hour an asf (acknowledgement status file) file confirming the acknowledgement of all (tlm, err, qac) files received from DDS. The DDS shall pull this asf file from the JDAT at every hour on the half hour. [DSI S3.1.2.1:10 S3.1.2.3.1:9]

(JDAT_005000) Data Capture shall create and update arc files.

The JDAT shall create an arc (archive) file containing all files received and archived by the JDAT from the DDS. This file will be created before 0:00 UTC because the file will get picked up by DDS at 00:15 UTC. [DSI S3.1.2.1:12 S3.1.2.3.1:10

JDAT Data Capture Driving Requirements (Cont.)

Housekeeping Data Input from MOC

(JDAT_006600) DC receives real time housekeeping (hk) from the MOC

The hk data will be sent real time. The SOC shall communicate over sockets to the MOC to receive housekeeping data [MSI S4.1.1 S4.2:2]

(JDAT_008100) DC may receive non-real time housekeeping data over socket.

The MOC can playback archived hk on demand, that is retransmit previously down linked telemetry over the socket. The playback of housekeeping data can be sent non-real time over a socket connection to JDAT. [MSI S4.1.2.2 , S4.2:2, S3.1.2.1:3]

(JDAT_008900) Data Capture may receive non-real time housekeeping

The hk data will be sent from the MOC to the SOC as a non-real time data set (or sometimes called 24 hour data set) file. The files contain packets for a single APID. [MSI S4.1.2.3 S4.1 S4.2:2]

JDAT Data Capture Driving Requirements (Cont.)

Housekeeping Data Input from DDS

(JDAT_009700) DC shall receive housekeeping data inserted in tlm files.

The hk packets that are inserted into the high-rate channel shall be extracted, and decoded to standard data types and checked for errors. This data shall be in tlm files.[JDP S2.3 F2]

(JDAT_009800) DC shall decode data keywords for hk data from tlm files.

The decoded hk data keywords shall be added to the header information of the level-0 image with which they are associated. [JDP S2.3]

JDAT Data Capture Driving Requirements (Cont.)

Telemetry and Housekeeping Data Archive

(JDAT_010100) DC creates two permanent copies of telemetry data

Two copies shall be produced on permanent media. One is retained locally, and the other shall be removed for offsite storage. [JDP S2.2]

JDAT_010300) DC maintains 30 days cache of telemetry online

The JSOC shall be able to retain a 30 day cache of telemetry online. [JDP S2.2:2]

Data Capture Infrastruture

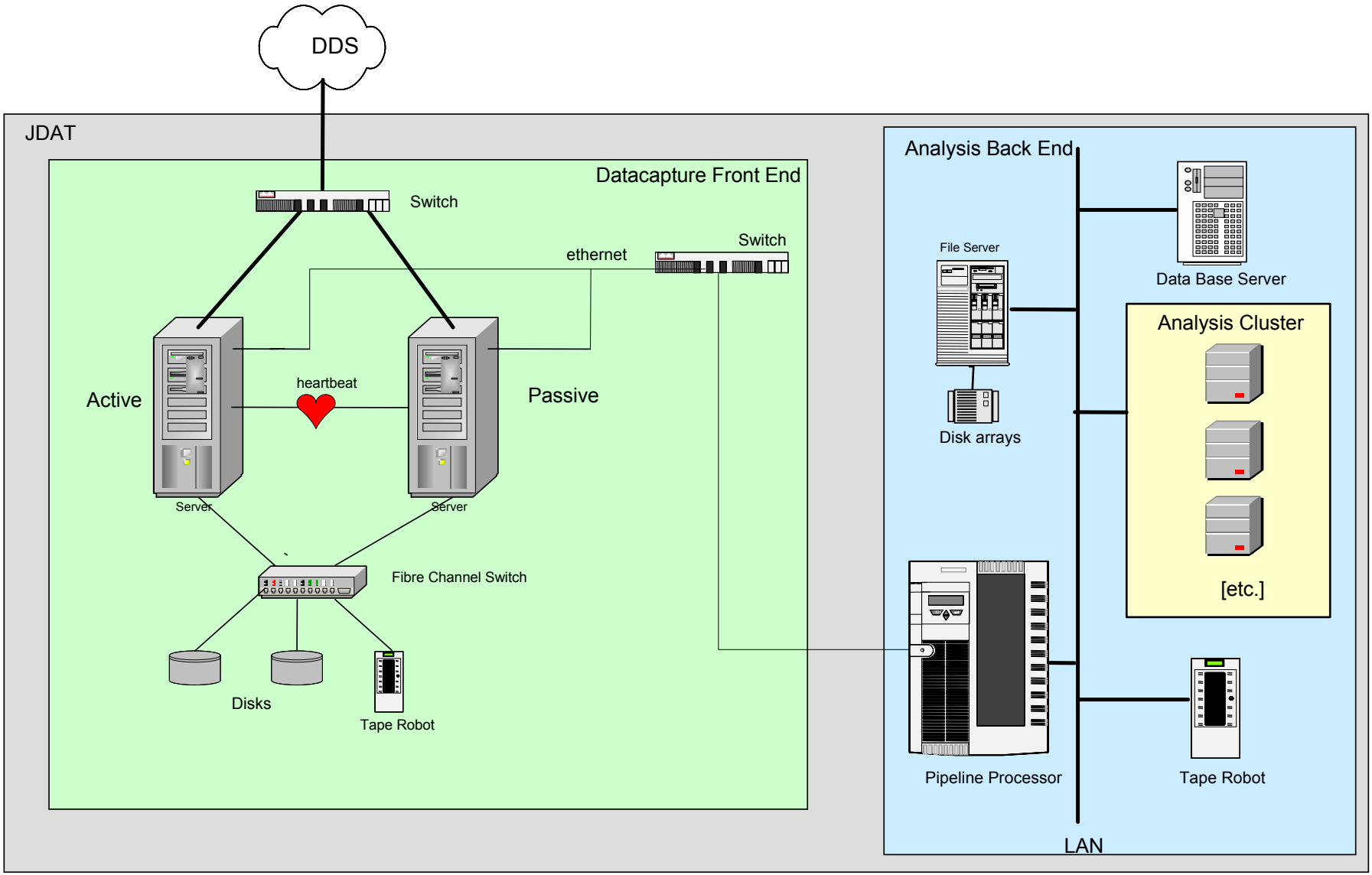
(JDAT_010400) DC sents telemetry/hk data to Pipeline Processing System

The system shall send tlm and qac data to Pipeline Processing System. [JDP S2.2]

(JDAT_011100) DC data quality tracking and reporting

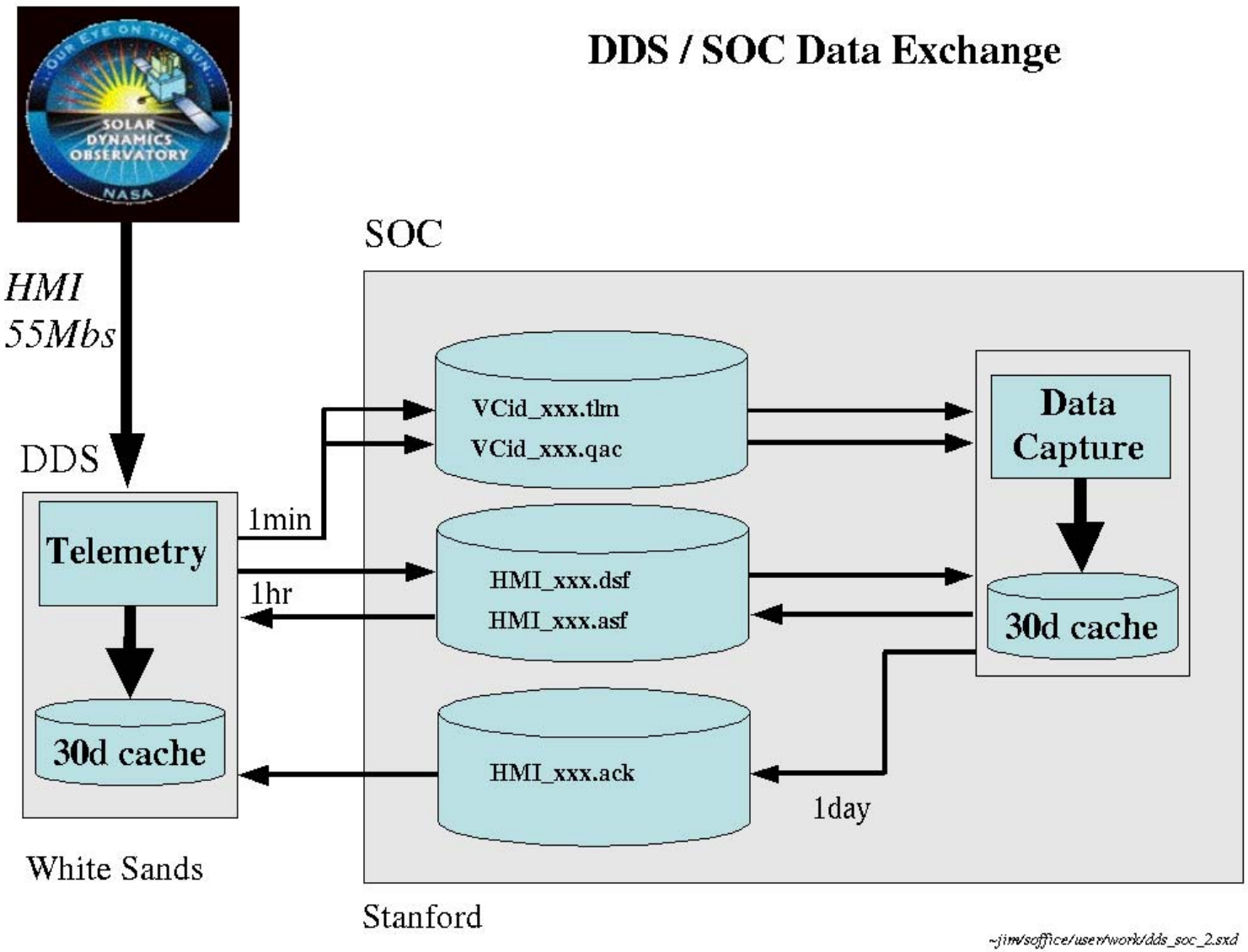
There shall be a data quality tracking and reporting subsystem. [JDP S1.4:2]

JDAT (Stanford Science Data Processing) Configuration

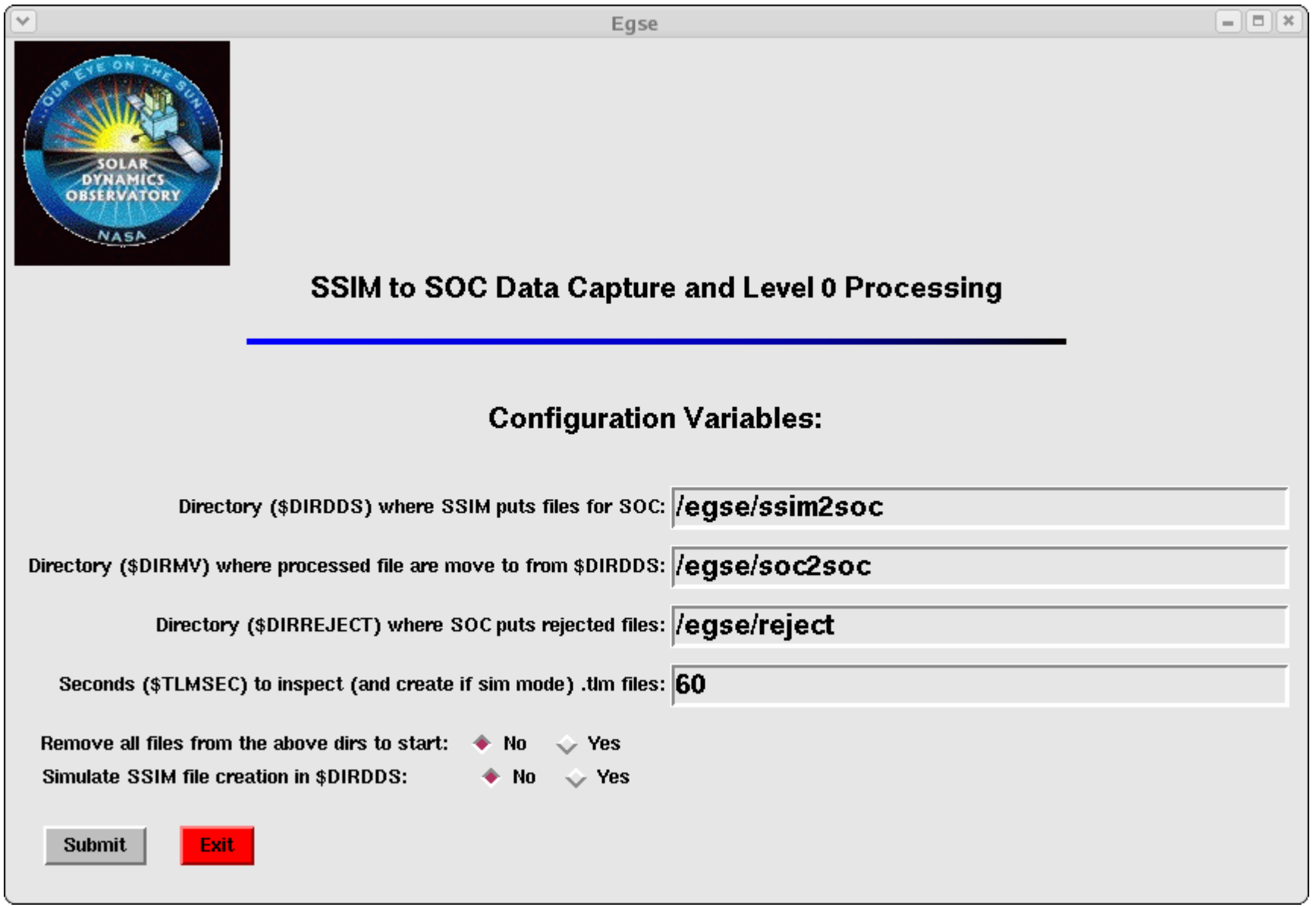


jim\My Documents\hardware_config3.vsd

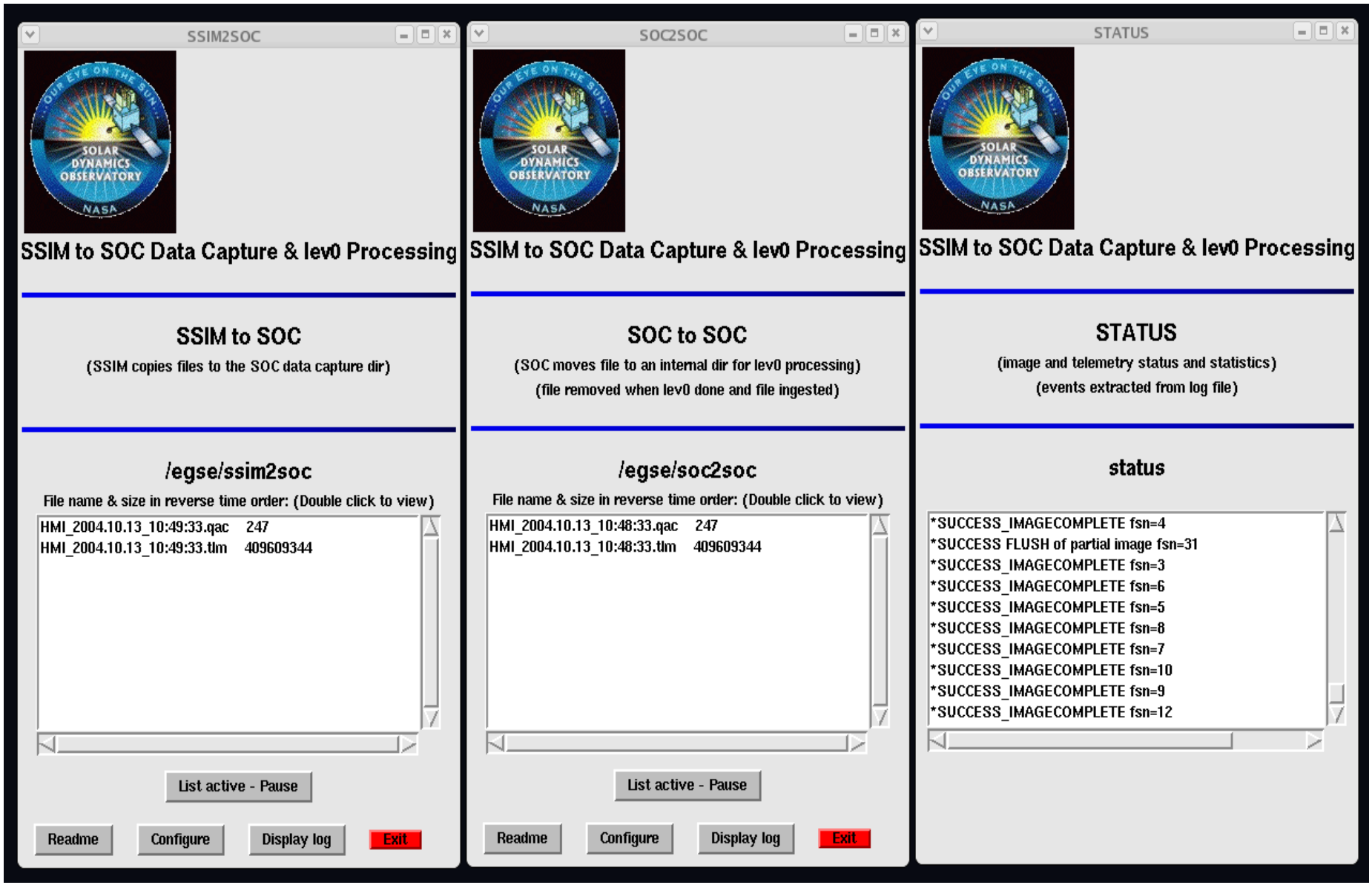
DDS / JSOC Data Exchange



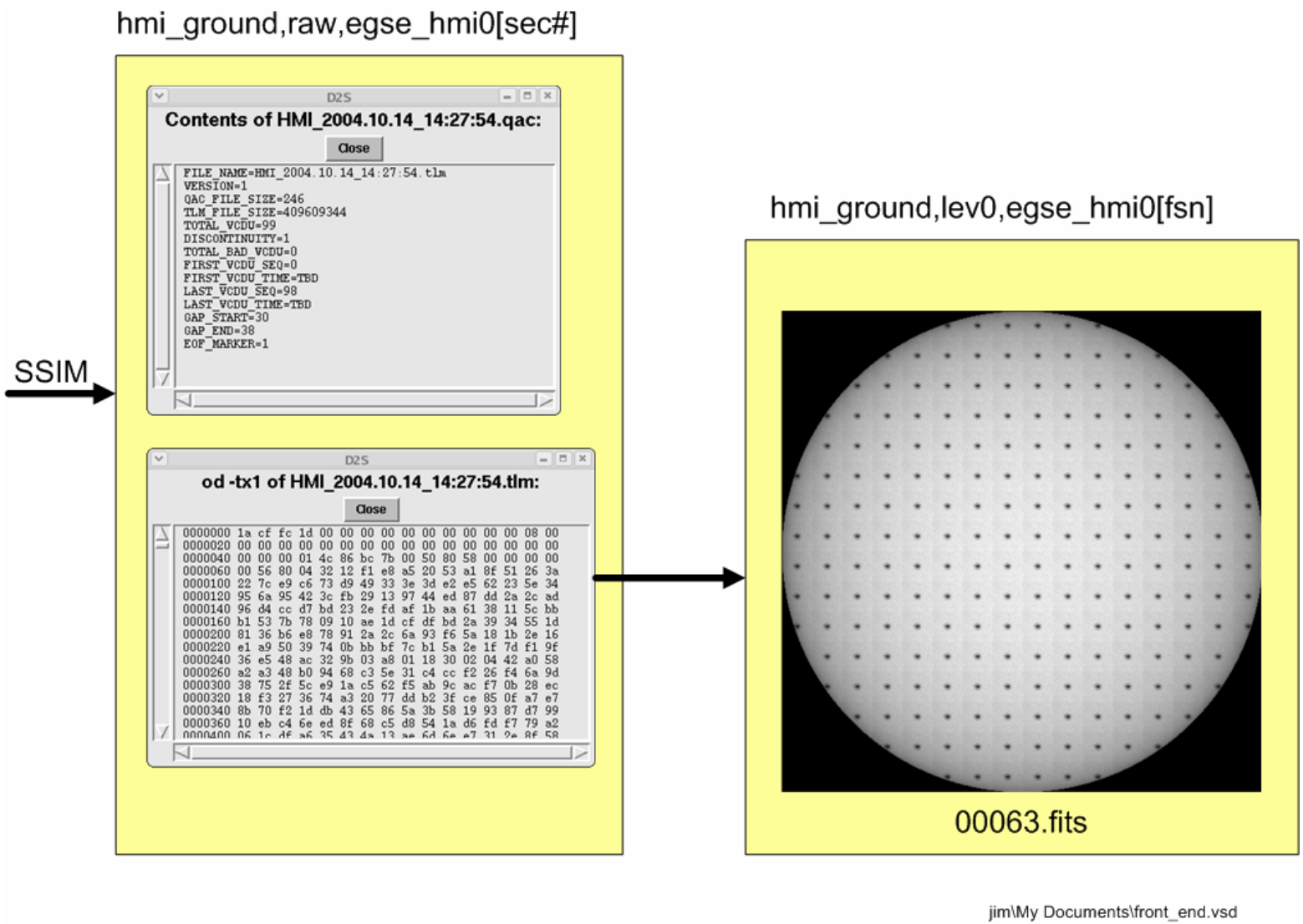
EGSE Configuration Screen



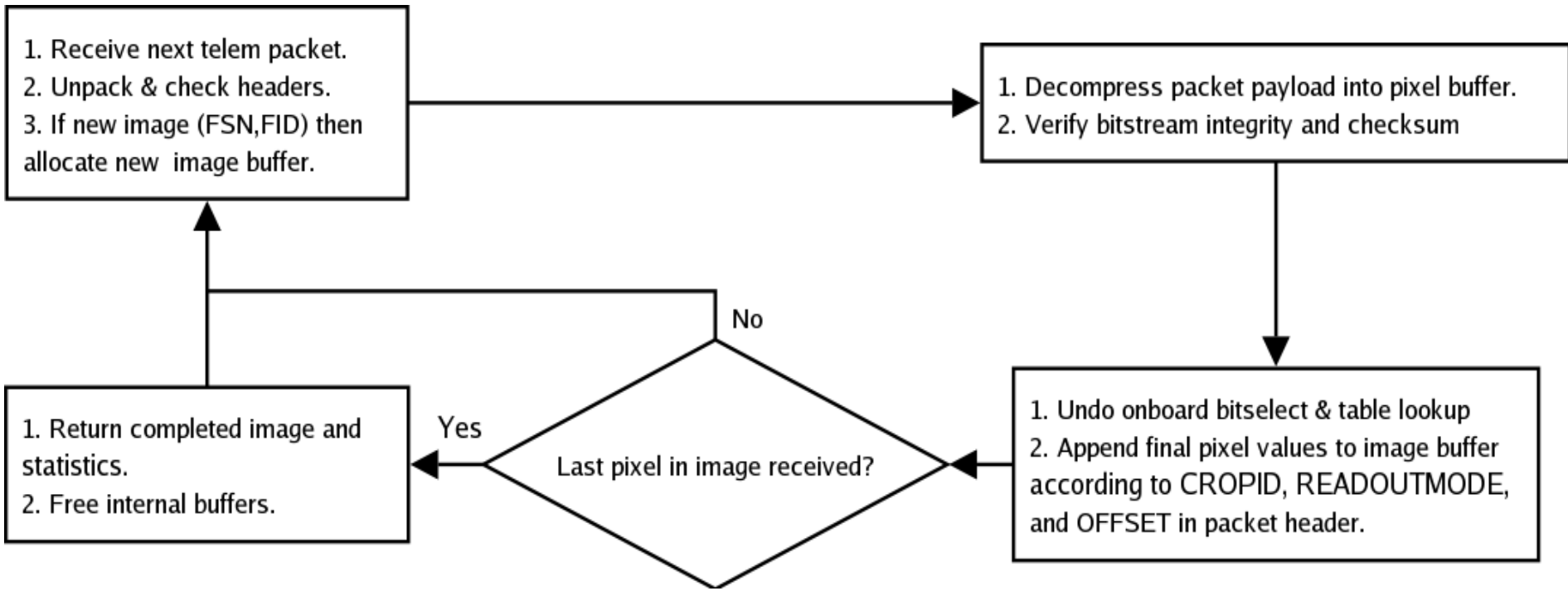
EGSE Run Screens



EGSE Raw and Lev0 Datasets



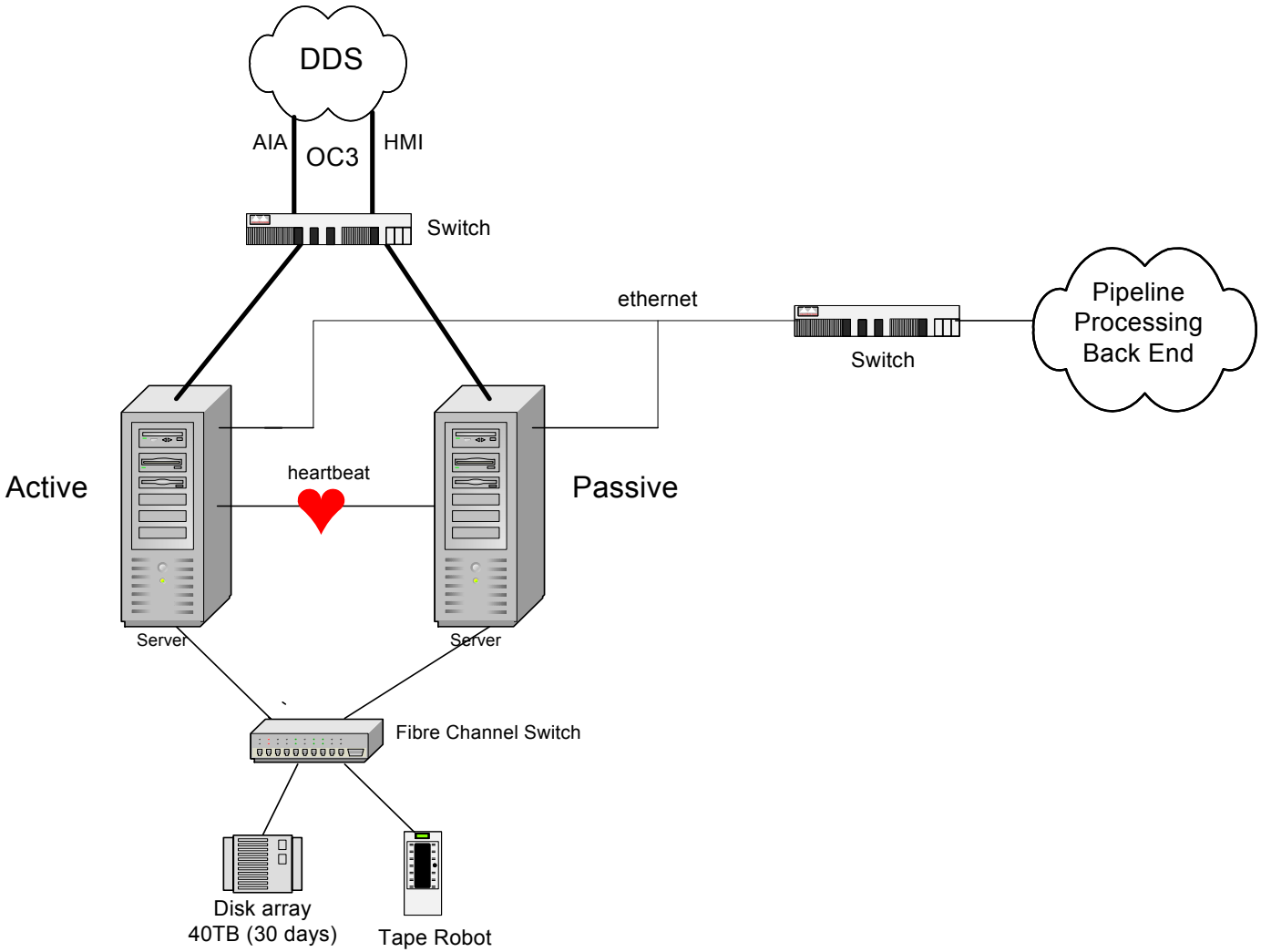
Decode Image



EGSE Archiver

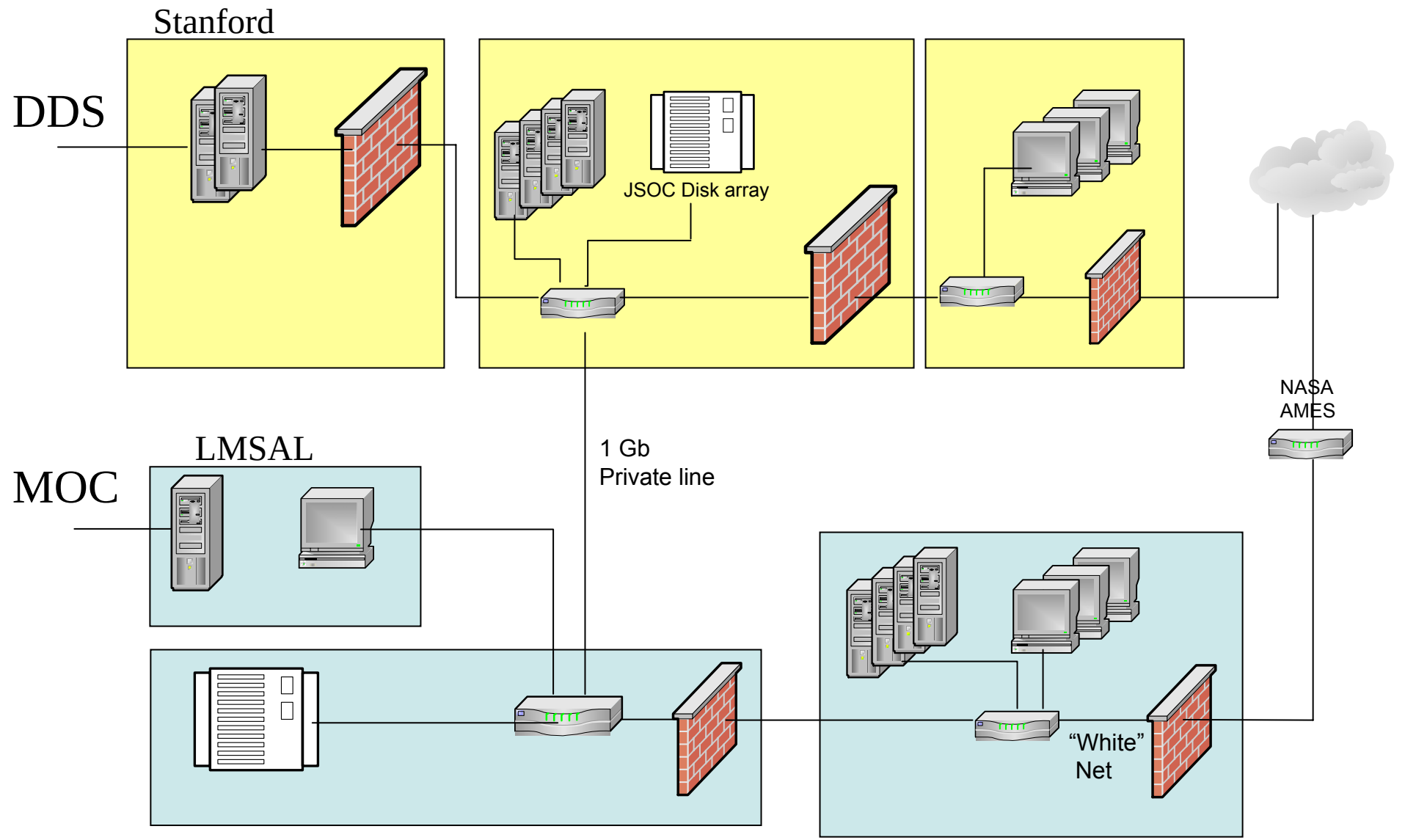
```
csh> egsearc

Usage: egsearc [  -v] [-d] [-q] [-a archive_dir]   database_name

       -v = verbose mode
       -d = run  in debug mode
       -q = query only to see what's available for archive
       -a = give the dir to cp the archived ds to
            the default archive_dir is /hmi0/archive
            Use /dev/null to not archive but make del pend
            Use /dev/mt to write to tape
csh>
```

JSOC Data Capture Front End



datacapture_frontend3.vsd

Stanford/Lockheed Connections



Telemetry Data Archive

- Telemetry data is archived twice
- The Data Capture Front End archives tlm files for offsite storage
- Archive tapes are shipped to the offsite location and verified for reading
- A feedback mechanism will be established to ack the JDAT that a tape is verified or that another copy needs to be sent
- The Data Capture Front End copies tlm files to the Pipeline Processing Back End system
- The Back End archives tlm data for local storage and acks the JDAT when it is successful
- Only when the JDAT has received positive acks on both archive copies does it inform the Front End processing to include the tlm file in the .arc file to the DDS, who is now free to remove the file from its tracking logic

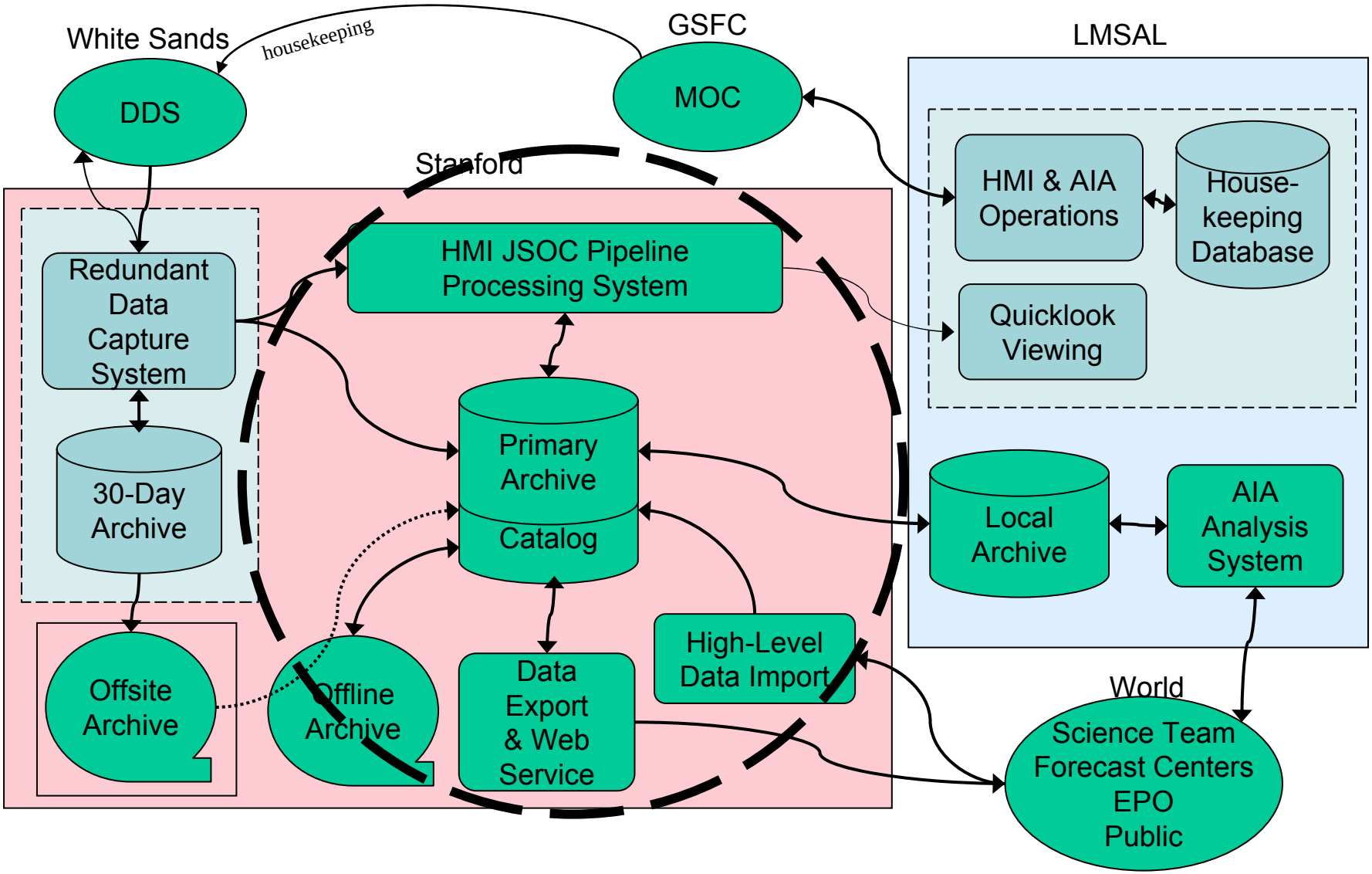
Test Schedule

JSOC Science Data Processing (SDP) / DDS I&T Start Dates

Delivery of Flight EGSE SDP	June 2005
Prototype SDP System Ready	Dec 2005
JSOC Network Ready	Dec 2006
DDS-JSOC Testing	Dec 2006
GSRT#2- Science Data Processing Test (Ka-band)	Jan 2007
HMI Connectivity, Dataflow, Retransmissions Test	Feb 2007
AIA Connectivity, Dataflow, Retransmissions Test	Feb 2007
GSRT#3-Mission Operations& RF Communications Test	Mar 2007
GSRT#4-Fully Integrate Ground System	Mar 2007
Ground System Freeze	Jan 2008
GSRT#4-Launch Readiness Test	Feb 2008

Carl

HMI & AIA JSOC Architecture



JDAT Requirements and Goals

JDAT Requirement Document

This document is composed of a list of requirements and goals for the JDAT system. The JDAT documents discusses two basic subsystems.

- Data Capture (DC)
- Pipeline Processing and Science Analysis (PPSA)

JDAT Requirements

The requirements are items to be completed based on the current resources, budget and schedule. These items will be defined in the JDAT Requirements document in the traceability table.

JDAT Goals

The goals are items to be completed based on resources, budget, and schedule time available after JDAT Requirements are completed. These items we would prefer to complete. These items will be defined in JDAT Requirements Document in the traceability table.

JDAT Pipeline Processing and Science Analysis System Requirements - Applicable documents

Document (Abbreviated Trace Document Name)	Number
Mission Requirements Document (MRD)	464-SYS-REQ-0004(Revision B)
Detailed Mission Requirements Document (DMR)	464-GS-REQ-005 / HMI00525
MOC/SOC ICD (MSI)	464-GS-ICD-001
DDS/SOC ICD (DSI)	464-GS-ICD-0010(10/25/2004)
Data Compression/High Rate Interface (DCHRI)	2H00125A(Draft)
Instrument Software Requirements (ISWR)	2H0004(11,Nov 2004)
HMI/AIA JSOC Ground Data System Plan Overview (JDP)	HMI-S019
JSOC Processing Plan (JPP)	HMI-S021
HMI Data Products (HDP)	HMI-S022
JSOC SDP Requirements	HMI-S023
JSOC SDP IT Security Plan (JSP)	HMI-S024

JDAT Pipeline Processing and Science Analysis (PPSA) System Driving Requirements

Level 0 Processing- Image decompression

(JDAT_012000) PPSA is compliant to DCHRI Function Specification.

The decompression and reconstruction steps outlined below shall comply with Functional Specification, Data Compression/High Rate Interface. [DCHRI S3.7]

(JDAT_0121000) PPSA extracts science data packets from VCDU.

The payload of each science data packet from the high-rate channel shall be extracted from the VCDU, it's individual header fields extracted, decoded to standard data types and checked for errors. [DCHRI].

(JDAT_012600) Decoded pixels are used to reconstruct the image.

The decoded pixel values shall be copied to a 16 bit signed integer image buffer dimensioned to hold the complete reconstructed image. The location to which the pixels from a given packet are copied shall be determined by header fields indicating the pixel offset count, and the CCD read-out mode and cropping applied. [DCHRI]

Level 0 Processing- Image decompression

(JDAT_013100) Each Level-0 image cataloged.

Each level-0 image shall be cataloged as a dataset of a single .fits file with the filter gram series number as its series number index. [FITS Reference]

Storage and Cataloging

(JDAT_013400) Store Level 0 image in compressed format

When a level-0 image is complete it shall be stored in (TBD) compressed format.

(JDAT_013500) PPSA stores header keywords in Catalog Database

The header keywords describing the level-0 image shall be inserted into the catalog database.

(JDAT_013600) PPSA archives Level 0 image to permanent media

The level-0 image shall be archived on permanent media.

(JDAT_013700) PPSA retains 30 cache of level 0 image data online

The JSOC shall retain a 30 day cache of level 0 images online.

JDAT Pipeline Processing and Science Analysis System Driving Requirements (Cont.)

Level 1 Processing for HMI Instrument Data

(JDAT_013800) PPSA calibrates Level 0 filtergrams

The level 0 filtergrams shall be calibrated for exposure time, flat field and corrected for missing pixels.

(JDAT_013900) PPSA determines Doppler shifts and Stokes components

Proper combinations of the calibrated filtergram shall determine continuum intensity and equivalent line width, Doppler shifts and Stokes I, Q, U, and V components.

(JDAT_014000) PPSA calibrates line parameters

The line parameters shall be calibrated and in turn be interpreted by suitable inversions as physical observables such as the thermodynamic state variables, line-of-sight velocity, and magnetic field strength and orientation.

(JDAT_014100) PPSA creates Level 1 data

Images of the line parameters and/or the derived physical observables shall constitute the Level 1 data.

JDAT Pipeline Processing and Science Analysis System Driving Requirements (Cont.)

Level 2-3 Science Data Products for HMI Instrument Data

(JDAT_014200) The JSOC shall produce the standard data products.

Data Archive

(JDAT_014300) All raw telemetry data shall be archived on two separate media. One for local storage, the other for off-site storage.

(JDAT_014400) All level 0 data shall be archived.

(JDAT_014500) Archiving of high level data products is optional as deemed appropriate.

JDAT Pipeline Processing and Science Analysis System Driving Requirements (Cont.)

Data Distribution

(JDAT_014600) Data for exploration, analysis, comparison, and interpretation shall be extracted from the JSOC archive.

(JDAT_014700) The archive shall have the potential for the selection of observables, times and places, and temporal and spatial scales and resolution.

(JDAT_014800) All of the HMI and AIA basic data products will be available for export.

(JDAT_014900) The internal representation of the data shall be transformed and exported in standard fits files with embedded keywords.

(JDAT_015000) Requested data products not currently on-line will automatically be retrieved from archive storage.

(JDAT_015100) Very large data requests will be copied to external media and delivered offline.

(JDAT_015200) The HMI/AIA data catalogs will be both directly accessible via the web and accessible via the VSO.

(JDAT_015300) Any existing telemetry dataset shall be capable of being exported to an external user via user initiated export requests. [JDP]

System Infrastructure

(JDAT_015400) The system shall support multi-user and multi-tasking capabilities and provide for process scheduling, control and inter-process communications.

(JDAT015500) The system shall manage disk storage for all datasets that transit through the system. Automatic storage assignment, retention and deletion shall be provided.

(JDAT_015600) Programs shall access data by abstract dataset names which shall be resolved automatically to physical files.

(JDAT_015700) A central database shall provide for keyword and image data cataloging.

(JDAT_015800) Central message and error logging facilities shall be provided.

(JDAT_015900) Debug modes shall be integrated into the system functions.

(JDAT_016000) There shall be a data quality tracking and reporting subsystem.

(JDAT_016100) There shall be a central event handling facility to allow process scheduling and error handling.

Flight Dynamic Products

(JDAT_016200)

Each SOC shall be able to receive flight dynamics products from the MOC at Goddard needed to plan science operations and process science data. The specific products received by each SOC and their format shall be documented in the MOC/SOC ICD. [MSI S1.3:3]

(JDAT_016300)

Each SOC shall use the Flight Dynamic Products to do further data processing as needed to meet the science data requirements. [JDP]

(JDAT_016400)

The Flight Dynamic Products data shall be further processed to create the ancillary data values to be use for the Science Data Products. [TBD]

(JDAT_016600) The Flight Dynamic Product data shall be used to create a list of events to help determine the quality of the science data. [TBD]

MOC Operational Reports

(JDAT_016800) JDAT capable to receive operational reports

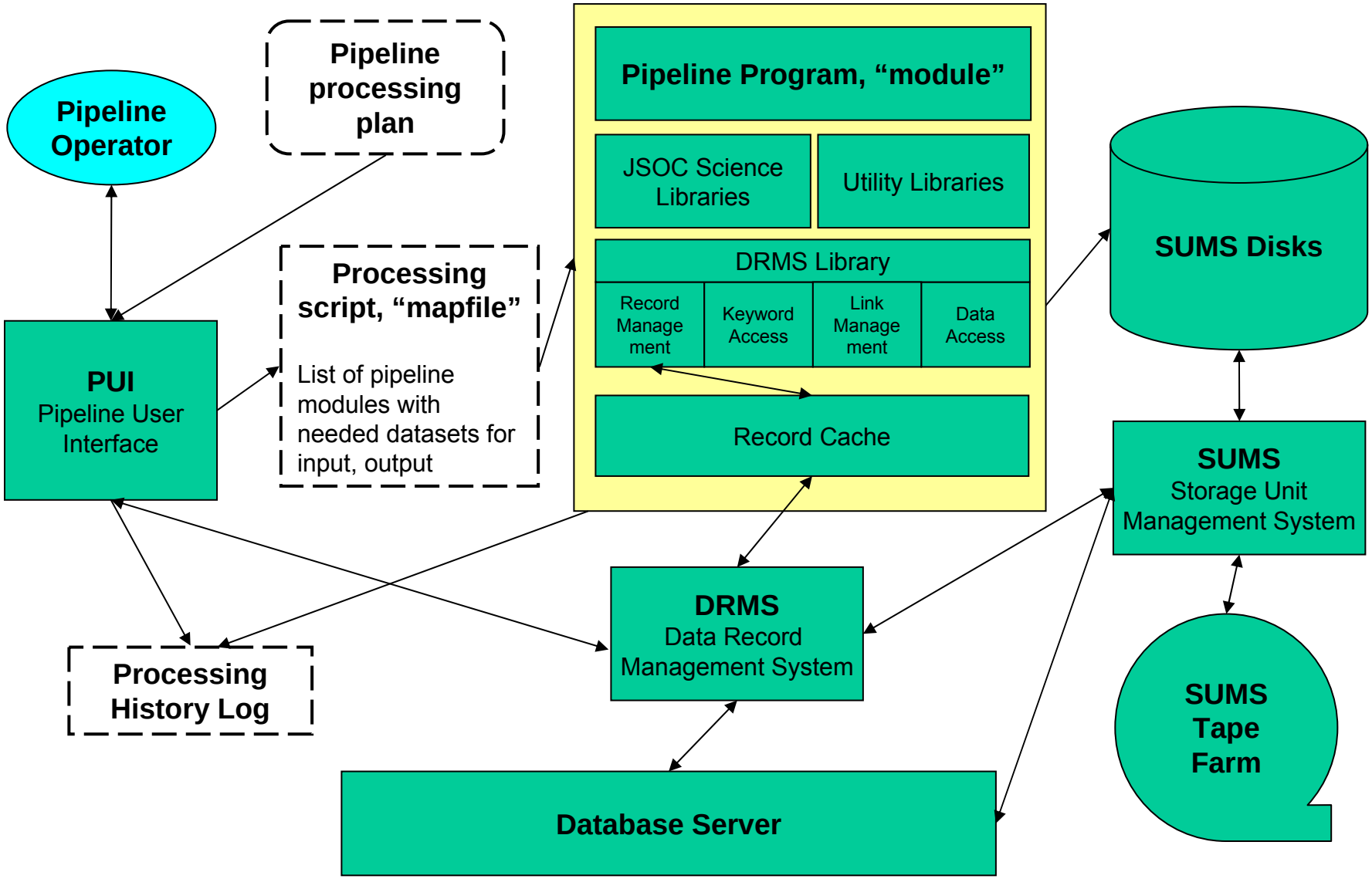
Each SOC shall be capable of receiving various operational reports from the MOC. These include trending reports, command history report, event log reports, time and time correlation log. [MSI]

(JDAT_016900) JDAT use report formats outlined in MOC/SOC ICD

The specific reports received by each SOC and their format shall be documented in the MOC/SOC ICD. [MSI]

JIM

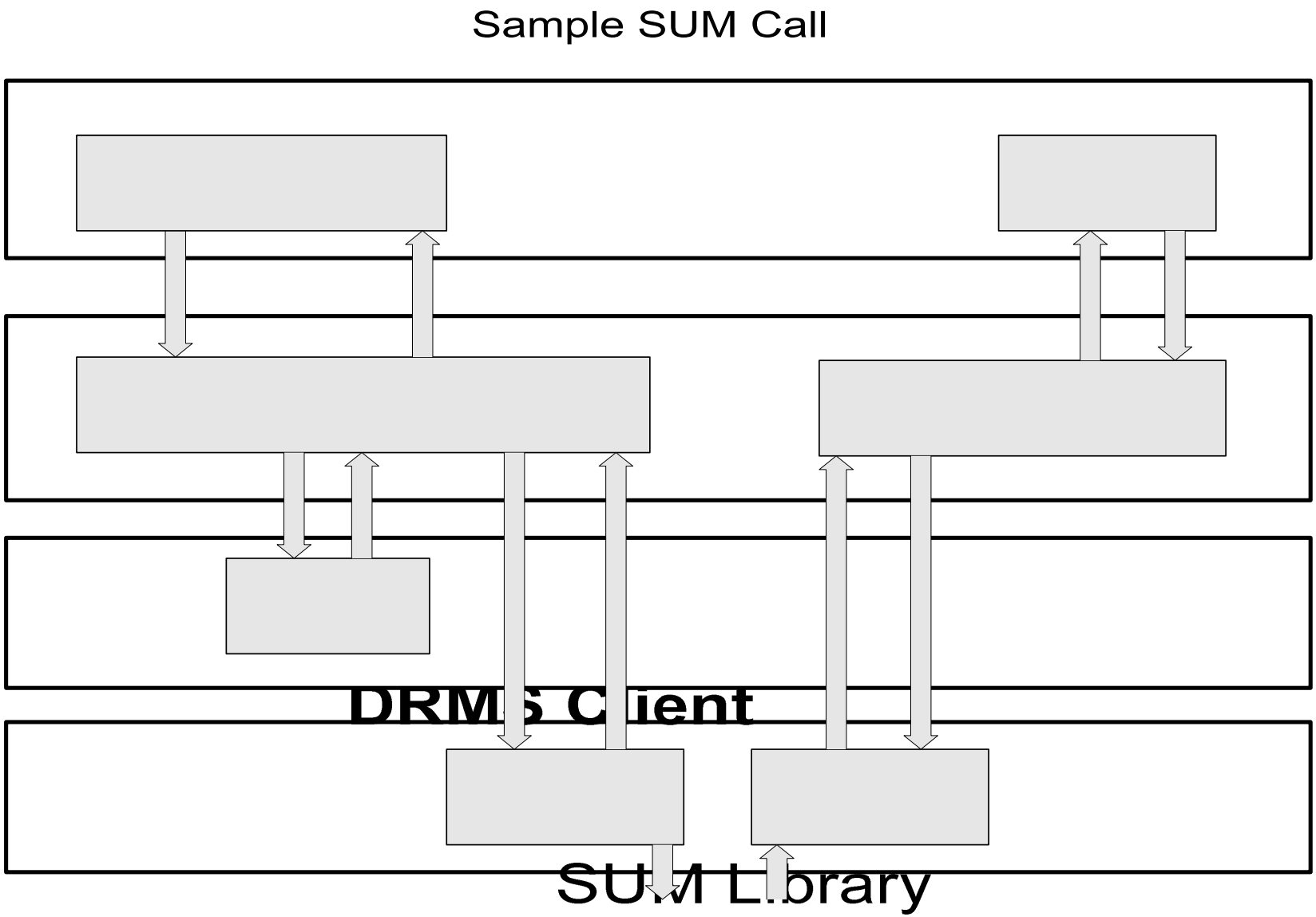
JSOC Pipeline Processing System Components



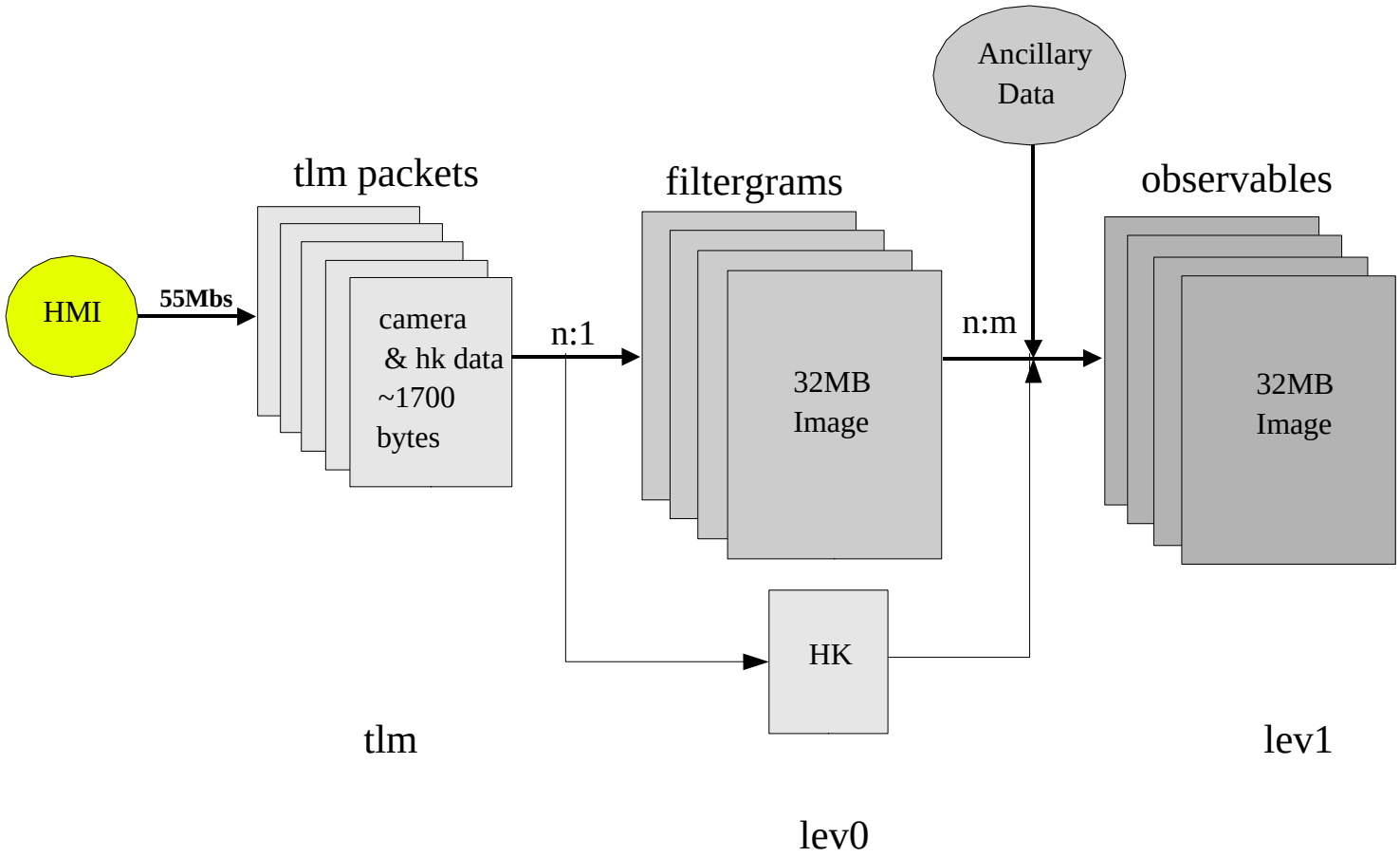
Storage Unit Management Sybsystem (SUMS) API

- **SUM *SUM_open(char *dbname)**
  Start a session with the SUMS
- **int SUM_close(SUM *sum)**
  End a session with the SUMS
- **int SUM_alloc(SUM *sum)**
  Allocate a storage unit on the disks
- **int SUM_get(SUM *sum)**
  Get the requested storage units
- **int SUM_put(SUM *sum)**
  Put a previously allocated storage unit
- **int SUM_poll(SUM *sum)**
  Check if a previous request is complete
- **int SUM_wait(SUM *sum)**
  Wait until previous request is complete

SUM_get() API Call Sequence

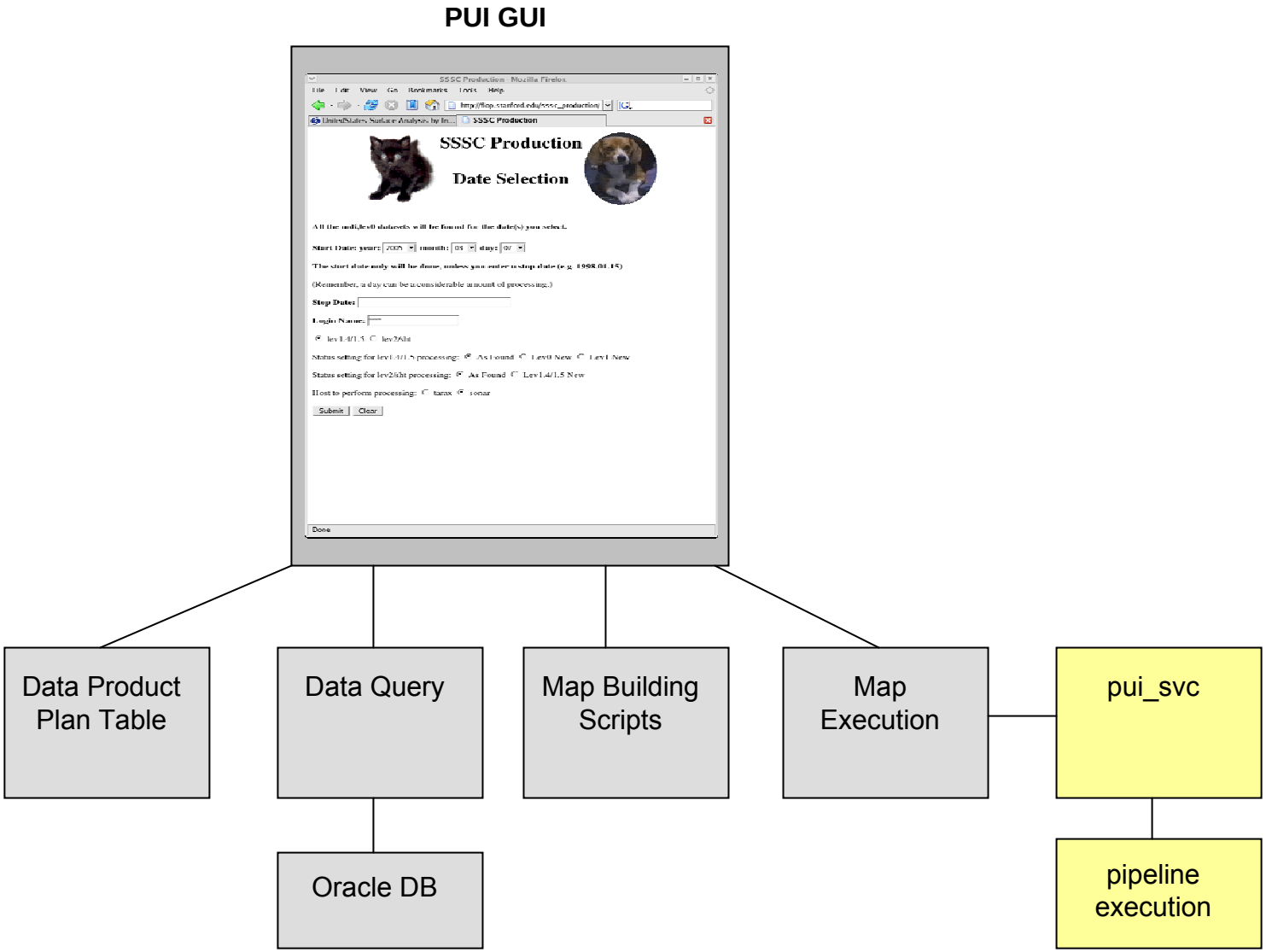


HMI Dataset Sequence

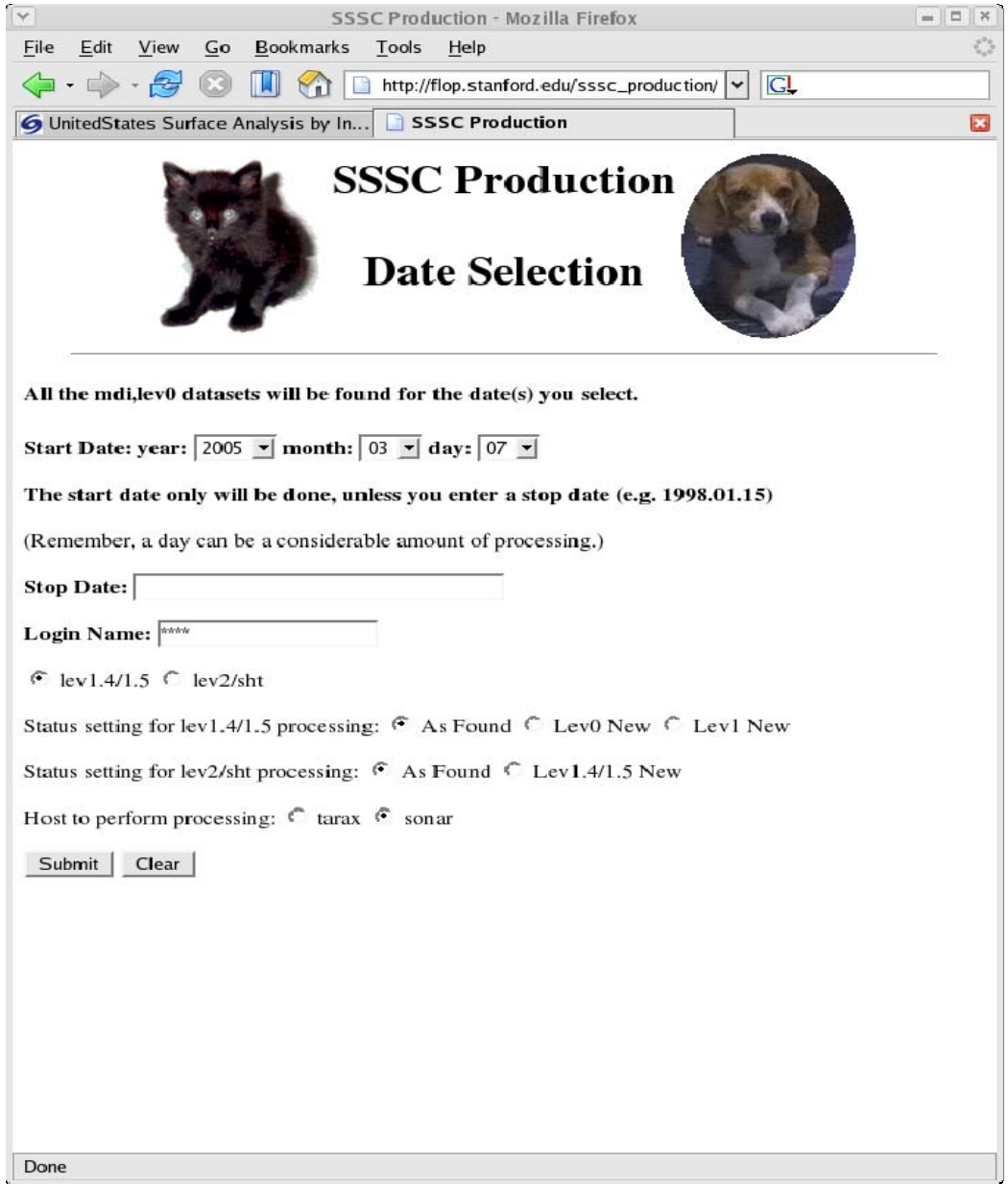


/home/jim/soffice/user/work/dataset_seq3.sxd

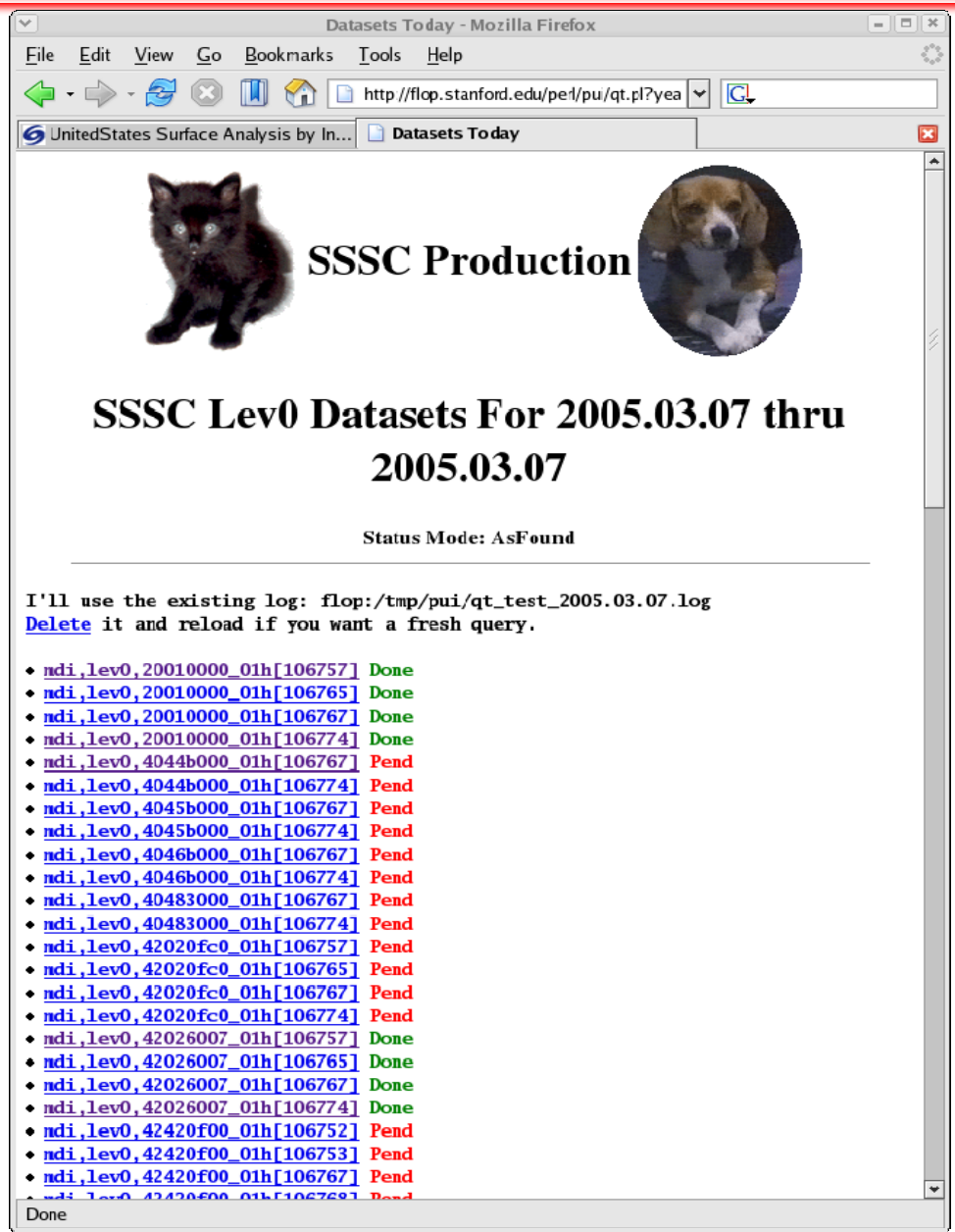
Pipeline User Interface (PUI) Block Diagram



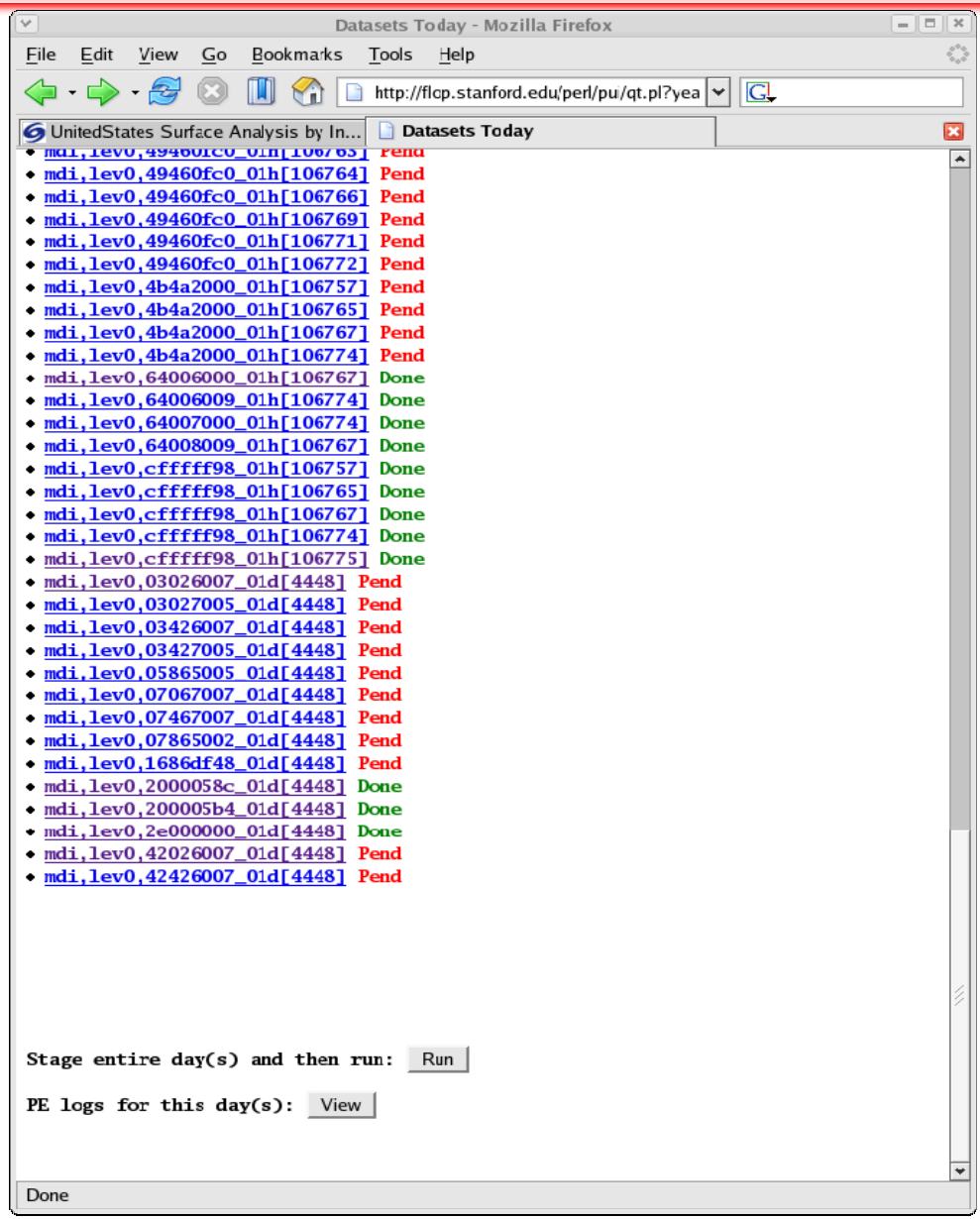
Pipeline User Interface (PUI)



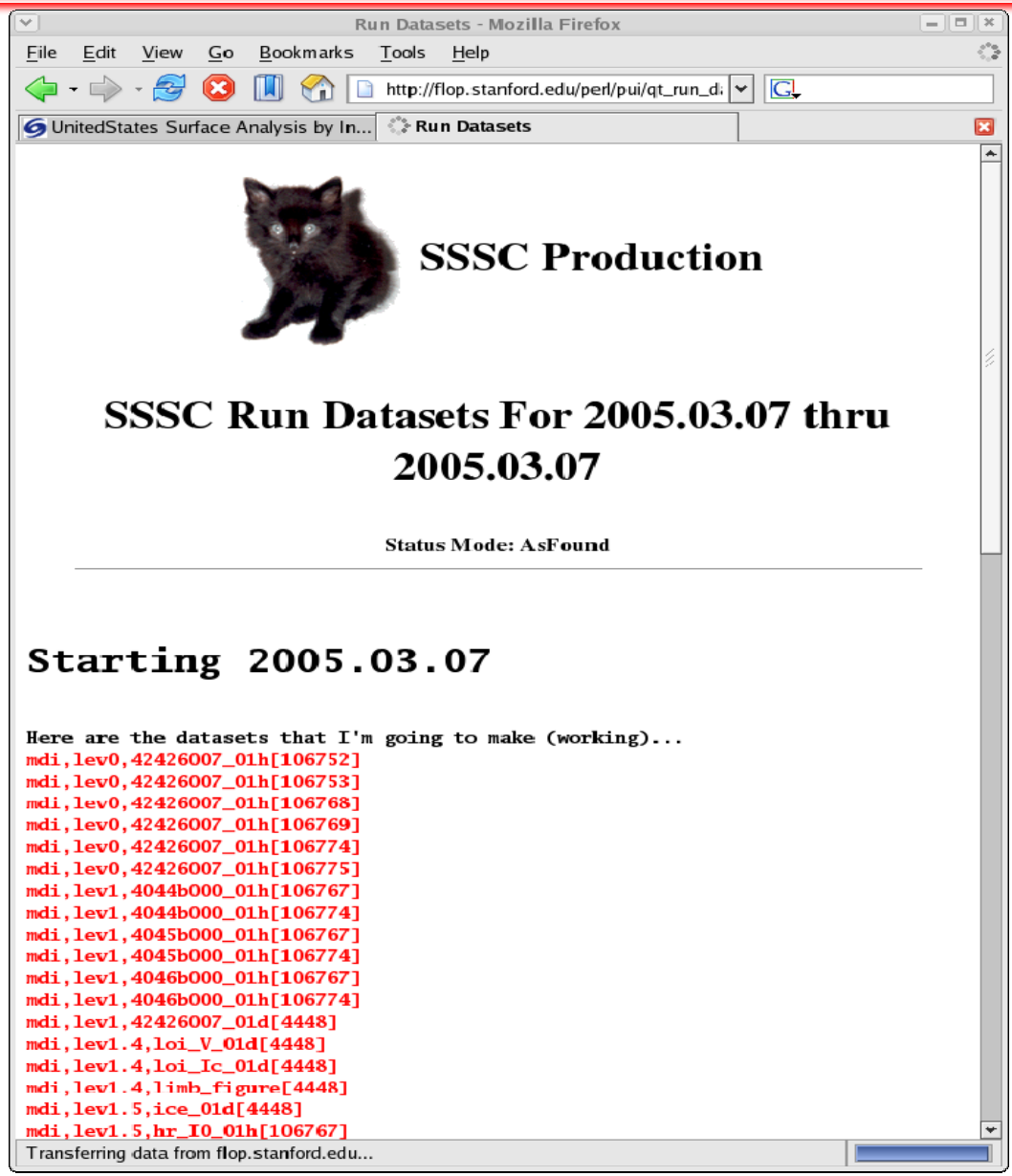
Pipeline User Interface (PUI)



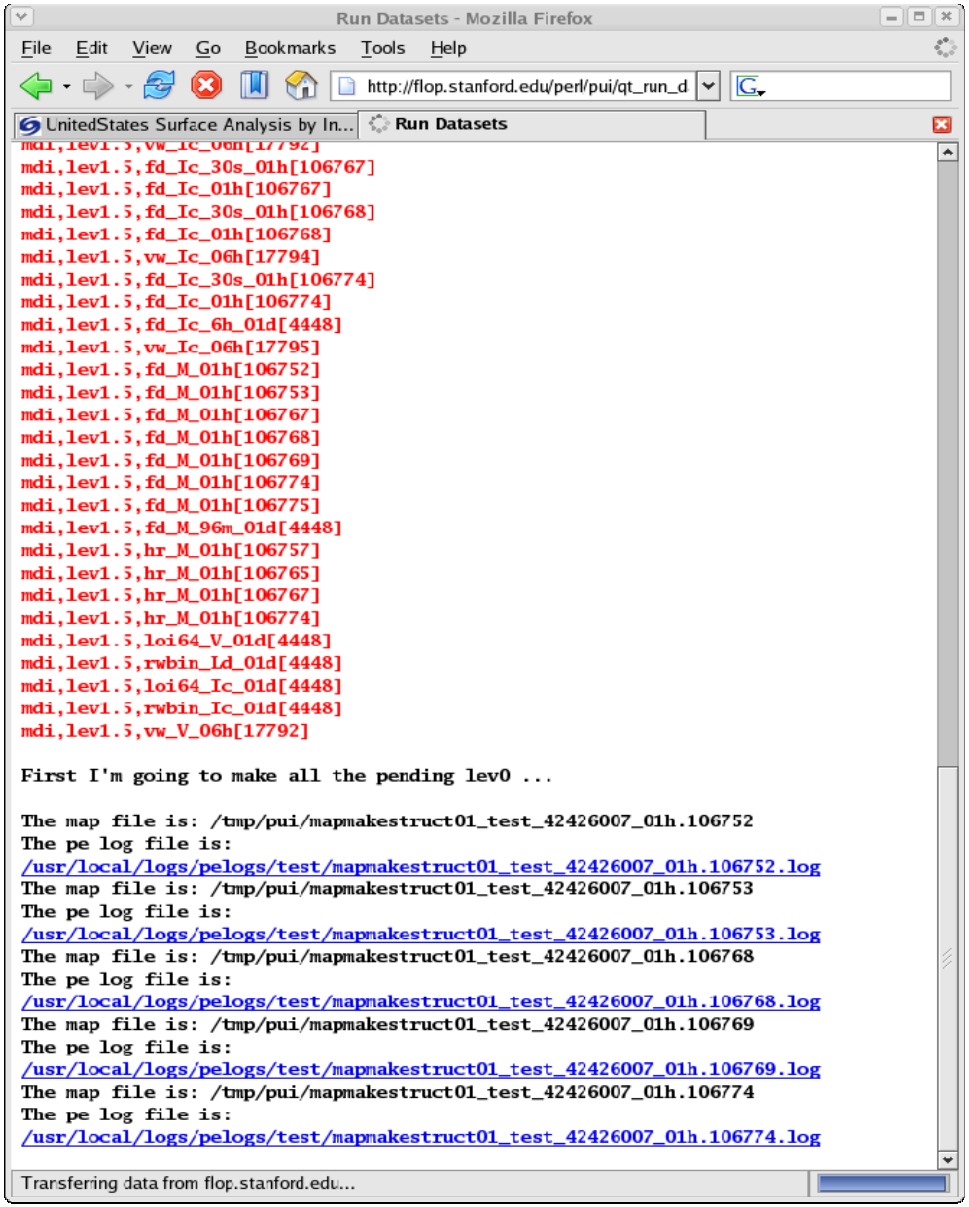
Pipeline User Interface (PUI)



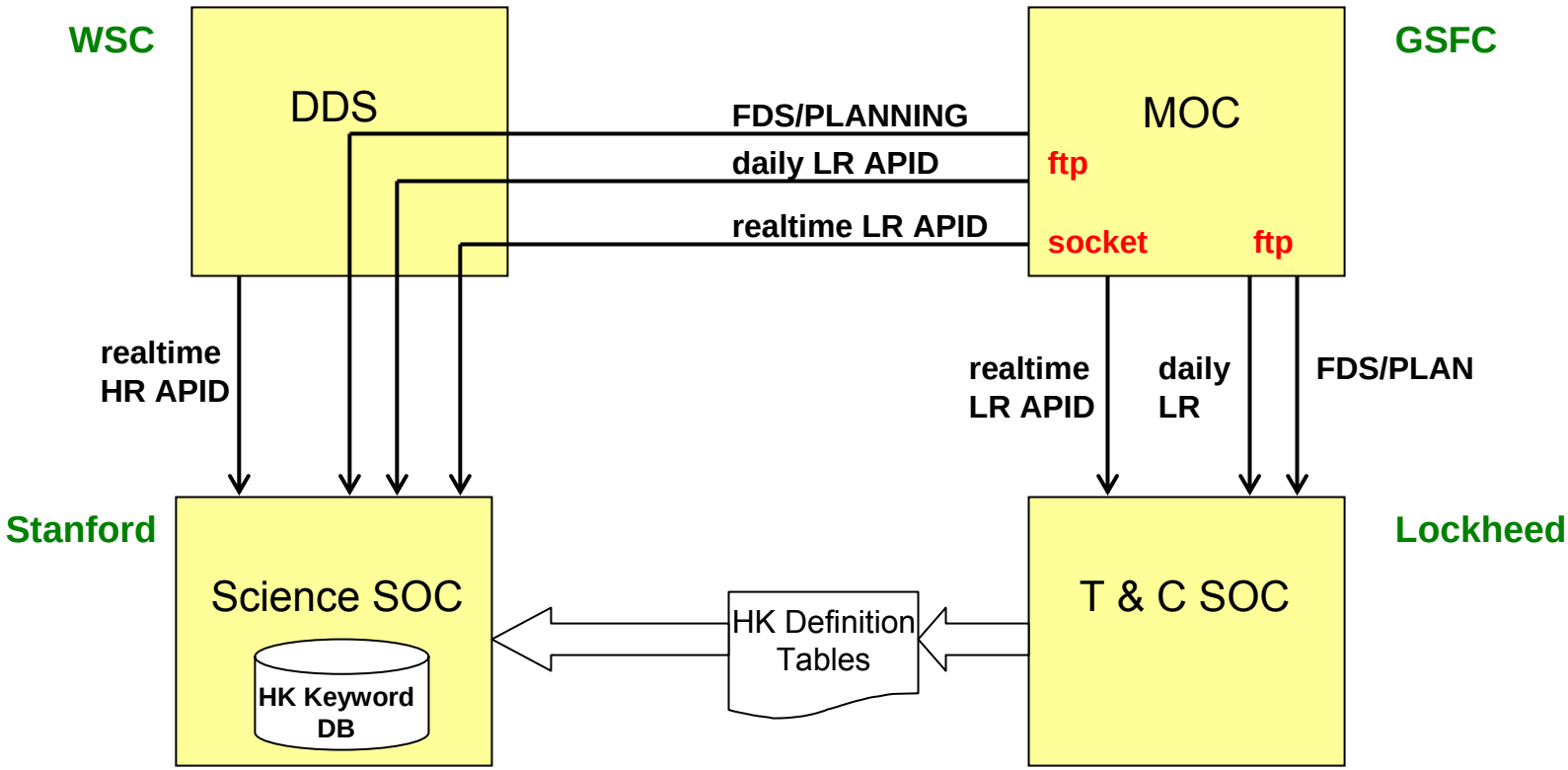
Pipeline User Interface (PUI)



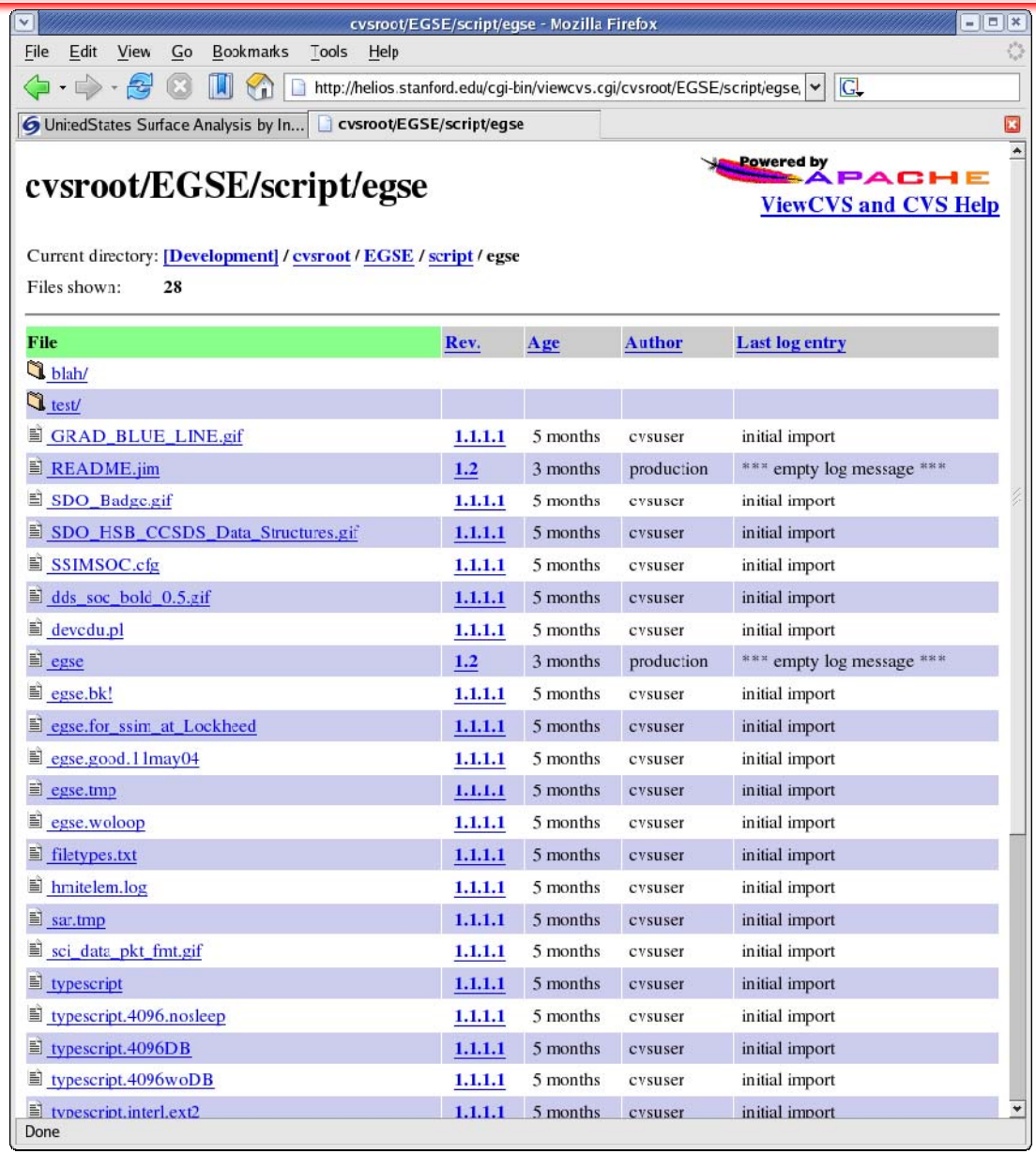
Pipeline User Interface (PUI)



HK Data Flow


WSC
DDS
GSFC
MOC
FDS/PLANNING
daily LR APID
realtime LR APID
ftp
socket
ftp
realtime
HR APID
realtime
LR APID
daily
LR
FDS/PLAN
Stanford
Science SOC
HK Keyword
DB
HK Definition
Tables
T & C SOC
Lockheed

CM with CVS


cvsroot/EGSE/script/egse - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://helios.stanford.edu/cgi-bin/viewcvs.cgi/cvsroot/EGSE/script/egse/
UnitedStates Surface Analysis by In...
cvsroot/EGSE/script/egse
cvsroot/EGSE/script/egse
Powered by APACHE
ViewCVS and CVS Help
Current directory: [Development] / cvsroot / EGSE / script / egse
Files shown: 28
File | Rev. | Age | Author | Last log entry
blah/
test/
GRAD_BLUE_LINE.gif | 1.1.1.1 | 5 months | cvsuser | initial import
README.jim | 1.2 | 3 months | production | *** empty log message ***
SDO_Badge.gif | 1.1.1.1 | 5 months | cvsuser | initial import
SDO_HSB_CCSDS_Data_Structures.gif | 1.1.1.1 | 5 months | cvsuser | initial import
SSIMSOC.cfg | 1.1.1.1 | 5 months | cvsuser | initial import
dds_soc_bold_0.5.gif | 1.1.1.1 | 5 months | cvsuser | initial import
devcdu.pl | 1.1.1.1 | 5 months | cvsuser | initial import
egse | 1.2 | 3 months | production | *** empty log message ***
egse.bk! | 1.1.1.1 | 5 months | cvsuser | initial import
egse.for_ssim_at_Lockheed | 1.1.1.1 | 5 months | cvsuser | initial import
egse.good.11may04 | 1.1.1.1 | 5 months | cvsuser | initial import
egse.tmp | 1.1.1.1 | 5 months | cvsuser | initial import
egse.woloop | 1.1.1.1 | 5 months | cvsuser | initial import
filetypes.txt | 1.1.1.1 | 5 months | cvsuser | initial import
hmitelem.log | 1.1.1.1 | 5 months | cvsuser | initial import
sar.tmp | 1.1.1.1 | 5 months | cvsuser | initial import
sci_data_pkt_fmt.gif | 1.1.1.1 | 5 months | cvsuser | initial import
typescript | 1.1.1.1 | 5 months | cvsuser | initial import
typescript.4096.nosleep | 1.1.1.1 | 5 months | cvsuser | initial import
typescript.4096DB | 1.1.1.1 | 5 months | cvsuser | initial import
typescript.4096woDB | 1.1.1.1 | 5 months | cvsuser | initial import
typescript.interl.ext2 | 1.1.1.1 | 5 months | cvsuser | initial import
Done

RASMUS

JSOC Pipeline Processing:
Data organization, Infrastructure, and Data Products

Rasmus Munk Larsen, Stanford University

rmunk@quake.stanford.edu

650-725-5485

Overview

- JSOC data series organization
- Pipeline execution environment and architecture
- User libraries
- Co-I analysis module contribution
- Pipeline Data Products

JSOC data organization

- **Evolved from FITS-based MDI dataset concept to**
  - Fix known limitations/problems
  - Accommodate more complex data models required by higher-level processing
- **Main design features**
  - Lesson learned from MDI: Separate meta-data (keywords) and image data
    - No need to re-write large image files when only keywords change (lev1.8 problem)
    - No (fewer) out-of-date keyword values in FITS headers
    - Can bind to most recent values on export
  - Easy data access through query-like dataset names
    - All access in terms of sets of data records, which are the “atomic units” of a data series
    - A *dataset name* is a query specifying a set of data records (possibly from multiple data series):
      - `jsoc:hmi_lev0_fg[recordnum=12345]` (a specific filtergram with unique record number 12345)
      - `jsoc:hmi_lev0_fg[12300-12330]` (a minute’s worth of filtergrams)
      - `jsoc:hmi_fd_V[T_OBS>=‘2008-11-01’ AND T_OBS<‘2008-12-01’ AND N_MISSING<100]`
  - Storage and tape management must be transparent to user
    - Chunking of data records into storage units for efficient tape/disk usage done internally
    - Completely separate storage and catalog (i.e. series & record) databases: more modular design
    - Legacy MDI modules should run on top of new storage service
  - Store meta-data (keywords) in relational database (Oracle)
    - Can use power of relational database to rapidly find data records
    - Easy and fast to create time series of any keyword value (for trending etc.)
    - Consequence: Data records for a given series must be well defined (i.e. have a fixed set of keywords)

Logical Data Organization

JSOC Data Series

Data records for series hmi_fd_V

Single **hmi_fd_V data** record

hmi_lev0_cam1_fg
aia_lev0_cont1700
hmi_lev1_fd_M
hmi_lev1_fd_V
aia_lev0_FE171
• • •

hmi_lev1_fd_V#12345
hmi_lev1_fd_V#12346
hmi_lev1_fd_V#12347
hmi_lev1_fd_V#12348
hmi_lev1_fd_V#12349
hmi_lev1_fd_V#12350
hmi_lev1_fd_V#12351
hmi_lev1_fd_V#12352
hmi_lev1_fd_V#12353
• • •

Storage Unit
= Directory

Keywords:

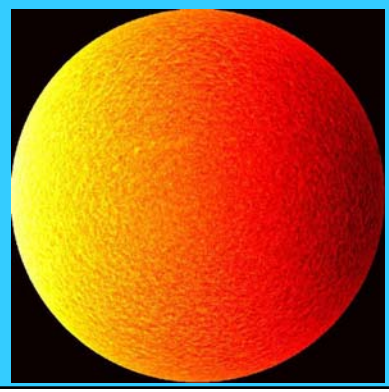
RECORDNUM = 12345 # Unique serial number
SERIESNUM = 5531704 # Slots since epoch.
T_OBS = '2009.01.05_23:22:40_TAI'
DATAMIN = -2.537730543544E+03
DATAMAX = 1.935749511719E+03
...
P_ANGLE = LINK:ORBIT,KEYWORD:SOLAR_P
…

Links:

ORBIT = hmi_lev0_orbit, SERIESNUM = 221268160
CALTABLE = hmi_lev0_dopcal, RECORDNUM = 7
L1 = hmi_lev0_cam1_fg, RECORDNUM = 42345232
R1 = hmi_lev0_cam1_fg, RECORDNUM = 42345233
…

Data Segments:

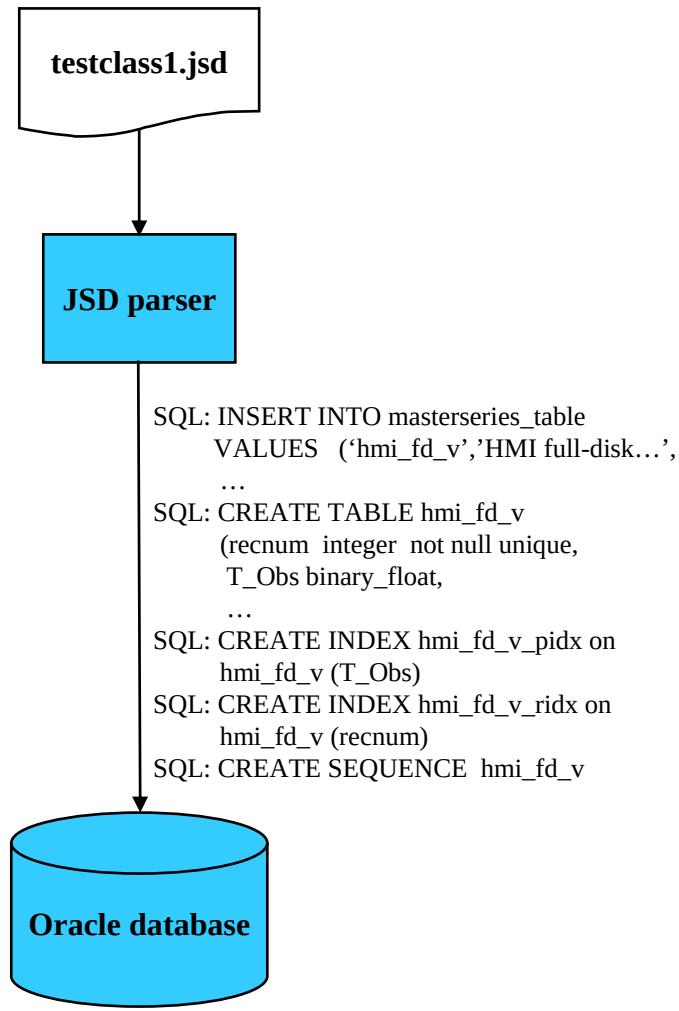
Velocity =



JSOC Series Definition (JSD)

```
#======================= Global series information  ====================
Seriesname:     “hmi_fd_v"
Description:    “HMI full-disk Doppler velocity. ..."
Author:         “Rasmus Munk Larsen"
Owners:         “production"
Unitsize:       90
Archive:        1
Retention:      40000
Tapegroup:      2
Primary Index:  T_Obs

#============================ Keywords ================================
# Format:
#   Keyword: <name>, <type>, <default value>, <format>, <unit>, <comment>
# or
#   Keyword: <name>, link, <linkname>, <target keyword name>
#
Keyword: “T_Obs",   time,   “1970.01.01_00:00:00_TAI”, "%F %T", “s",
         “Nominal observation time"
Keyword: “D_Mean",  double, 0.0, “%lf", “m/s", “Data mean"
Keyword: “D_Max”,   double, 0.0, “%lf", “m/s", “Data maximum"
Keyword: “D_Min",   double, 0.0, “%lf", “m/s", “Data minimum"
Keyword: ...
Keyword: “P_Angle”, link, “Attitude”, “P_Angle”

#============================ Links ===================================
# Format:
#    Link: <name>, <target series>, { static | dynamic }
#
Link: “L1", “hmi_lev0_fg", static
Link: “R1", “hmi_lev0_fg", static
Link: “L2", “hmi_lev0_fg", static
Link: “R2", “hmi_lev0_fg", static
Link: ...
Link: “Caltable”, “hmi_dopcal”, static
Link: “Attitude”, “sdo_fds”, dynamic

#============================ Data segments ===========================
# Data: <name>, <type>, <naxis>, <axis dims>, <unit>, <protocol>
#
Data: "velocity", float, 2, 4096, 4096, "m/s", fitz
```

Creating a new Data Series:



Global Database Tables

master_series_table:

Series	Author	Created	Description	Archive	Tapegroup	Retention	Owner	Index
hmi_fd_v	Jesper	2006–05–02 10:52:44	Doppler velocity	1	2	40000	production	T_Obs
hmi_lev0_fg	Rasmus	2006–05–02 10:52:42	Filtergram ...	1	1	6000	production	T_Obs
testclass1	Rasmus	2004–10–06 13:14:15	simple testclass	0	0	0	cmunk	Time
...	...	...	...	...	...	...	...	...

master_keyword_table:

Series	Keyword	Type	Scope	Default value	Format	Unit	Linkname	Target Name
hmi_fd_v	T_Obs	datetime	variable	`1970–01–01`	"%F %T"	s	NULL	NULL
hmi_fd_v	D_Mean	float	variable	`0.0`	"%12.5f"	m/s	NULL	NULL
...	...	...	...	...	...	...	...	...
hmi_fd_v	P_Angle	link	NULL	NULL	NULL	NULL	Orbit	PANGLE
hmi_sht_v	lmax	int	variable	`0`	"%d"		NULL	NULL
...	...	...	...	...	...	...	...	...

master_link_table:

Series	Link	Target_Series	Type
hmi_fd_v	Orbit	sdo_fds	dynamic
hmi_fd_v	L1	hmi_fg	static
hmi_fd_v	R1	hmi_fg	static
...	...	...	...
hmi_fd_v	Caltable	hmi_dopcal	static
	...	...	...

master_data_segment_table:

Series	Name	Protocol	Type	Unit	Naxis	Axis
hmi_fd_v	velocity	FITS	float	m/s	2	4096, 4096
hmi_lev0_fg	intensity	FITZ	short		2	4096, 4096
...	...	...	...	...	...	...

Database tables for example series hmi_fd_v

- **Tables specific for each series contain per record values of**
  - Keywords
  - Record numbers of records pointed to by links
  - DSIndex = an index identifying the SUMS storage unit containing the data segments of a record
  - Series sequence counter used for generating unique record numbers

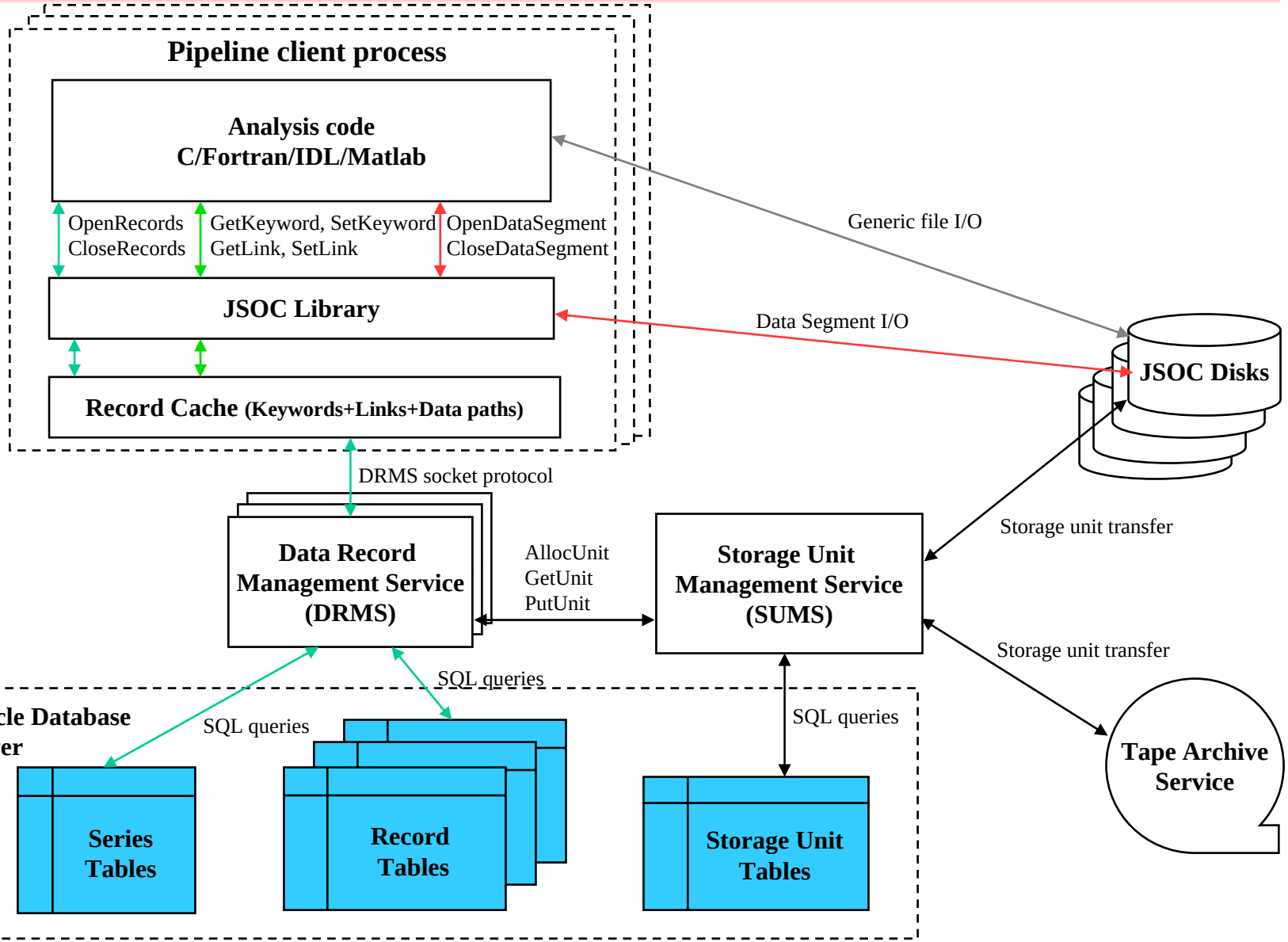
hmi_fd_v:

1D	...	T_Obs	D_Mean	...	Orbit_1D	L1_1D	DSIndex
0	...	`2008...`	123.456	...	7	2341	123456
1	...	`2008...`	123.456	...	7	2341	123457
2	...	`2008...`	234.567	...	8	2361	123456
...	...			...			
9588392	...	`2010...`	234.567	...	48	64112361	123457

hmi_fd_v_seq:

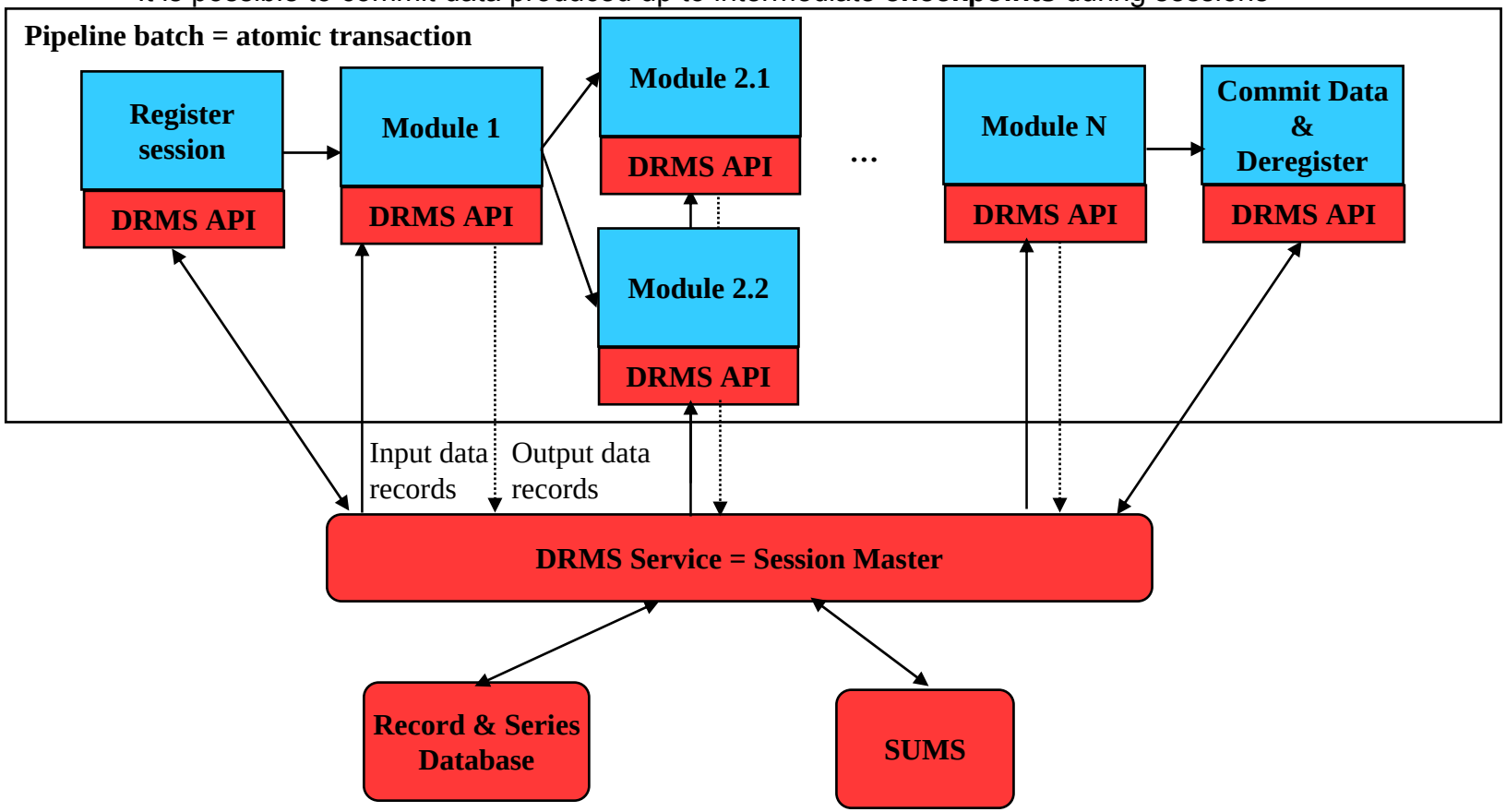
1D
9588392

Pipeline client-server architecture



Pipeline batch processing

- **A pipeline batch is encapsulated in a single database transaction:**
  - If no module fails all data records are **commited** and become visible to other clients of the JSOC catalog at the end of the session
  - If failure occurs all data records are deleted and the database **rolled back**
  - It is possible to commit data produced up to intermediate **checkpoints** during sessions



Sample DRMS client API calls

- `DRMS_Session_t *drms_connect(char *drms_locator, char *username)`
  - Establish socket connection to DRMS server process designated by locator string
  - Retrieve and cache global series information from database
- `void drms_disconnect(DRMS_Session_t *session, int abort)`
  - If abort=0 then commit new storage units (data segments) to SUMS, and commit meta-data to the database
  - If abort=1 then tell SUMS to discard new storage units. Roll back all database (meta-data) manipulations since last commit
  - Close socket connection to DRMS server
- `int drms_commit(DRMS_Session_t *session)`
  - Commit without closing connection
- `DRMS_RecordSet_t *drms_open_records(DRMS_Session_t *session, char *dataset, char *mode)`
  - Parse dataset descriptor in "`dataset`" and generate SQL queries to retrieve the specified records
  - Populate DRMS_Record_t data structures with meta-data from the matching records
  - Extract set of unique DSIndex values from retrieved records and call SUMS to get their online location
  - This call may involve waiting for SUMS to stage data from tape. A non-blocking version will also be provided
  - `mode` can take the values RD (read), CLONE_COPY, CLONE_SHARE. The latter two make new copies of the data records with new unique record numbers
- `DRMS_RecordSet_t *drms_create_records(DRMS_Session_t *session, char *series, int num_recs)`
  - Create `num_recs` new records for the specified series. Assign them new unique record numbers generated by the database
- `char *drms_get_record_path(DRMS_Record_t *record)`
  - Returns a string with the directory in which data (segments) for the record is stored

Example of module code:

- A module doing a (naïve) Doppler velocity calculation could look as shown below
- Usage example: doppler **helios.stanford.edu:33546** "2009.09.01_16:00:00_TAI" "2009.09.01_17:00:00_TAI"

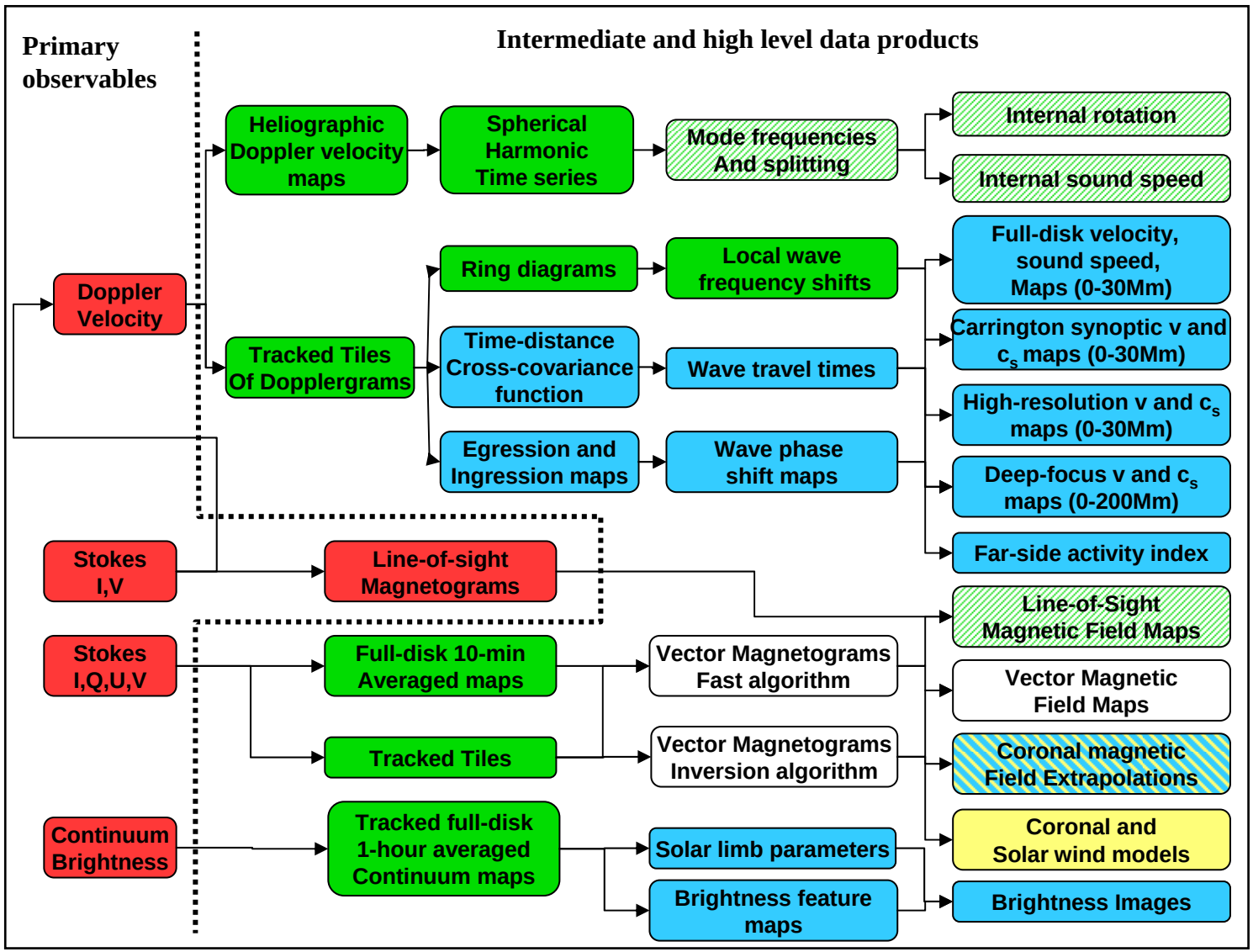
```
int main(int argc, char *argv[])
{
  DRMS_Session_t *session;
  DRMS_RecordSet_t *filtergrams, *dopplergram;
  int first_frame, status;
  char query[1024];

  session = drms_connect(argv[1], “production“, “passwd”);
  sprintf(query, "hmi_lev0_fg[T_Obs>=%s AND T_Obs<%s]",
          argv[2], argv[3]);
  filtergrams = drms_open_records(session, query, "RD", &status);

  if (filtergrams->num_recs==0)
  {
    printf("Sorry, no filtergrams found for that time interval.\n");
    drms_disconnect(session, 1);
    return -1;
  }
```

```
  first_frame = 0; /* Start looping over record set. */
  for (;;)
  {
    first_frame = find_next_framelist(first_frame, filtergrams);
    if (first_frame == -1) /* No more complete framelists. Exit. */
      break;
    dopplergram = drms_create_records(session, "hmi_fd_v", 1,
                                      &status);
    compute_dopplergram(first_frame, filtergrams, dopplergram);
    drms_close_records(session, dopplergram);
  }
  drms_disconnect(session, 0);
  return 0;
}
```

Example continued…

```
int compute_dopplergram(int first_frame, DRMS_RecordSet_t *filtergrams,
                                DRMS_RecordSet_t * dopplergram)
{
  int n_rows, n_cols, tuning;
  DRMS_Segment_t *fg[10], *dop;
  short *fg_data[10], *pol;
  float *dop_data;
  char linkname[3];

  /* Get pointers for doppler data array. */
  dop = drms_open_datasegment(dopplergram->records[0], "v_doppler", "RDWR");
  n_cols = drms_getaxis(dop, 0);
  n_rows = drms_getaxis(dop, 1);
  dop_data = (float *)drms_getdata(dop, 0, 0);

  /* Get pointers for filtergram data arrays and set associated link in dopplergram record. */
  for (i=first_frame; i<first_frame+10; i++)
  {
     fg[i] = drms_open_datasegment( filtergrams->records[i], "intensity", "RD");
     fg_data[i] = (short *)drms_getdata(fg, 0, 0);
     pol = drms_getkey_string(filtergrams->records[i], "Polarization");
     tuning = drms_getkey_int(filtergrams->records[i], "Tuning");
     sprintf(linkname,"%c%1d",pol[0],tuning);
     drms_set_link(dopplergram->records[0], linkname, filtergrams->records[i]->recnum);
}

  /* Do the actual Doppler computation.*/
  calc_v(n_cols, n_rows, fg_data, dop_data);
}
```

HMI module status and MDI heritage



- MDI pipeline modules exist
- Standalone production codes in use at Stanford
- Research codes in use at Stanford
- Codes being developed in the community
- Codes developed at HAO
- Codes developed at Stanford

Analysis modules: co-I contributions and collaboration

- **Contributions from co-I teams:**
  - Software for intermediate and high level analysis modules
  - Output data series definition
    - Keywords, links, data segments, size of storage units etc.
  - Documentation (detailed enough to understand the contributed code)
  - Test data and intended results for verification
  - Time
    - Explain algorithms and implementation
    - Help with verification
    - Collaborate on improvements if required (e.g. performance or maintainability)
- **Contributions from HMI team:**
  - Pipeline execution environment
  - Software & hardware resources (Development environment, libraries, tools)
  - Time
    - Help with defining data series
    - Help with porting code to JSOC API
    - If needed, collaborate on algorithmic improvements, tuning for JSOC hardware, parallelization
    - Verification

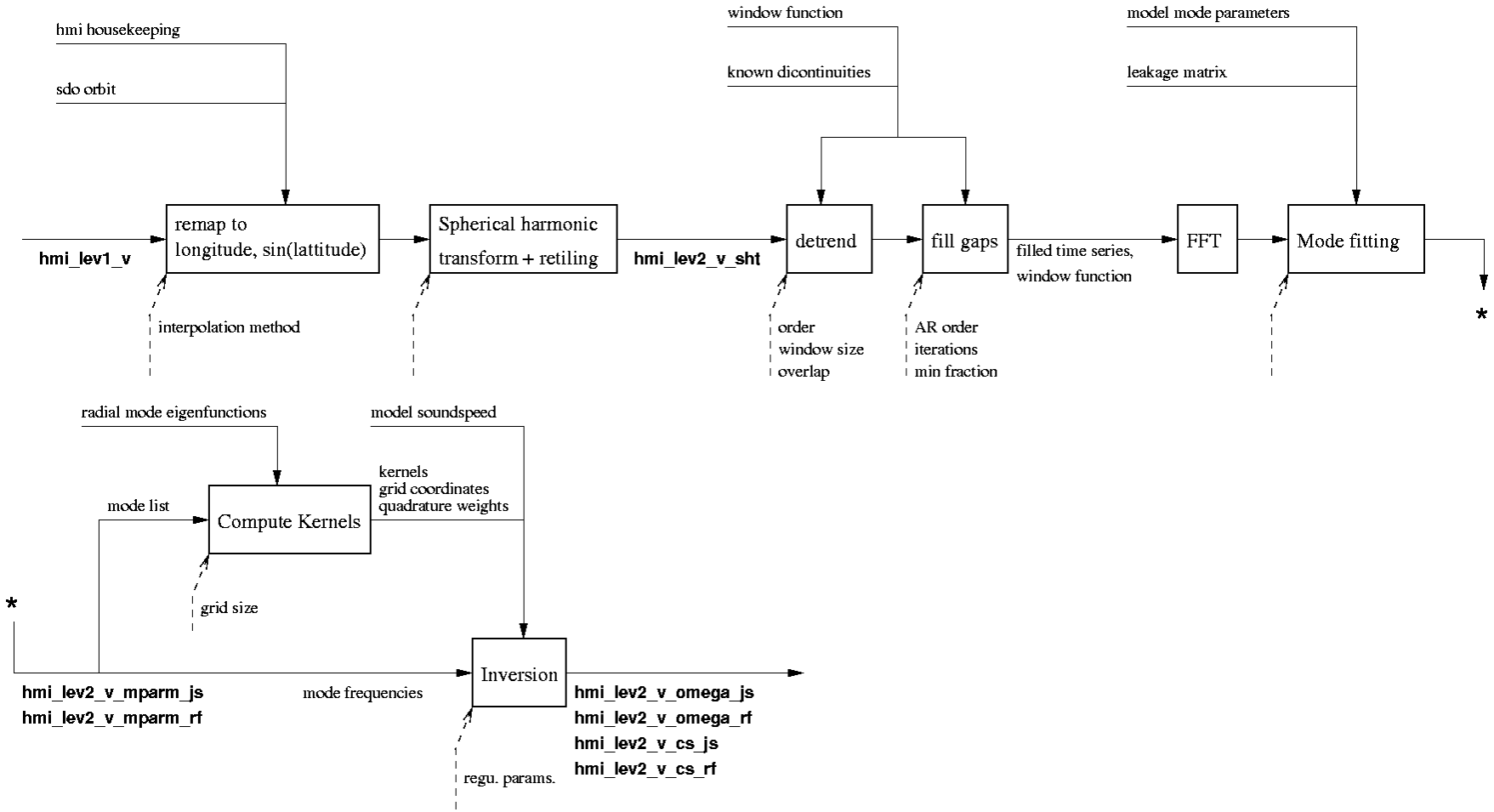
Questions addressed by HMI team meeting Jan. 2005

- **List of standard science data products**
  - Which data products, including intermediate ones, should be produced by JSOC?
  - What cadence, resolution, coverage etc. will/should each data product have?
    - Eventually a JSOC series description must be written for each one.
  - Which data products should be computed on the fly and which should be archived?
  - Have we got the basic pipeline right? Are there maturing new techniques that have been overlooked?
  - **Have preliminary list. Aiming to have final list by November 2005.**

- **Detailing each branch of the processing pipeline**
  - What are the detailed steps in each branch?
  - Can some of the computational steps be encapsulated in general tools that can be shared among different branches (example: tracking)?
  - What are the computer resource requirements of computational steps?

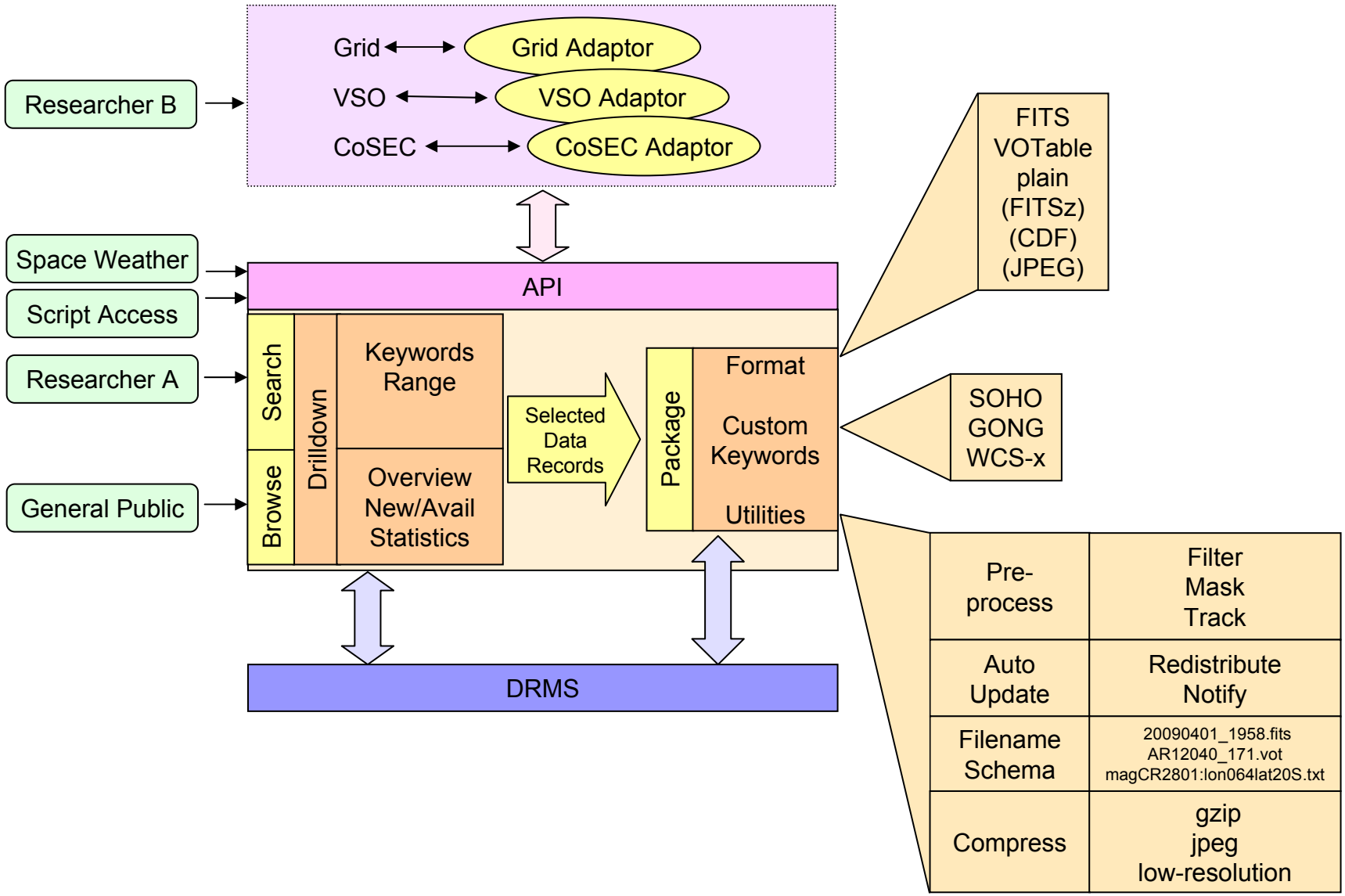
- **Contributed analysis modules**
  - Who will contribute code?
  - Which codes are mature enough for inclusion? Should be at least working research code now, since integration has to begin by c. mid 2006.
  - **Fairly well defined for seismology pipeline, less so for vector magnetic processing. Aiming to have final list of codes to include by April 2006.**

Example: Global Seismology Pipeline



Karen

JSOC Data Export System



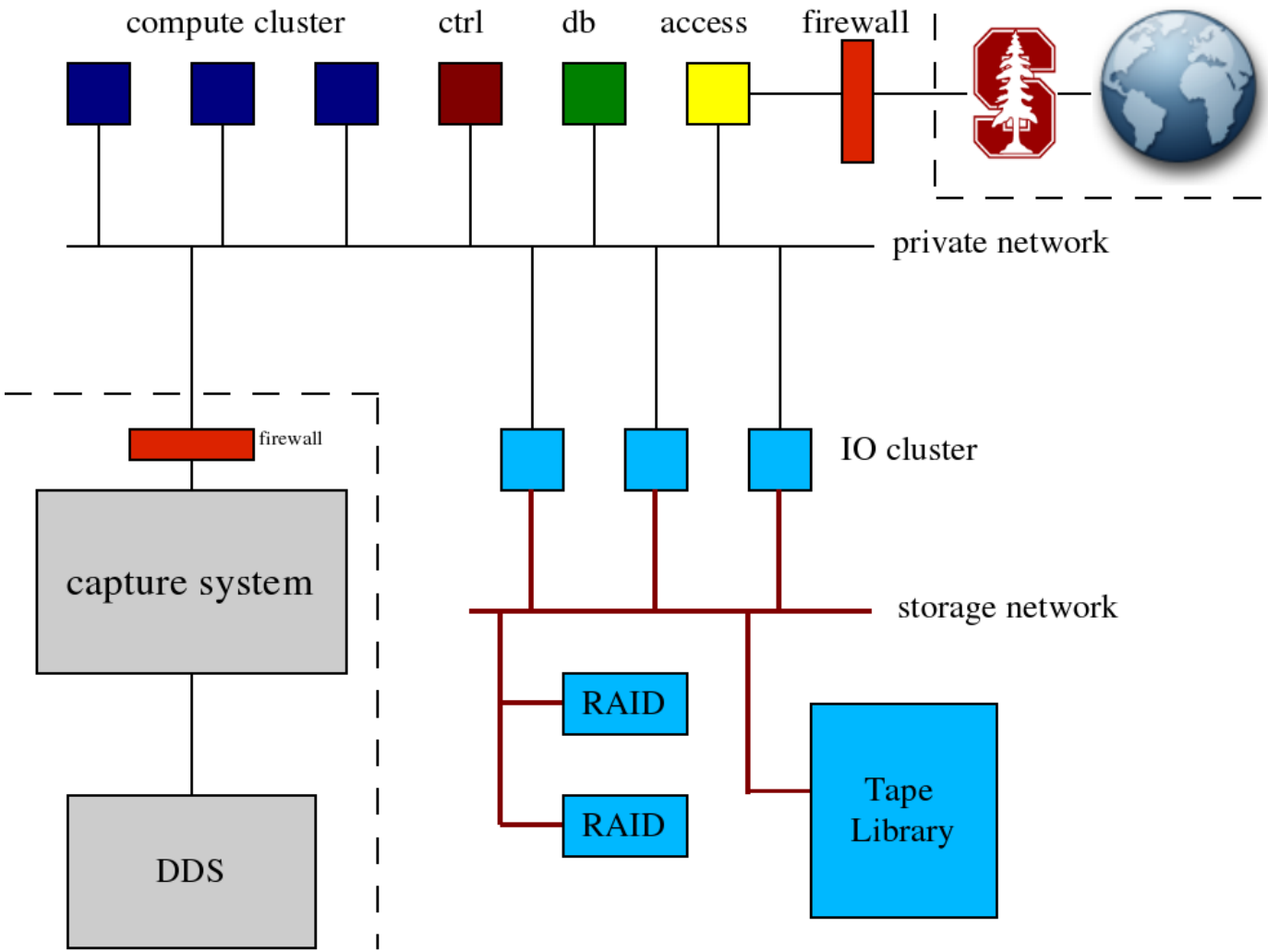
Keh-Cheng

JDAT Production Hardware

- **Compute nodes (< 100)**
  - 2-, 4-, 8-multicore processors per node
  - 16+ GB per processor
  - 64-bit linux
- **Database nodes (< 5)**
  - Oracle cluster
  - 5 TB shared database volume
- **I/O nodes (< 10)**
  - High-availability NFS server cluster
  - Multiple fibre channel connections to non-shared disks and tape drives
  - Multiple gigabit ethernet connections to compute nodes
- **RAID disk storage**
  - 400 TB initially
  - 100 TB annual increment
  - SATA drives (500 GB today)
- **Tape Archive**
  - Two PB-sized tape libraries initially
  - ½ PB per library annual increment
  - SAIT (500 GB, 30 MB/s today) or LTO (400 GB, 80 MB/s today)

JDAT Prototype

JDAT network



Reality Check

- **AIA/HMI combined data volume** — **2 PB/yr = 60 MB/s**
  - read + write — x 2
  - quick look + final — x 2
  - one reprocessing — x 2
  - 25% duty cycle — x 4

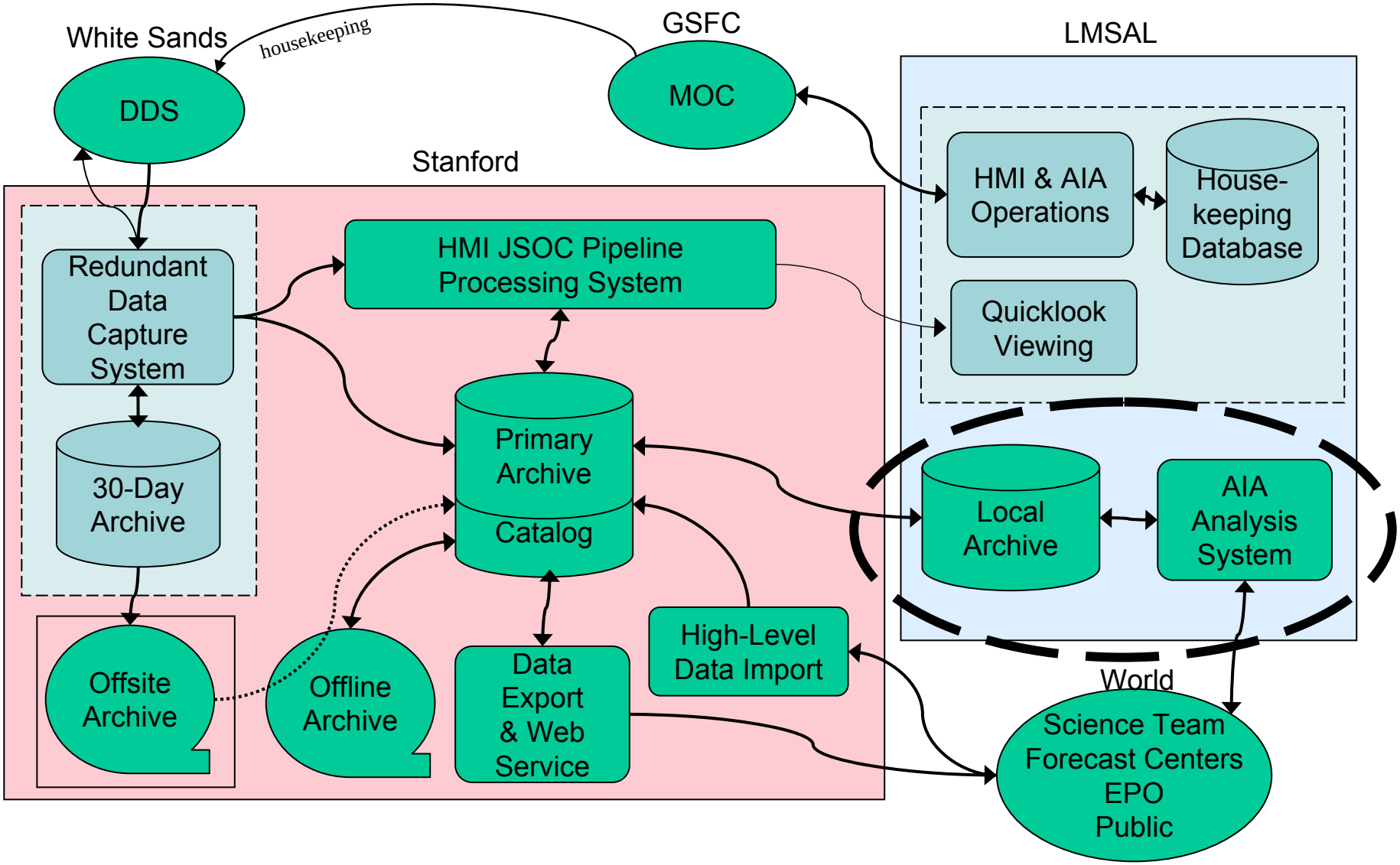
  2 GB/s (disk)

  1/2 GB/s (tape)

- **NFS over gigabit ethernet** — **50 – 100 MB/s**
  - 4 – 8 channels per server, 5 servers (today)
- **SAIT-1 native transfer rate** — **25 – 30 MB/s**
  - 10 SAIT-1 drives per library, 2 libraries (today)

Neal

HMI & AIA JSOC Architecture



AIA Science Data Processing Infrastructure

Neal Hurlburt

AIA Data Scientist

hurlburt@lmsal.com

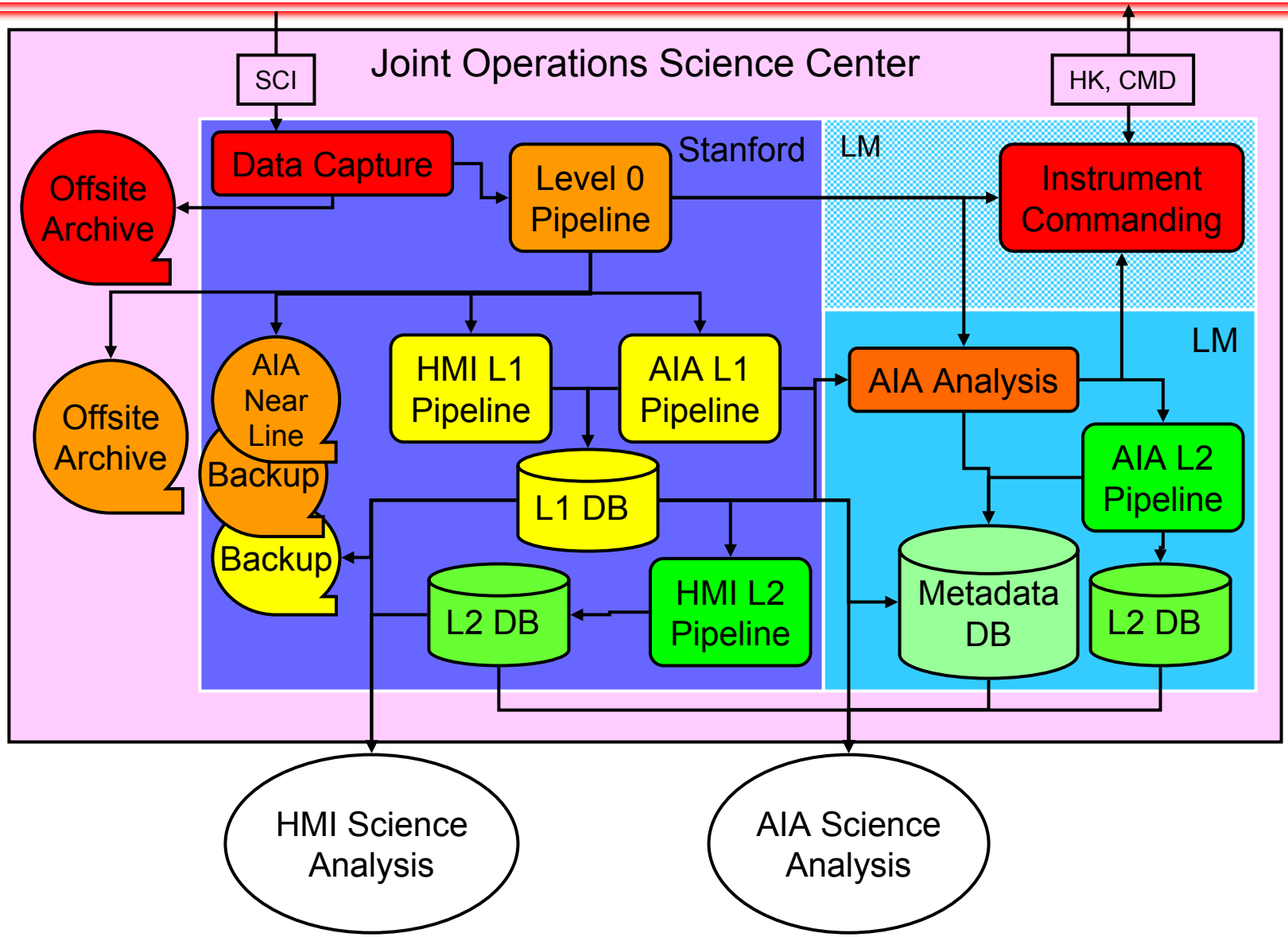
AIA Data Products 1

- **Level 0 (Available to entire science team)**
  - "Raw" files (images) in JDAT database in internal HMI format
    - Available within minutes of receipt
    - Updated for lost or erroneous packets as needed for first 30 days
    - Retrieved as FITS
  - Housekeeping and calibration/configuration data
- **Level 1 (Available to public)**
  - Flat-fielded with best available calibration and de-spike at time of creation
  - Standard Products (Level 1a)
    - Generated soon after first receipt of Level 0 data
    - Low resolution summary image sets (1Kx1K intensity scaled images)
    - Full-resolution active region image sets
    - Notable features and events image sets
  - Custom products via web services

AIA Data Products 2

- **Level 2**
  - De-convolved; temperature maps; irradiance curves; field line models
- **Metadata**
  - Scaled, colorized, compressed & annotated movies of L1 Standard Products
  - Image catalogs, features & events, observer logs, notes, processing heritage

JSOC Processing



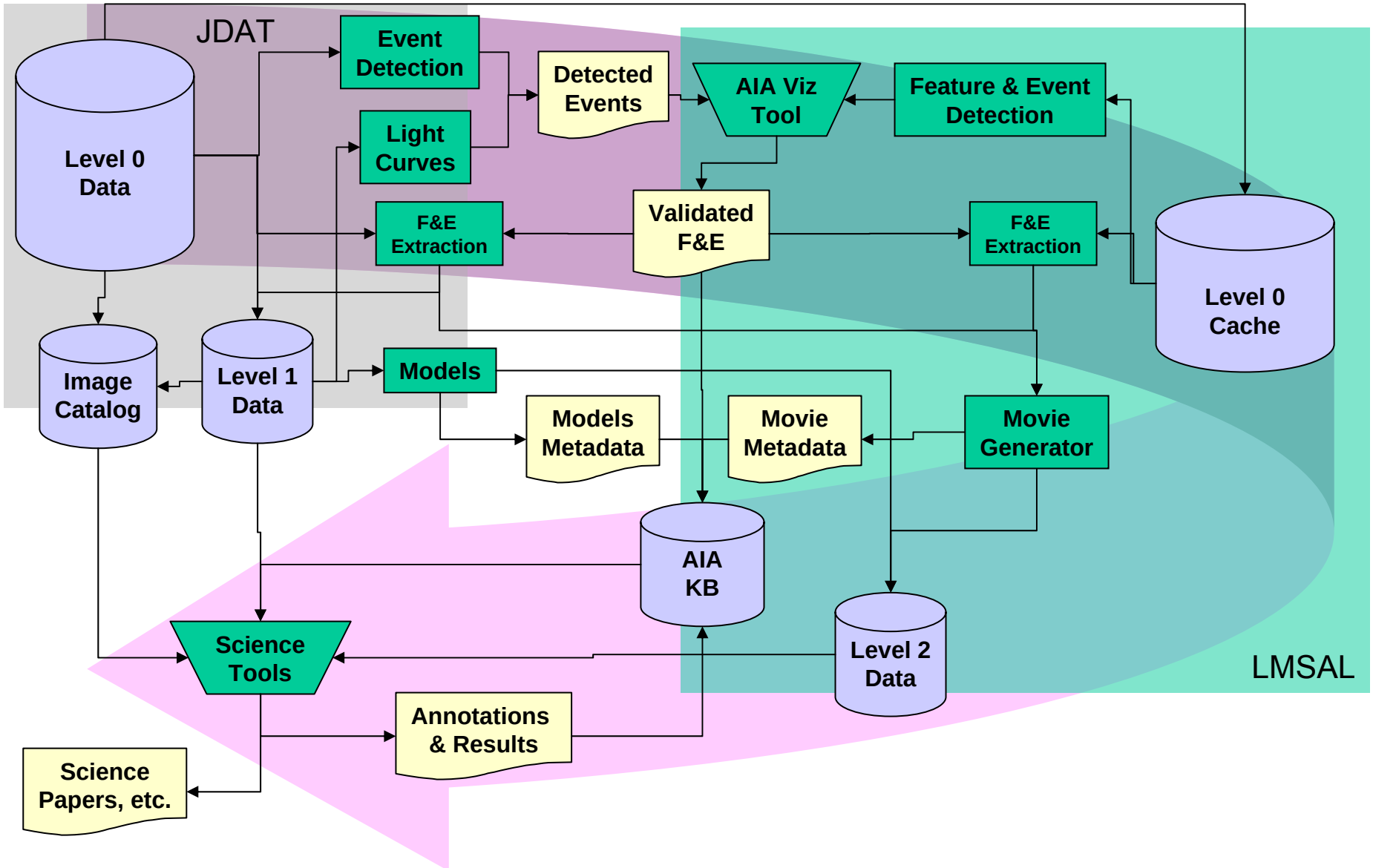
AIA Level 2 & Metadata Compute Needs

- **CPU Requirements:**
  - Spec CF2000_rate>500
  - ~32p SGI Altix 350 w/1.6GHz Itanium2
    - Total today (Mar 2005): ~$250K
- **Disks**:
  - 90-day cache of Level 0 (100 TB)
  - all of the Level 2 data and Metadata for the life of mission (20 TB/yr) on RAID arrays
  - 100TB of cache for interim processing.
  - Total disk: 300 TB.
  - Fibrechannel RAID array with SATA disks
    - $2.3 per GB (Apple XRAID 5.6TB/$13k).
  - With 3x improvement in price/performance: $250K
- **Visualization**
  - Two 16 Mpixel workstations w/control software for viewing 16Mp movies
    - Today: 2p 2.5GHz Mac G5 w/dual IBM T221 displays ~$25k each
  - Large Screen display (6-2560x1600 LCD displays) ~$20k today
- **Network**
  - Gigabit between Stanford and LMSAL (5x sustained L0 dataflow)
  - T3+ to community

AIA Data Services

- **Flare & CME Alerts**
  - Automated notices during standard processing (~minutes)
  - Light curves of events (~minutes)
  - Alerts and log entries from AIA analysis staff (~hours)
- **Online Browse & search tools**
  - Movies, image thumbnails and image catalogs
  - Integrated Summaries (e.g., “The Sun today”)
  - Searchable knowledgebase including:
    - Notable events & features
    - Daily summaries & observer logs
    - Processing heritage
    - Annotations by data users
    - Related higher-level data products & models
  - Custom products via web services
  - Similar to TRACE today
  - Time & wavelength selection, image cutouts, custom calibrations

DRAFT AIA Operational Dataflow



AIA JSOC Schedule

- **AIA Level 0/1 Pipeline Infrastructure**
  - Start prototype Level 0 & Level 1 pipeline modules — Dec 2005
  - Fully functional modules — Jan 2008
  - Data capture from SU — Dec 2005
  - Infrastructure operational — April 2007
- **AIA Analysis & Level 2 Infrastructure**
  - Prototype Analysis system — June 2005
  - Infrastructure operational — April 2007
  - Level 2 Science modules — Jan 2008
- **Metadata Infrastructure**
  - Prototype based on Solar-B — Nov 2006
  - Operational — Jan 2008

AIA Data System Group

- **N. Hurlburt**
  - AIA Data Scientist
  - CoSEC/VSO liaison
- **J. Serafin**
  - Level 0/1 Data Pipeline
  - Data management
- **M. DeRosa**
  - Level 2 Science Algorithms
  - Visualization Tools
- **S. Freeland**
  - Analysis Modules
  - SolarSoft liaison
- **D. Schiff**
  - Web design
  - Web services

JSOC data products and their user base

Data product: Processing Level	Light curves, flare flag and locators *Level 2*	Event log *Metadata*	Summary movies; "the Sun today" *Metadata*	Field, wind, thermal models *Level 2*	Images, movies, descriptions of interesting events *Metadata & Level 1*
Timeliness:	**Within 15 min.**	**1-24 h (autonomous and observer logs)**	**Within 4h, updating**	**Within 1 day at 6h intervals**	**Within 1-7 days**
Supplemental input:	**EVE, NOAA/SEC**	**HMI, NOAA/SEC**	**HMI, EVE**	**HMI**	**Misc.**
Space-weather nowcasting	√	√	√	√	
SDO and other LWS ops. planners	√	√	√		
Space-weather forecasting			√	√	
Observatory planners, observers	√	√	√	√	√
Solar & helio- spheric scientists		√	√	√	√
Geo-seleno space, other planets	√	√	√	√	
Astrophysical community		√	√		√
Press, educators, musems, …	√		√	√	√
Public, E/PO			√	√	√

Generated autonomously by the JDAT pipeline

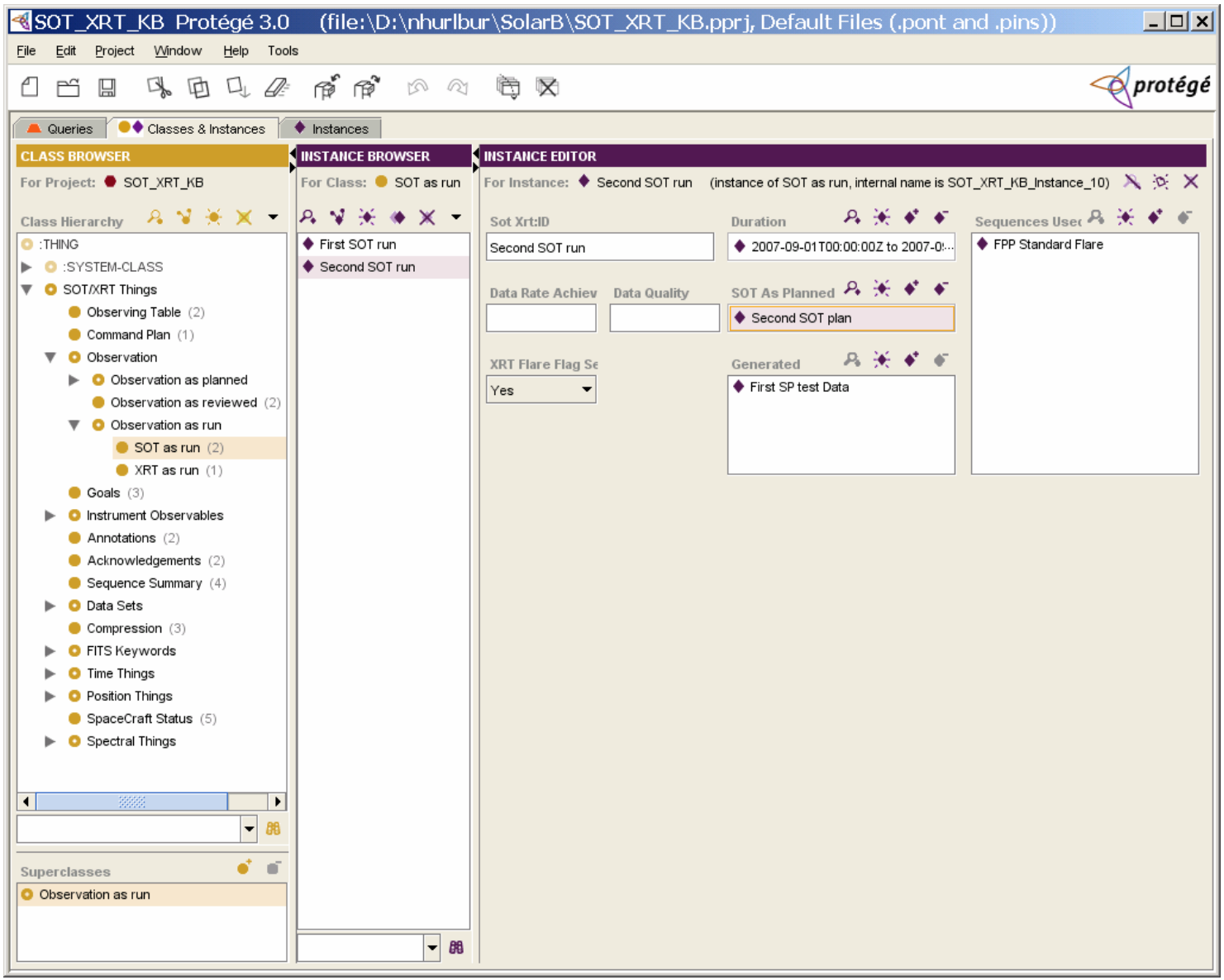
Generated by the JDAT pipeline guided and complemented by LM observers

Generated by LM observers and external scientists

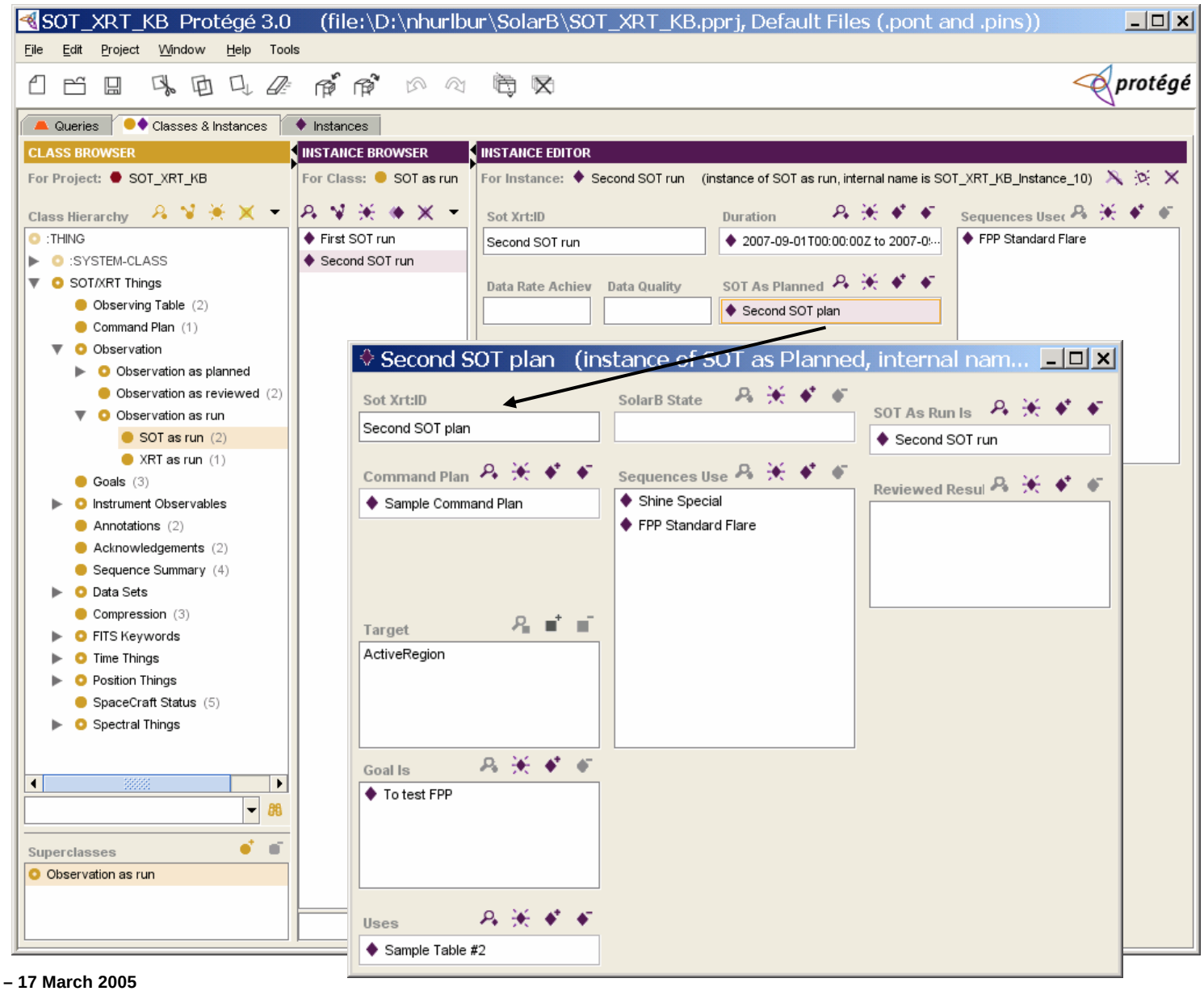
Knowledgebase Example

- **Under development for SolarB mission**
- **Tracks entire data lifecycle**
  - Observation plan
    - Intent & Target
    - Observing program
  - Observations as run
    - Time of observation
    - Data quality & volume
    - Environmental conditions
    - Links to data generated
  - Observations as used
    - User annotations & comments
    - Associated publications

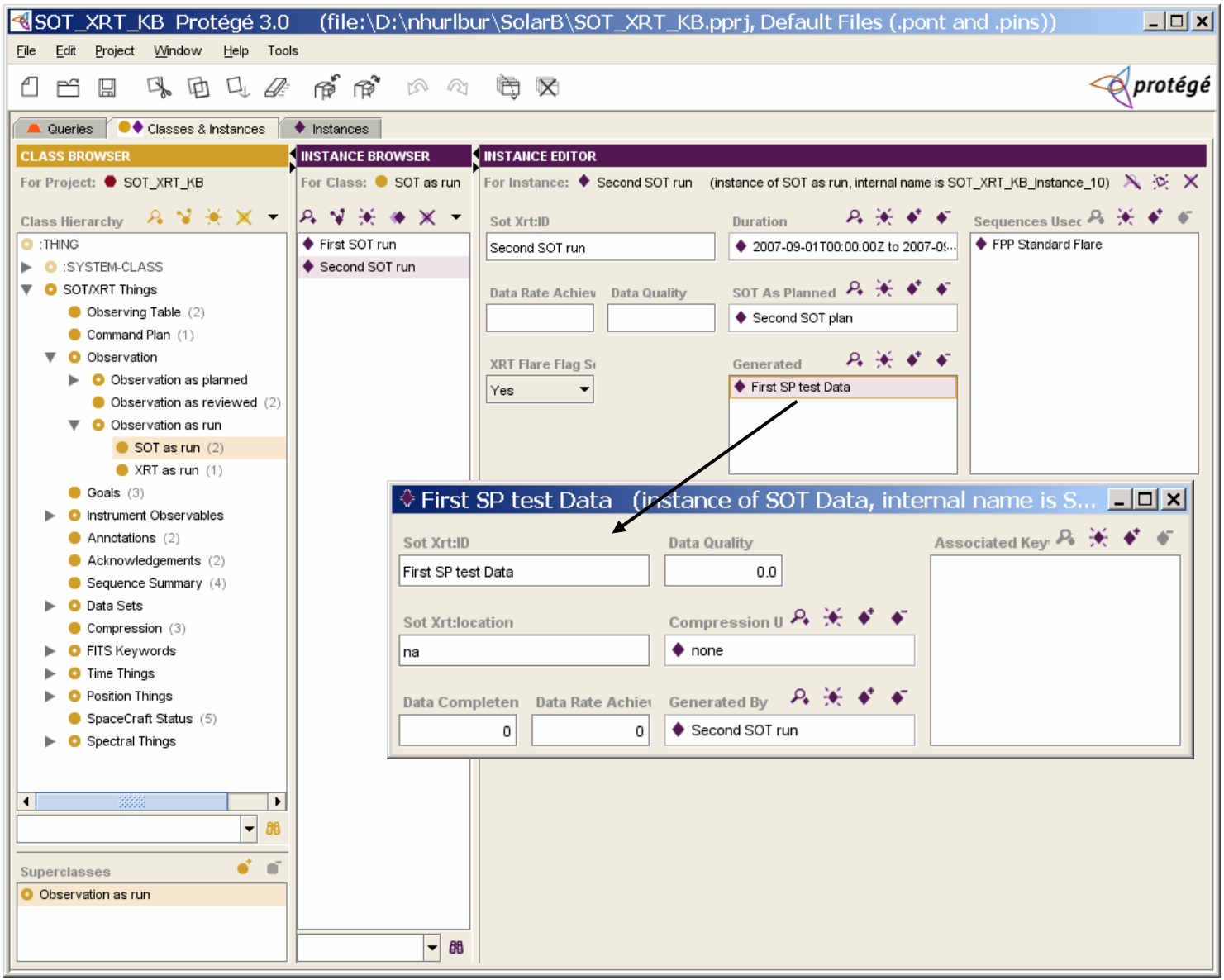
SolarB KB: Observation as run



SolarB KB: Observation as Planned



SolarB KB: Data Products



SolarB KB: User annotation