GLAST Large Area Telescope

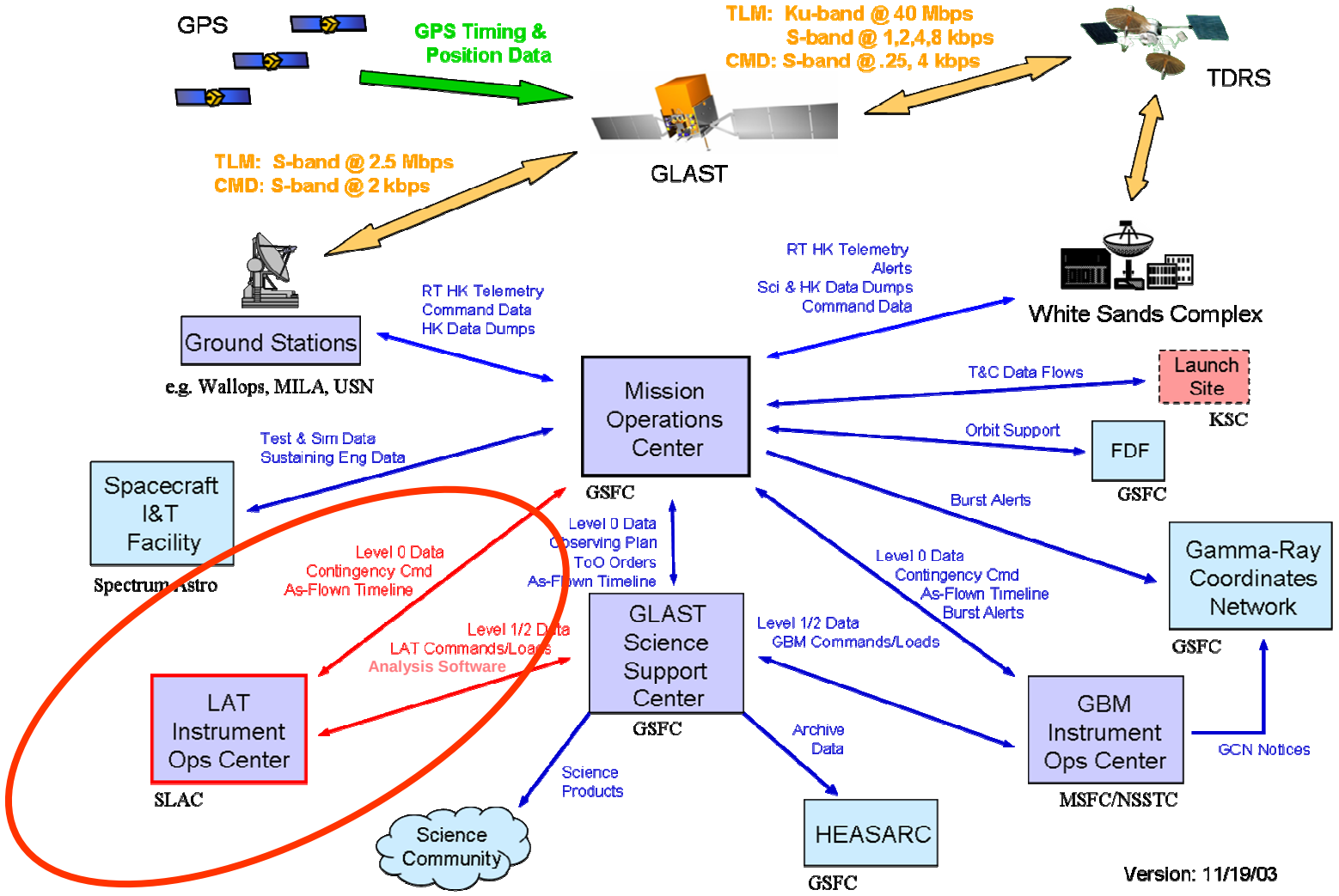
LAT
Instrument Science Operations Center

Rob Cameron
Stanford Linear Accelerator Center
rac@slac.stanford.edu
650-926-2989

Outline

- Overview
- ISOC Organization
  - Commanding, Health and Safety
  - Flight Software
  - Performance Verification and Optimization
  - Science Products
  - Science Analysis Tools
- Operations Scenarios
- Software Architecture and Tools
- Operations Facility Planning
- Development Schedule

LAT ISOC's Role in the GLAST GDS



LAT ISOC Objectives

- The LAT ISOC is organized to:
  - safely operate the instrument
  - produce the LAT science data products
- Functions:
  - Command generation; health and safety monitoring
  - Maintain and modify FSW and Testbed
  - LAT performance verification and optimization
  - Process and archive Level 1 and Level 2 data
  - Maintain and optimize the software pipeline that produces science data products
- These functions are organized as teams that share personnel

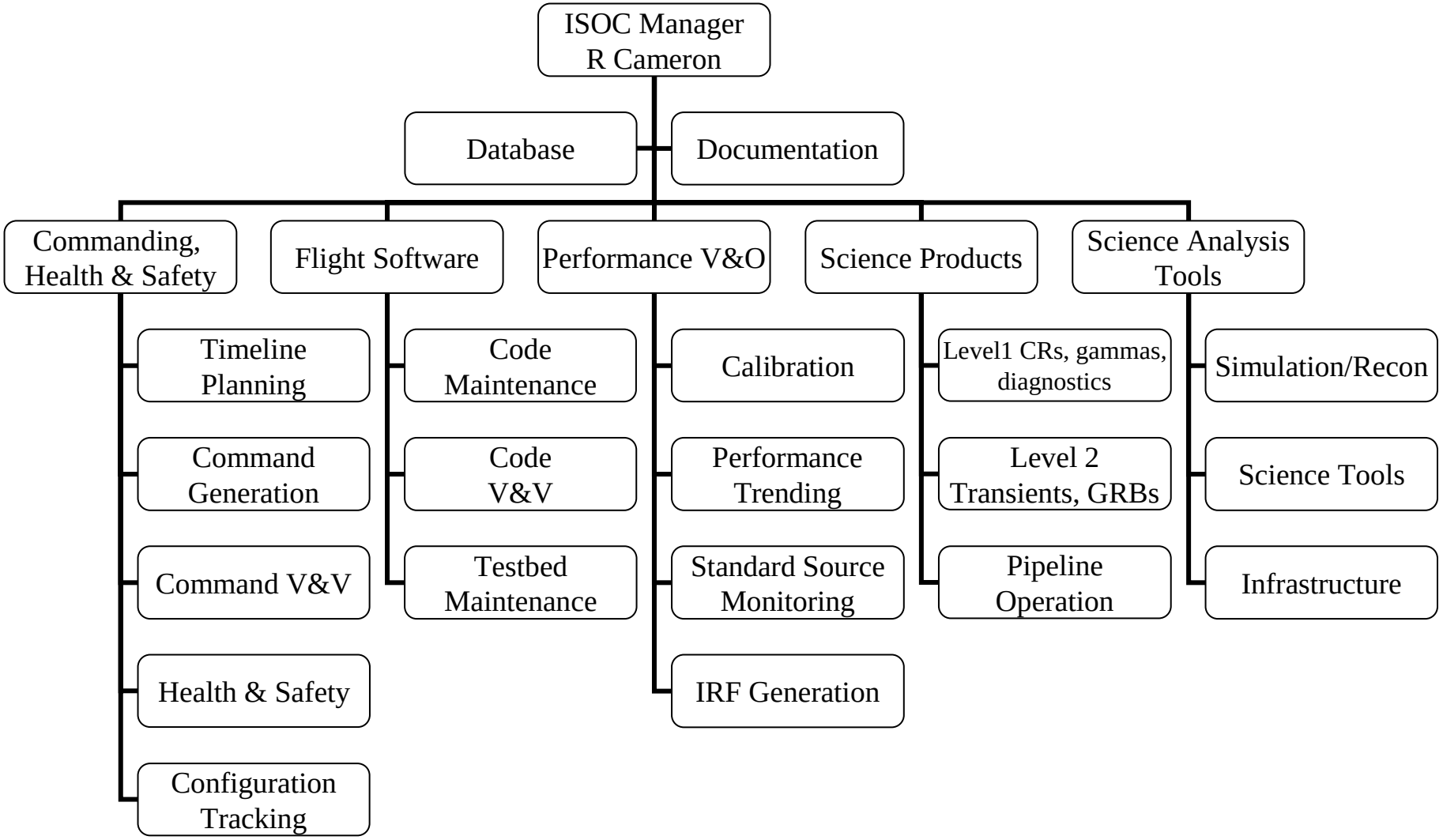
ISOC Reviews

- ISOC Peer Review: 2 March 2004
- ISOC CDR: 4 August 2004
- GLAST GSDR: 18-19 August 2004

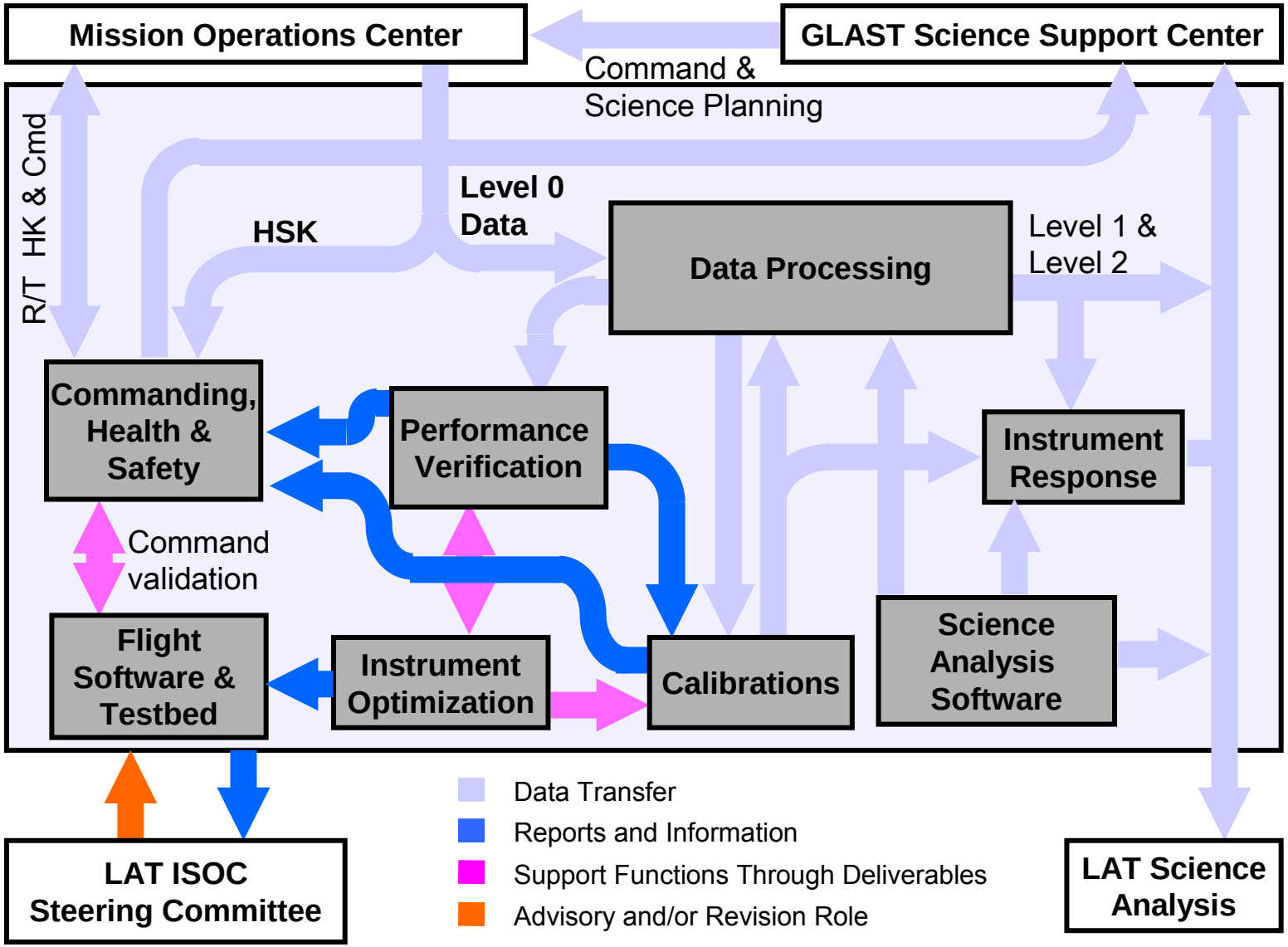
- CDR: very successful review
  - 8 RFAs and 8 Recommendations received
  - 6 RFA responses submitted for review, others in work
  - All recommendations completed

- GSDR: very successful review
  - No ISOC-specific RFAs
  - Ground-system RFAs will be applied to ISOC as needed

ISOC Organization



LAT ISOC Architecture



Commanding, Health and Safety

- The Commanding, Health and Safety (CHS) team is responsible for:
  - generation and validation of commands and command sequences,
  - passing LAT commands to the GSSC,
  - verifying these commands were executed,
  - receiving Level 0 data from the MOC,
  - logging and archiving of all commands and Level 0 data,
  - monitoring data to ascertain and track the health and safety of the instrument,
  - continuous knowledge of the configuration of the LAT.

CHS System

- ITOS used for command, health and safety functions
  - HK data limit checking
  - Telemetry and command definition file validation
  - Command load verification and validation
- Other tools
  - Level 0 receipt and archiving
  - HK trending
  - Data transmission
  - Mission planning and generation of file uploads
  - Anomaly tracking and notification
  - Relational database queries for trending and analysis
  - Configuration management tools

CHS Team

- Instrument Physicist: Mission planning, telemetry review
- Software Engineer: Maintain CHS software, T&C database CM
- Instrument Operators: Command build, telemetry monitoring
- Weekday, day-time operations
  - Operator shift coverage
    - 5 am to 2 pm to cover MOC shift times on East Coast
    - 9 am to 6 pm to cover ISOC internal coordination needs
  - On-call support
    - Operators for real-time commanding or anomaly support
    - Software engineer for emergency software support
    - Team Lead and Instrument Physicist for anomalies

Flight Software

- The Flight Software (FSW) team is responsible for:
  - Updating and validation of all flight software files
  - Debug or problem fixes to the FSW
  - Implementation, and validation on the instrument test bed of authorized upgrades to FSW
  - Continuing maintenance of the instrument testbed to ensure it is available to validate code and command sequences as well as to investigate any anomalies seen on orbit

FSW and ISOC Interactions

- **Before FSQ (in April 2005)**
  - Coding the software that will operate the LAT
  - Testing the software
  - Configuration management
  - Development of Test Bed
- **After FSQ**
  - Continue code/test/CM cycle as part of the ISOC operations
  - Maintenance of Test Bed
  - Review commanding, HK, and performance on a frequent and regular basis

Performance Verification and Optimization

- The Performance Validation and Optimization (PVO) team is responsible for:
  - instrument calibration from low level through to IRFs
  - continuous monitoring of the LAT science performance, identification of instrument performance trends and resolution of performance anomalies
  - generation of performance reports
  - generation and initial validation of algorithms that improve on-orbit performance of the LAT
  - management of pre-launch test and calibration data
  - configuration and maintenance of the LAT reference geometry and the LAT Monte Carlo Model
- The basic infrastructure for the PVO team is in place for LAT I&T activities and is the basis for the ISOC implementation

Science Products

- The Science Products Team is responsible for
  - Generation, archiving and distribution of the Level 1 data
  - Generation, archiving and distribution of specific Level 2 data needed for transient source detection and GRB parameter determination
  - Configuration control of the pipeline and generated data sets

- The functions developed by the Science Analysis Software (SAS) subsystem of the LAT are leveraged by the Science Products team to provide deliverables for ISOC

Science Analysis Software

- The Science Analysis Software Team is responsible for
  - Development and maintenance of the pipeline machinery
  - Development and maintenance of the simulation, reconstruction and event classification software
  - Development and maintenance of the calibration algorithms, including low level cal and Instrument Response Function generation
  - Development and maintenance of the quicklook transient analysis tools
  - Development and maintenance of the high-level diagnostics derived from reconstruction and classification
  - Development and maintenance of the high-level analysis tools

LAT Operations Planning

LAT Operations Phases

ISOC will be involved in all phases of LAT operation:

- **LAT I&T**
  - **Pre-FSW (EM)**
  - **Post-FSW (Flight unit level)**
  - **TVAC test at NRL**
- **Observatory I&T**
  - **Spectrum**
- **Launch and Early Orbit (L&EO) – Phase 0**
  - **LAT power-on and configuration**
  - **Initial checkout**
- **First year – Phase 1**
  - **Survey mode**
- **Second and subsequent years – Phase 2**
  - **Pointed observations**
  - **Survey mode**

Initial Turn-On and Checkout (Phase 0)

- Launch and Early Orbit (L&EO) phase currently scheduled for 60 days
- Turn-on (power-up) procedure will not be executed automatically
  - Humans required to check environmental conditions prior to significant steps
  - Must establish correct LAT configuration at each step
- Functional checkout of DAQ, ACD, CAL and TKR
- Perform initial calibrations
- Support special requirements
  - E.g. monitor phototube high voltages in ACD during turn-on
- ISOC will have presence at MOC during L&EO, but data will also flow to west coast ISOC for processing

Science Operations (Phases 1 and 2)

- Data taking
  - Continuous
  - A few commands to initiate
- Calibration
  - Weekly, biweekly and monthly
  - A few commands to initiate
- Load changes to tables and FSW
  - Infrequent
  - A few commands and/or file uploads which may be large
- Load new tables and files
  - Infrequent
  - A few commands and/or file uploads which may be large
- Perform Diagnostics
  - Infrequent
  - A few commands and/or file uploads which may be large
- SAA management
  - FSW turns down high voltage automatically based on SAA message from S/C

Science Planning

- **Phase 0/1: ISOC maintains LAT science observation plan**
  - Organization of the scientific activities of the LAT collaboration outside of the ISOC is being defined
  - Steering Committee, with Collaboration and Project Scientist representation, will oversee LAT operations planning and serve as the interface between science and operations
    - Acceptance of updated algorithms for the LAT trigger or event filtering (onboard or ground)
    - Definitions of conditions when the LAT will autonomously request a repointed observation
- **Phase 2: GSSC generates Long Term Science Schedule**
  - GSSC assists in overall science schedule evaluation and will manage the guest investigator proposal process
  - Coordinated with LAT collaboration
  - Input to LAT Planning

LAT Timeline

- Contains all LAT commanding information to fulfill a one-week period of the Operations Plan
  - Commands for Absolute Time Sequence (ATS)
  - File loads
    - Table uploads
    - Configuration changes
    - FSW loads
  - Command procedures
    - Commands requested to be sent in real-time
- Generated by CHS team about 2 weeks before upload
- Coordinated with GSSC, MOC and GBM through weekly planning meetings
- Validated and verified on testbed

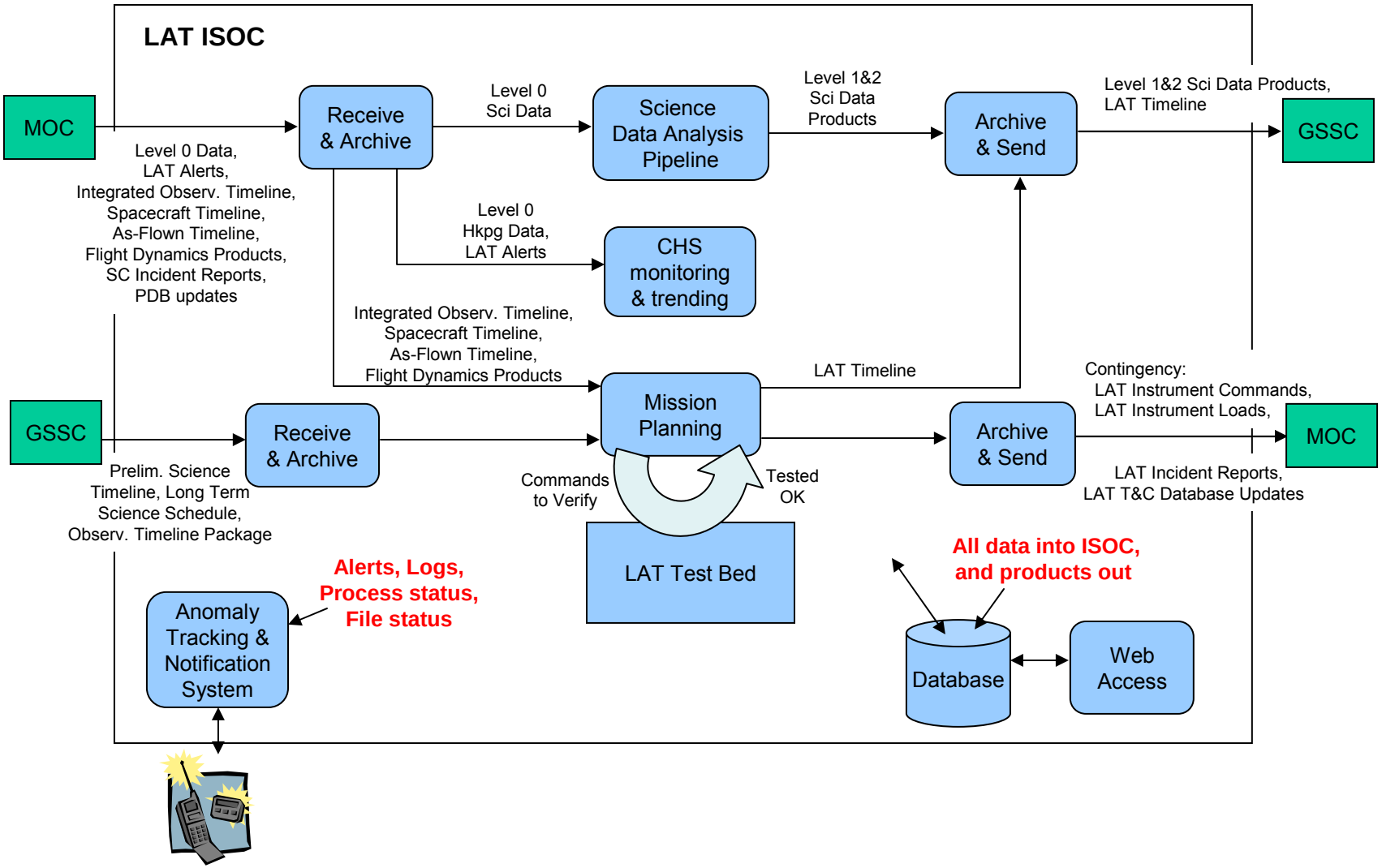
LAT Operations Planning Timeline

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
July 30	31	August 1	2	3	4	5
			GSSC Sends Preliminary Activity Timeline to MOC	MOC Requests TDRSS Contacts for the Week		
6	7	8	9	10	11	12
ISOC Generates Command Plan				ISOC Sends Command Plan to GSSC		
13	14	15	16	17	18	19
						Deadline for ISOC to Send Changes* to Week
20	21	22	23	24	25	26
GSSC Sends Final Activity Timeline to MOC		MOC Uploads ATS	ATS Goes Active			
27	28	29	30	31	September 1	2

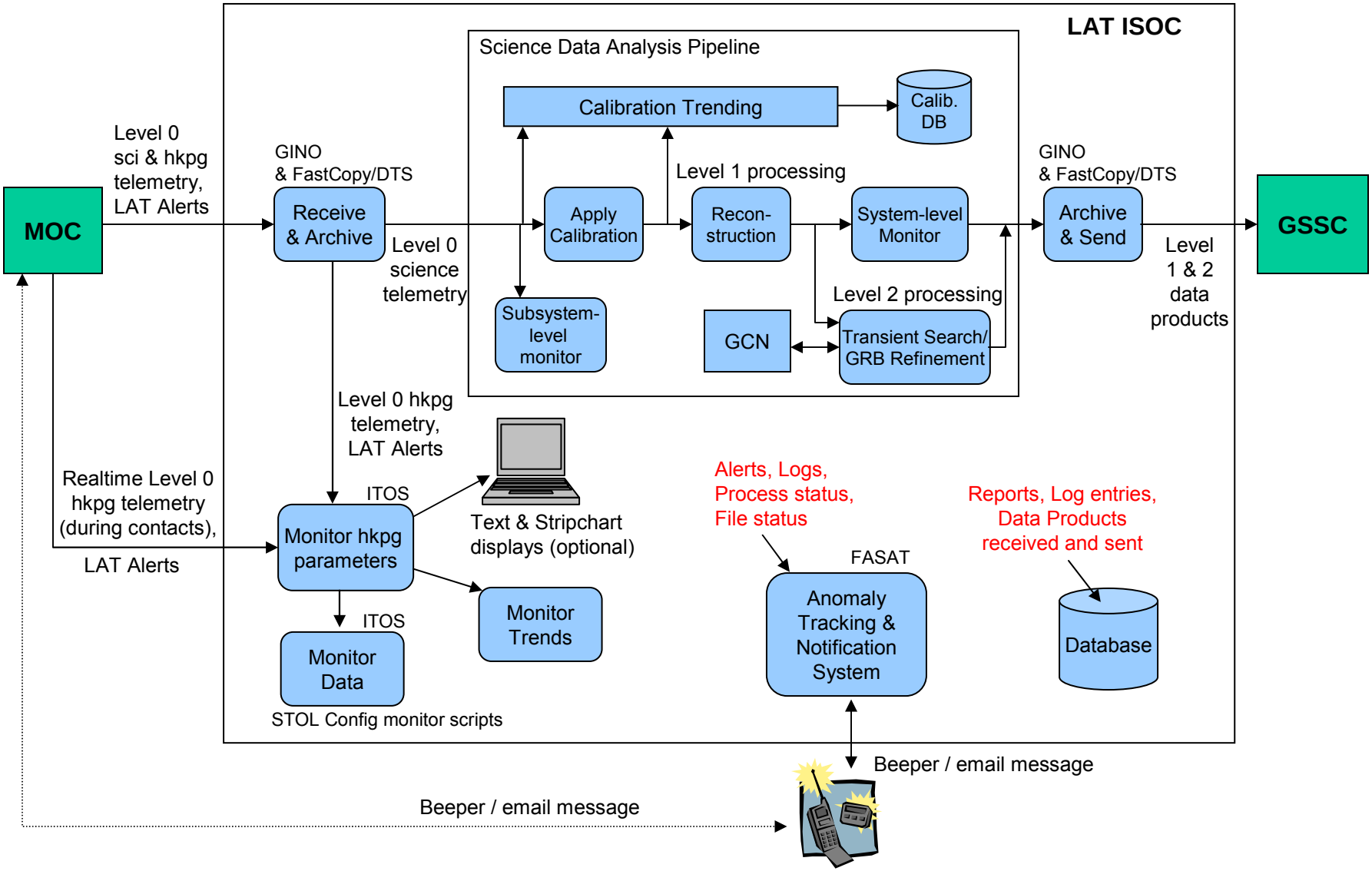
*Minor changes that don't affect observing schedule or TDRS contacts

Software Architecture and Tools

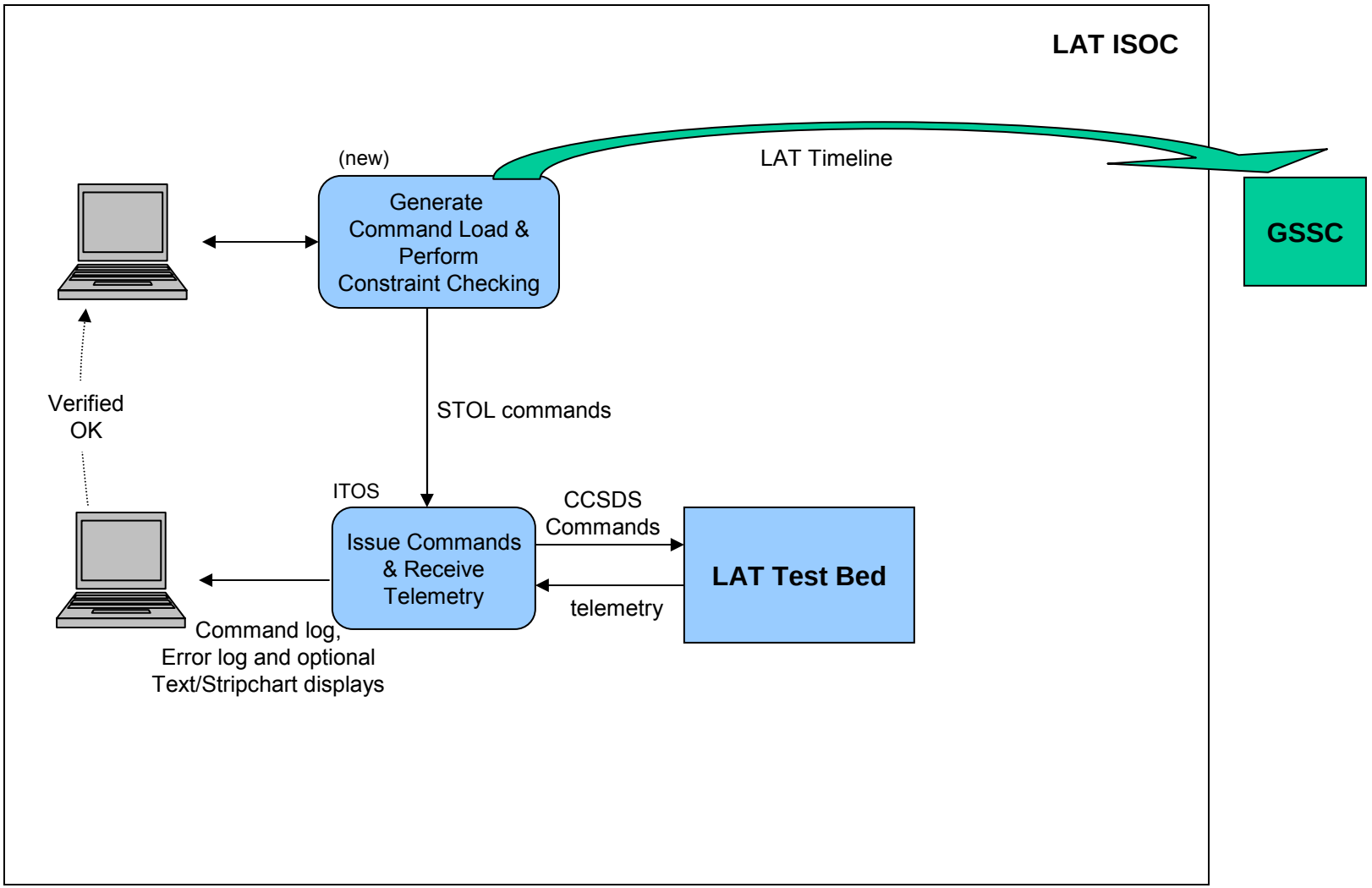
Primary Data Flows



Automatic Telemetry Processing



Command Load Generation & Verification



ISOC Requirements Mapped to Software

- ISOC requirements tracing is complete
- Each ISOC Level 3 requirement was identified as:

1.	Procedural (non-software)	42
2.	Existing software (commercial or other well-established software -- i.e. implementation Done!)	277
3.	Under development by SAS (mostly done, refer to SAS for status)	39
4.	To be developed by others (I&T, FSW, ITOS)	21
5.	Remaining new development	88
	total	467

- Some requirements map to multiple categories or SW tools, so total exceeds total number of Level 3 requirements (379)

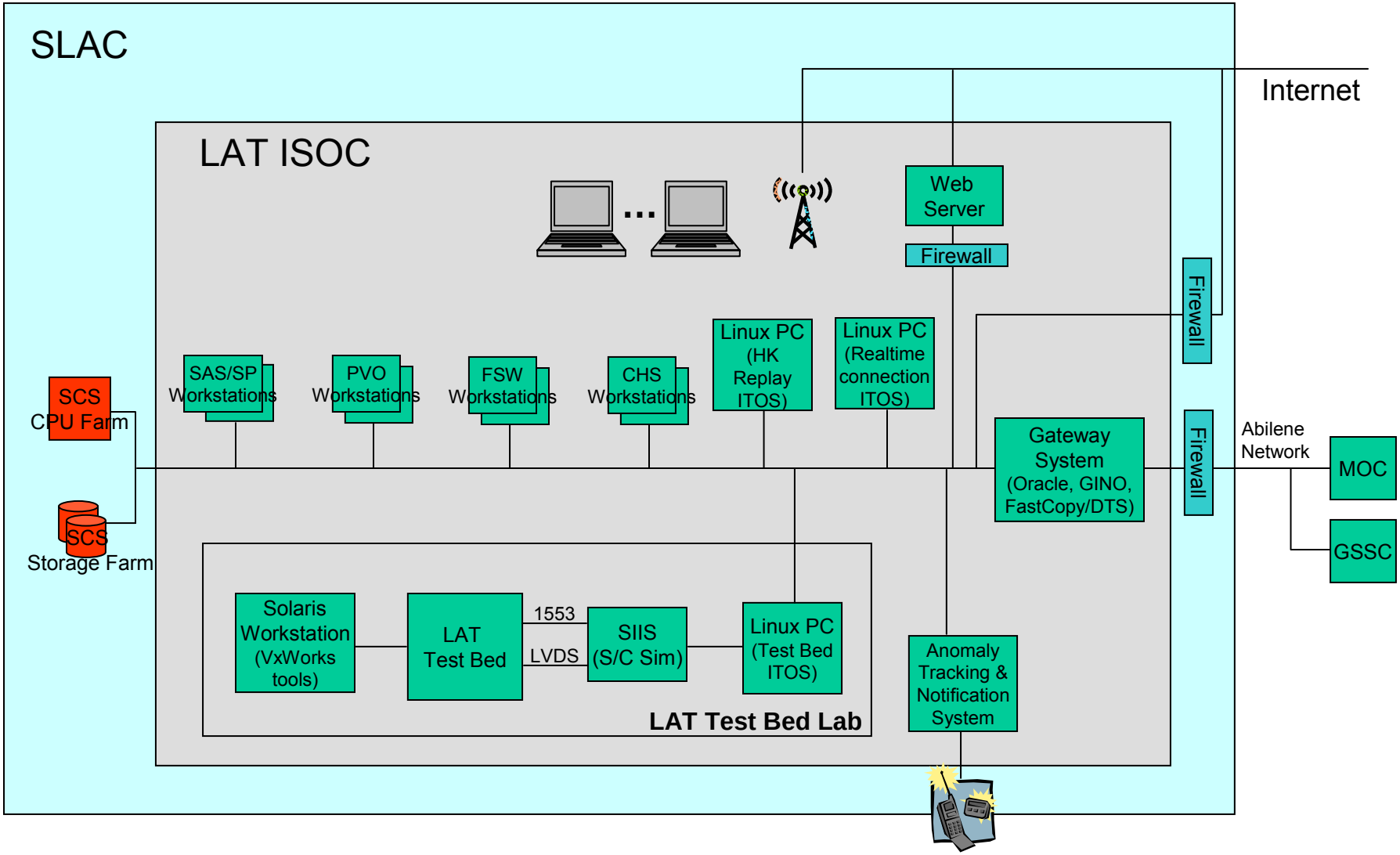
2. Existing software

Name	Description	# Level 3 Reqts	% of Reqts	Source
ITOS	satellite C&T package	215	46.0%	GSFC
ATNS	Anomaly Tracking and Notification System	32	6.9%	FASAT (commercial) or RXTE SOF Process Mgr (RXTE)
FastCopy	secure file transfer	15	3.2%	FastCopy (commercial)
CVS	file config mgmt tool	5	1.1%	Open Source
STK	Satellite Tool Kit	4	0.9%	commercial
LATDocs	LAT documentation management tool	4	0.9%	existing SLAC LAT tool
NTP	synchronize computers	1	0.2%	Open Source
email	electronic mail	1	0.2%	Open Source
Total		277	59.3%	

5. Remaining to be developed

Tool Name	Description	# Level 3 Reqts	% of Reqts	Comments
PLOTTOOL	plotting	28	6.0%	combination of existing tools (e.g. ROOT, HippoDraw, JAS, IDL) & new dev
TRENDTOOL	trending	16	3.4%	combination of IDL, DTAS (used by MOC), and/or TAPS (GSFC)
PLANTOOL	mission planning	6	1.3%	generate timeline and commands for LAT operation
CONSTRAINT TOOL	check command sequences against constraints	12	2.6%	
DB	database definition and implementation	10	2.1%	partially done by SAS, I&T, FSW - coordinating dev with SAS, I&T, FSW, SCS
DBIN	ingest ISOC data	7	1.5%	
WEBTOOL	provide web access to data products	9	1.9%	
Total		88	18.8%	

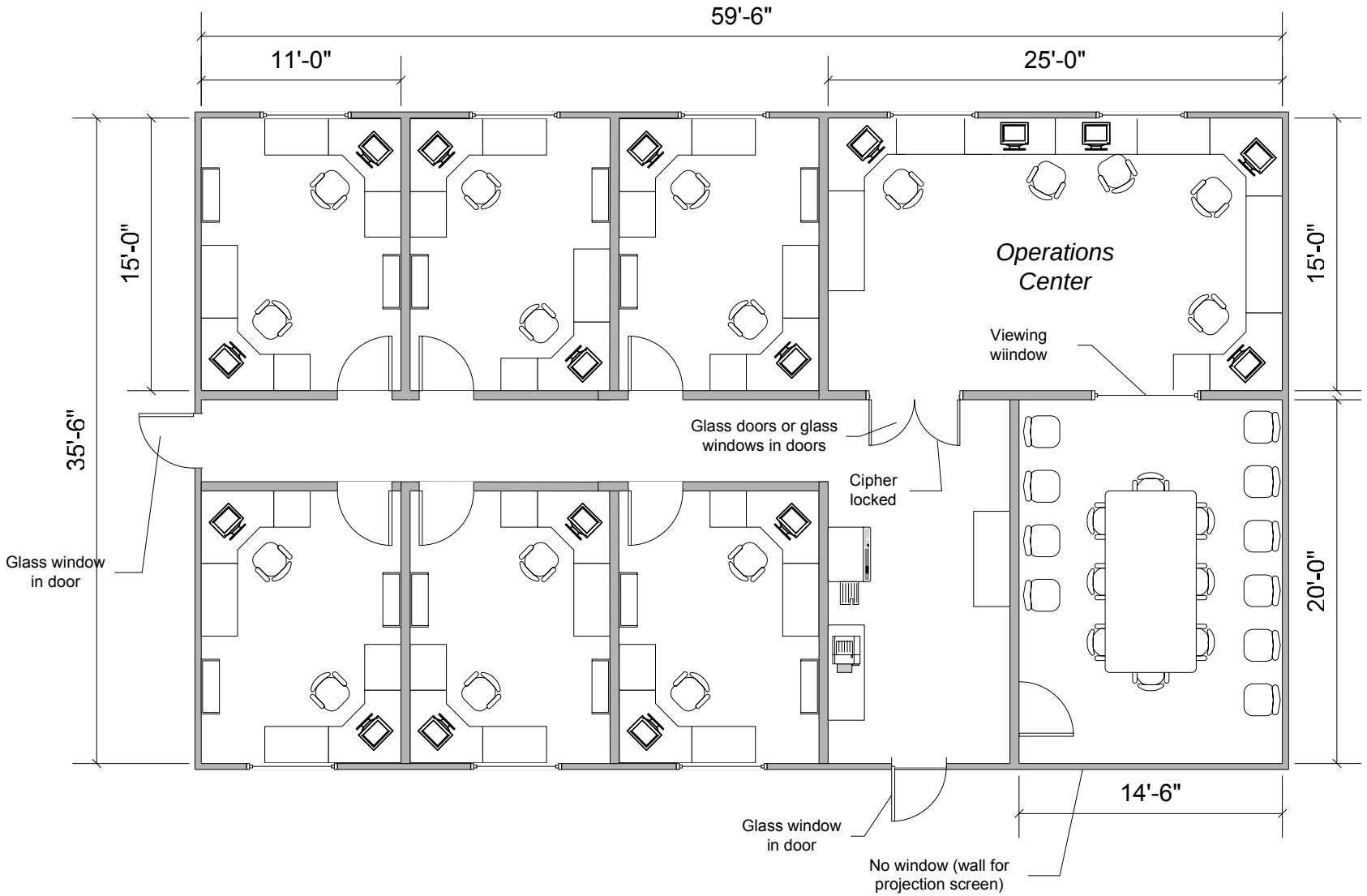
ISOC Network Architecture



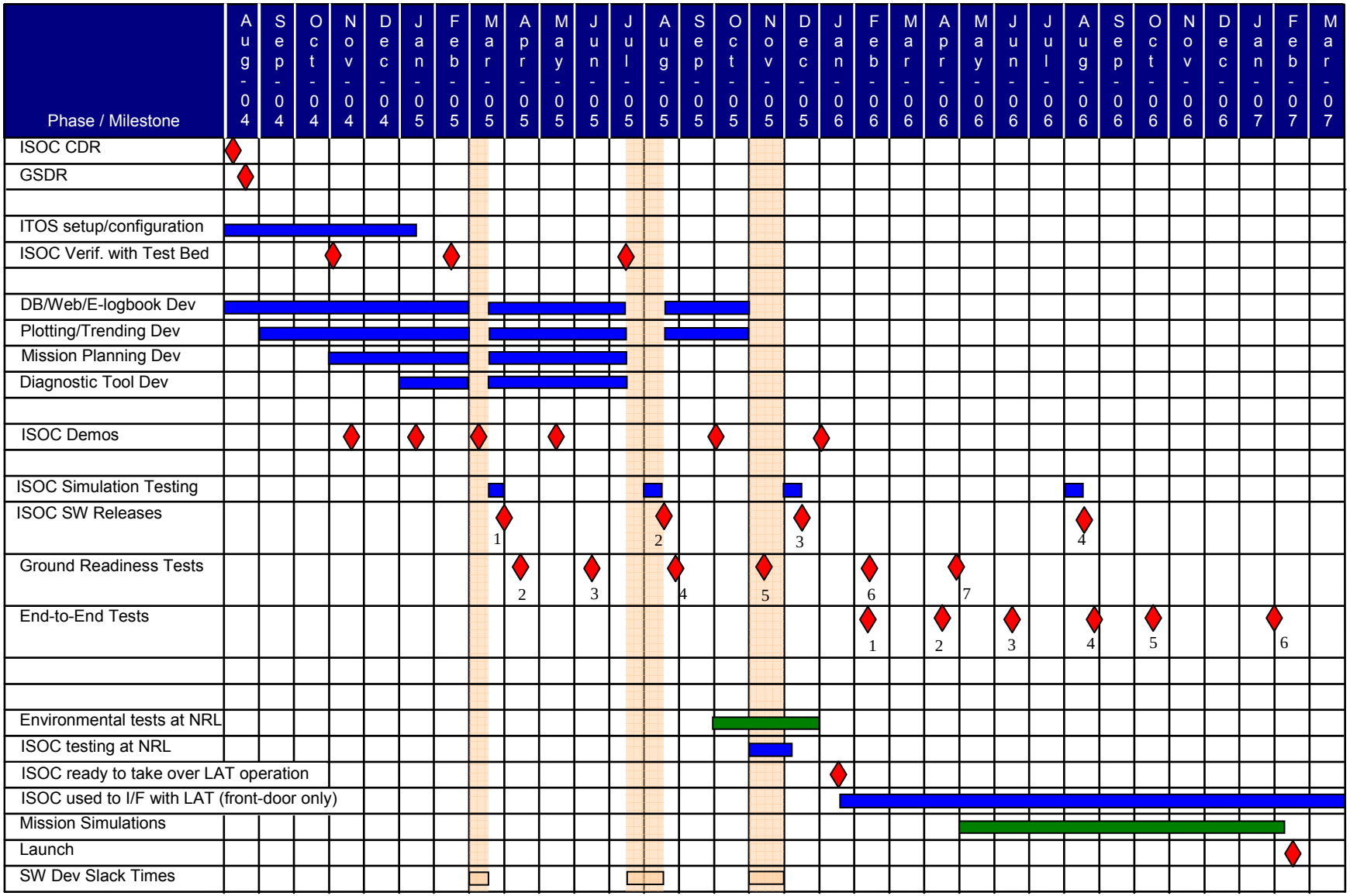
ISOC Operations Facility

- Working with SLAC management and Facilities group to define near-term ISOC operations facility. Coordinating ISOC space requirements with LAT project management.
- Near-term ISOC facility: a new temporary building at SLAC
- Long-term ISOC facility: discussions are starting with SLAC and KIPAC management on possible ISOC facility in new Kavli building at SLAC. Also ISOC presence on Stanford campus.

Proposed ISOC Layout for 60´x36´ Building



ISOC Development Schedule



ISOC Software Release Schedule

- The ISOC software release schedule has been coordinated with GSFC Ground System plans:
  - ISOC Software Release 1 (April 1, 2005)
    - Support Ground Readiness Test (GRT) 2 and 3
  - ISOC Software Release 2 (August 15, 2005)
    - Support GRT 4 and 5
  - ISOC Software Release 3 (December 15, 2005)
    - Support End-to-End 1, ETE 2, ETE 3, GRT 6, GRT 7, and Mission Sim
  - ISOC Software Release 4 (July 25, 2006)
    - Support remaining ETE's 4, 5, and 6

Summary

- ISOC development activity is ramping up
- A well defined ISOC organization and development plan is in place, with software releases, GRTs and ETE tests as milestones
- Lots of coordination effort needed between various project elements internal and external to LAT, to bring together all the elements of the ISOC