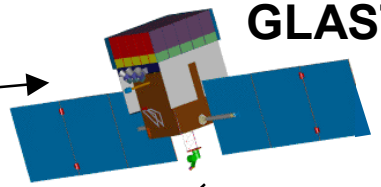
IOC Overview

- Overview
- Requirements
- WBS Organization
- Development Plan
- MO&DA Plan
- Prototyping and Trade Studies
- Conclusions

Mission Operations Architecture

Alerts



Two Contacts Per day

Routine Data

Alerts
Large loads
Target of Opportunity
Commands

Spacecraft, IOC and GBM data

LAT Instrument Operations Center

LAT data handling
LAT performance
Standard product processing

LAT Data
Command Loads
Status

Standard products
Schedule requests

Science Support Center

Science scheduling
Archiving
Guest Observer Support
Standard product processing

Schedules

Level 0 data for archiving

Standard products
Schedule requests

Mission Ops Center

Observatory safety
Spacecraft health
Commanding
Mission scheduling
Instrument data handling

GRB Coordinates Network

Burst and transient Alerts

GBM Data
Status
Command Loads

GBM Instrument Operations Center

GBM data handling
GBM performance
Standard product processing

LAT Operations Facility Functions

The LOF will consist of about 1/2 the resource of the FUSE Control Center at Johns Hopkins University (as shown here).

LAT Instrument Operations & Science Data Processing

LAT Operations Facility WBS 4.1.B
S. Williams, SU-HEPL

- LAT Data Verification
- LAT Health & Safety Monitoring
- LAT Commanding
- Test & Calibration Data Acquisition
- Validating & Maintaining Flight Software
- Alert Processing

Level 0 Science & Hsk Data

Performance & Cal Data

Data Processing Facility WBS 4.1.D
R. Dubois, SU-SLAC

- Science Data Processing
- Optimizing Analysis & Processing Algorithms
- LAT Calibration
- LAT Performance Assessment
- Data Distribution
- Analysis Software
- Mirror Sites

Level 0 Data, LAT Procs & Uploads

Science Plan, LAT Schedules

Science Support Center (SSC)

Level 1 Data, High Level Products, LAT IOC Data Products

Mission Operations Center (MOC)

Science Plan, Schedules, Level 0 Data

Level 1 Data, High Level Products, GBM IOC Data Products, GBM Schedules, Science Plan

S/C LAT, and GBM Data, Commands

Space and Ground Segments

Level 0 Data, GBM Procs & Uploads

GBM Instrument Operations Center

FUSE Comparison

INTEGRATED TOOLSET

- **SCL**
- **SAMMI**
- *O2*
- **STK**
- *Orbix*
- *NDDS*
- **IDL**

The LOF will consist of about 1/2 the resource of the FUSE Control Center at Johns Hopkins University (as shown here inside blue border). Probable common COTS S/W tools are shown in red.

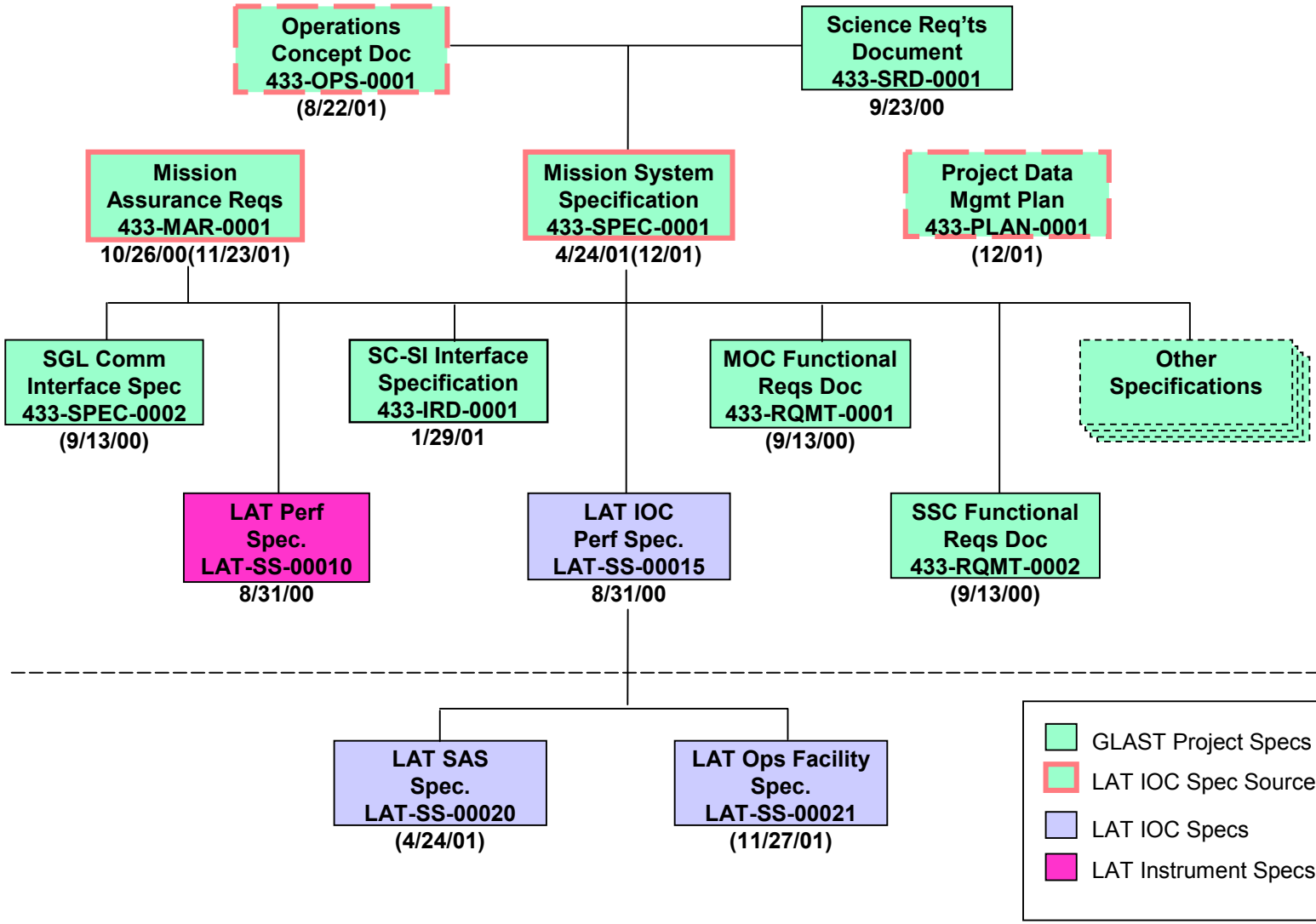
LAT Operations Facility Functions

- **Instrument Control & Operation**
  Status & condition monitoring, limit checking, procedure development, command generation, trending, logging.
- **Level 0 LAT Data**
  Data acquisition & management, archiving, data distribution, data quality verification.
- **Operations Uploads**
  Flight software updates, command sequences, parameter tables.
- **Test & Calibration**
  Mode control, procedure development, on–orbit calibration scheduling, implementation, and data acquisition, systems analysis.
- **Instrument Operations**
  Planning & scheduling, procedure development, upload validation and verification, anomaly resolution.
- **Communication Support**
  LAT IOC interfaces to MOC, SSC, SAS.
- **Operations Environment Maintenance**
  LOF maintenance and upgrade, LAT Testbed maintenance, Database maintenance, crew resource management, documentation.

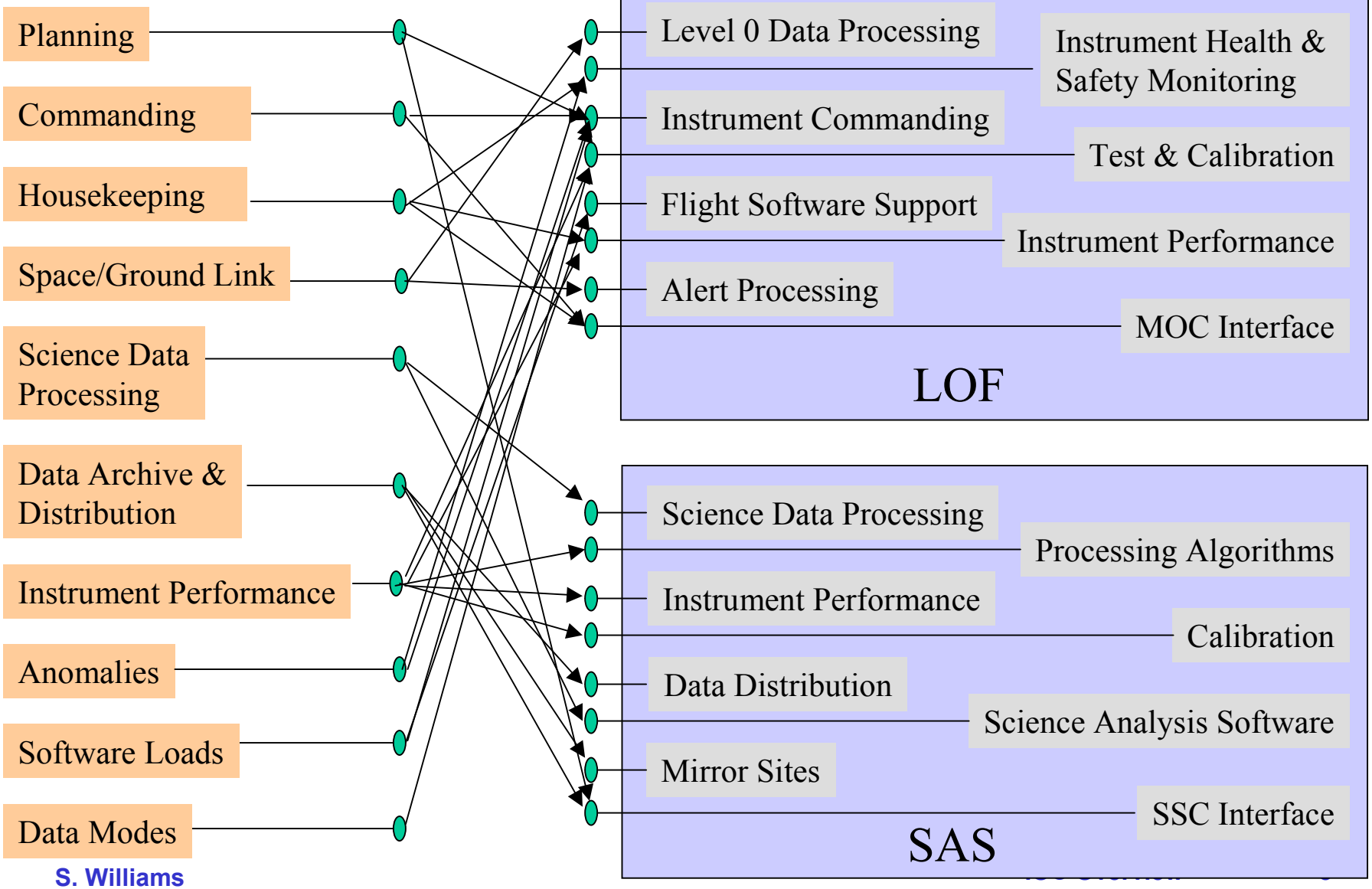
IOC Status

- **IOC effort is on schedule and budget**
- **Tasks completed since Pre-Baseline Review (2/13/01)**
  - **Released IOC Level III requirements document and conducted IOC Requirements Review - 5/4/01.**
  - **Conducted IOC Peer Design Reviews - 8/17/01, 10/11/01.**
  - **Participated in GLAST Operations Working Group (GLOWG) including revision of GLAST Operations Concept Document.**
  - **Supported the GLAST Data Products Working Group development of data product ICDs.**
  - **Supported I&T PDR preparations as Instrument Ops Coordinator.**
  - **Supported development of Online System (EGSE) requirements.**
  - **Supported balloon flight EGSE and operations procedures development and 8/4/01 flight.**
  - **Revised WBS, schedule, and cost estimate to support 6 month launch slip and mandatory descope. Completed inputs to PMCS.**

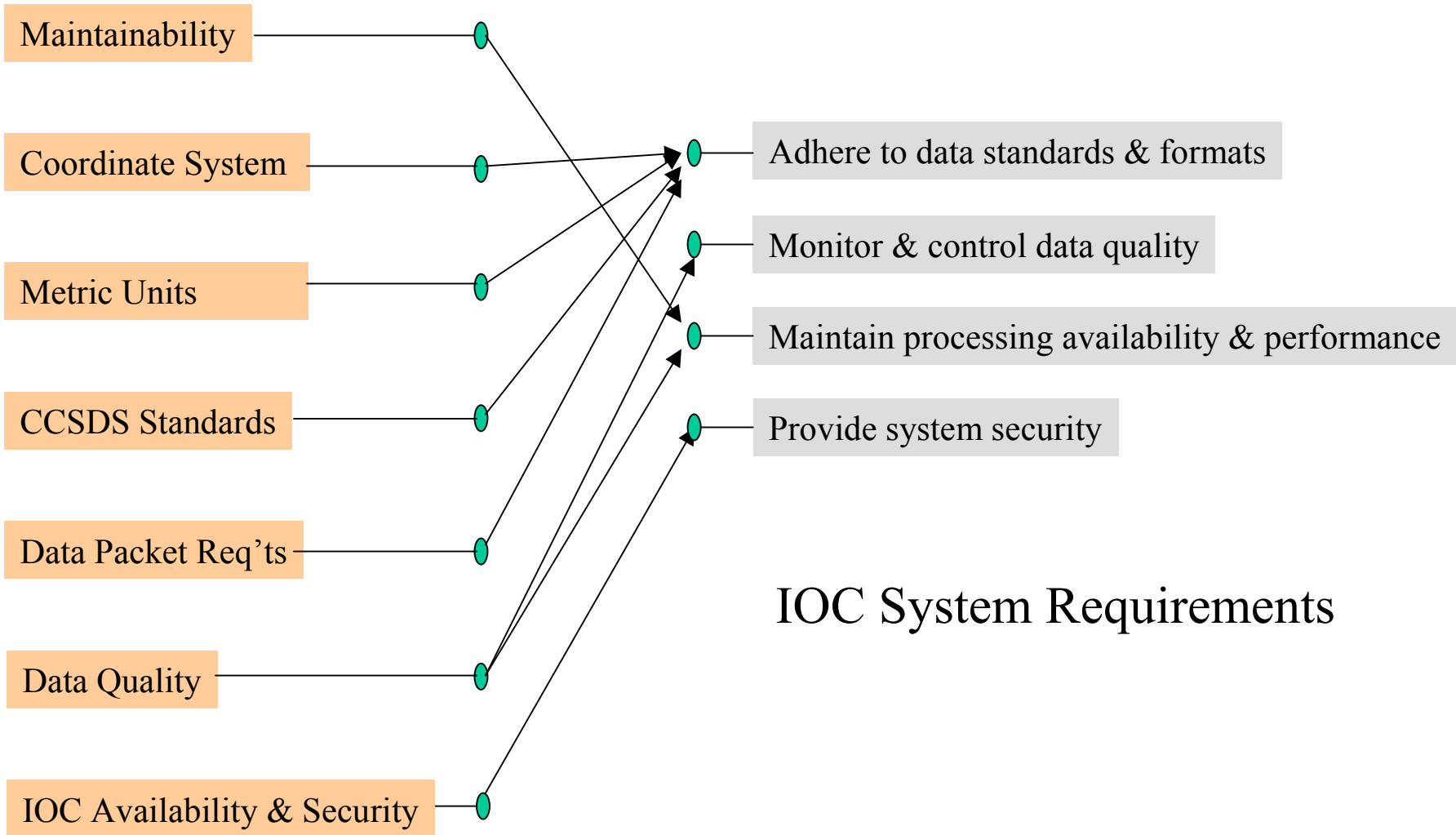
Requirements Traceability



Level II Requirements from OCD



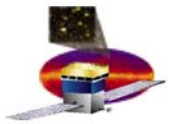
Level II Requirements from MSS



LOF Level III Requirements

Ref: LAT-SS-00021

Requirement	Function	Requirement Summary	Verification Method
5.2	Level Zero Data	The LAT IOC receives the Level 0 GLAST data from the MOC, verifies data quality, and distributes the data to the DPF for processing.	Demonstration
5.3	Instrument Health and Safety Monitoring	The IOC monitors, assesses, and records the health and safety of the instrument and supports the resolution of anomalies.	Demonstration
5.4	Instrument Commanding	The IOC develops command uploads and procedures for the instrument to adjust the instrument configuration, on-board calibration, or flight software.	Demonstration
5.5	Anomaly Detection and Resolution	The IOC monitors the LAT instrument for anomalies and provides analyses to support their safe resolution.	Demonstration
5.6	Operational Databases	The IOC develops and maintains databases for LAT operations.	Demonstration
5.7	Test and Calibration Data Processing	The IOC acquires test and calibration data to aid in assessing the performance of the instrument and adjust the instrument tables, engineering calibration, or software as required.	Demonstration
5.8	Instrument Performance Assessment	The IOC monitors and assesses the performance of the instrument.	Demonstration
5.9	Instrument Configuration	The IOC monitors and adjusts the instrument configuration, calibration, or software as required.	Demonstration
5.10	Validating and Maintaining LAT Flight Software	The IOC maintains the onboard LAT flight software.	Demonstration
5.11	LAT Testbed	The IOC maintains and operates a LAT testbed for use in developing, validating, and verifying changes to LAT flight software, command procedures, and instrument parameters.	Demonstration
5.12	Alerts	The IOC supports transient event alerts from GLAST.	Demonstration
5.13	Data Standards	The IOC adheres to mission specified data standards.	Demonstration
5.14	Data Formats	The IOC adheres to mission specified data formats.	Demonstration
5.15	Maintainability and Availability	The IOC meets mission specified maintainability and availability requirements	Demonstration
5.16	Security	The IOC shall be connected to the other operations and support centers by an intranet of wide area networks that is closed to, or protected from, public users of the external internet per NASA NPD 2810.1.	Demonstration
5.17	Quality Assurance	The IOC shall maintain the integrity of LAT uploads and science data during transmission and processing of the data.	Demonstration
5.18	Integration and Test Support	The IOC supports LAT and GLAST mission systems integration and test.	Demonstration
5.19	Mission Support	The IOC supports the GLAST mission launch and orbital operations.	Demonstration

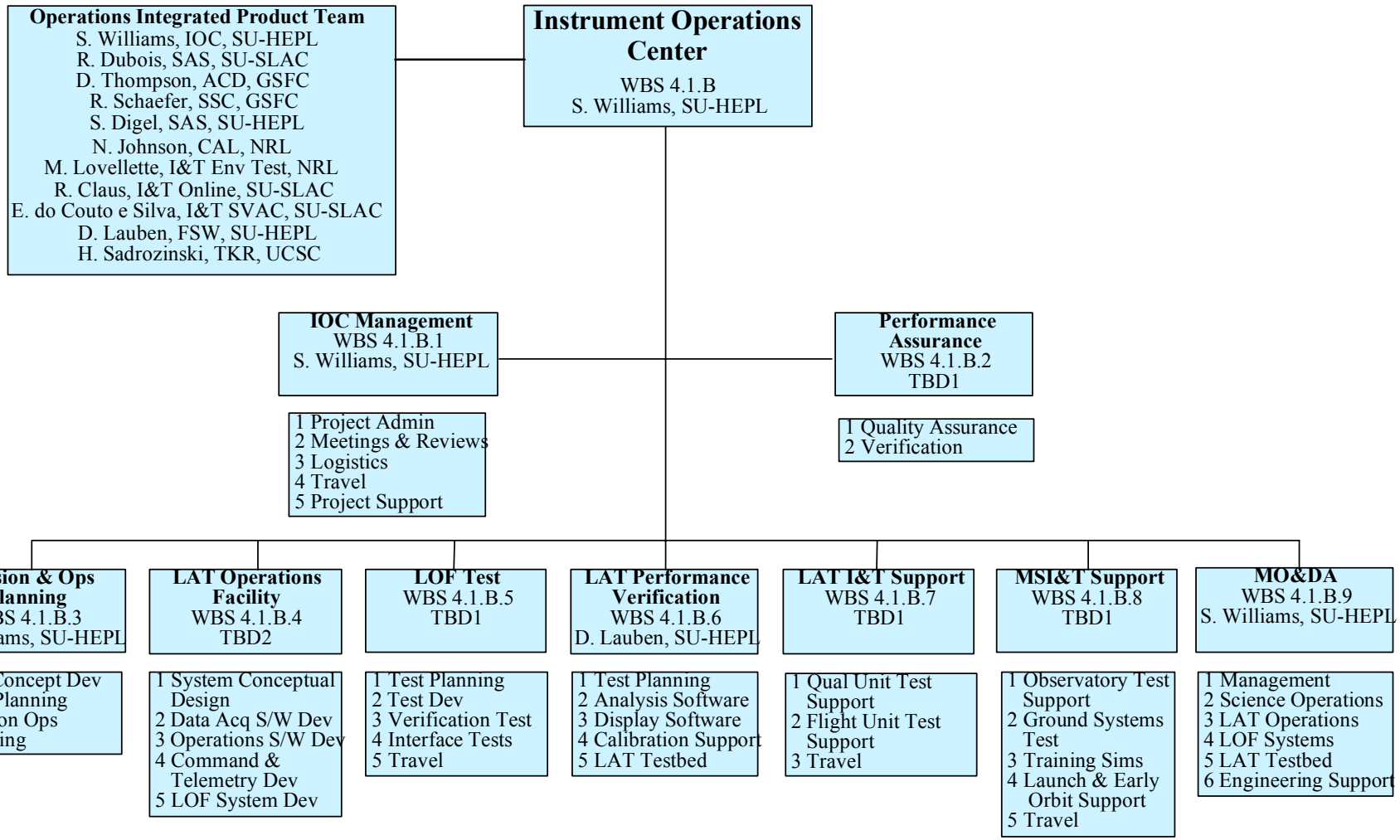


Work Breakdown Structure

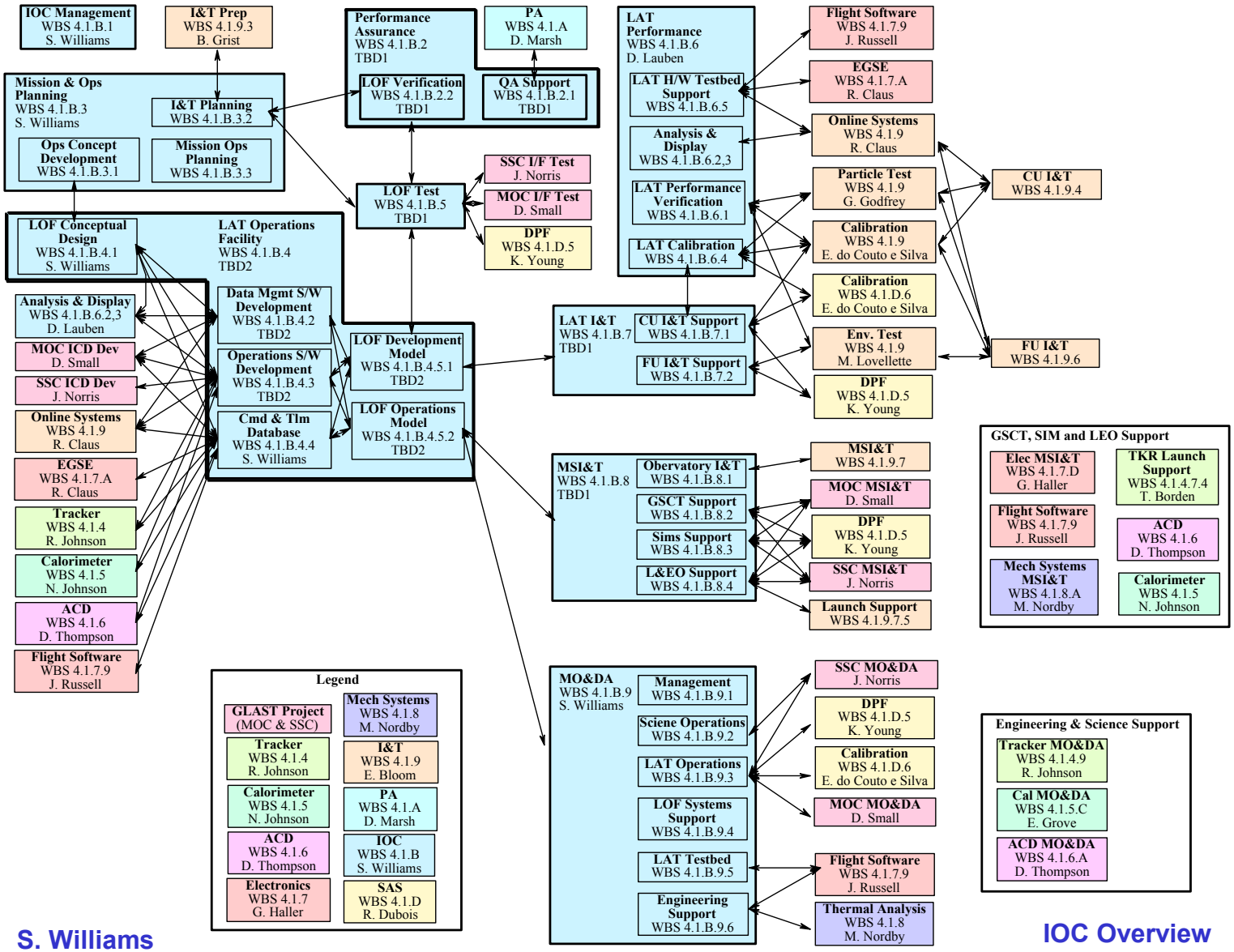
WBS	Task	Responsibility
4.1.B	Instrument Operations Center	Williams
4.1.B.1	Project Management	Williams
4.1.B.1.1	Project Administration	
4.1.B.1.2	Meetings & Reviews	
4.1.B.1.3	Logistics Management	
4.1.B.1.4	Travel	
4.1.B.1.5	Project Support	
4.1.B.2	Performance Assurance	TBD1
4.1.B.2.1	IOC Performance Assurance	
4.1.B.2.2	IOC Verification	
4.1.B.3	Mission & Operations Planning	Williams
4.1.B.3.1	Operations Concept Development	
4.1.B.3.2	Integration & Test Planning	
4.1.B.3.3	Mission Operations Planning	
4.1.B.4	LAT Operations Facility	TBD2
4.1.B.4.1	System Conceptual Design	
4.1.B.4.2	Data Acquisition S/W Development	
4.1.B.4.3	Operations Software Development	
4.1.B.4.4	Command & Telemetry Development	
4.1.B.4.5	LOF System Development	
4.1.B.5	LOF Test	TBD1
4.1.B.5.1	Test Planning	
4.1.B.5.2	Test Development	
4.1.B.5.3	Verification Testing	
4.1.B.5.4	LOF Interfact Tests	
4.1.B.5.5	LOF I&T Travel	

WBS	Task	Responsibility
4.1.B.6	LAT Performance Verification	Lauben
4.1.B.6.1	Performance Verification Test Planning	
4.1.B.6.2	Analysis Software	
4.1.B.6.3	Display Software	
4.1.B.6.4	LAT Calibration Support	
4.1.B.6.5	LAT Testbed	
4.1.B.7	LAT Integration & Test	TBD1
4.1.B.7.1	Qualification Unit Test Support	
4.1.B.7.2	Flight Unit Test Support	
4.1.B.7.3	LAT I&T Travel	
4.1.B.8	Mission Systems Integration & Test	TBD1
4.1.B.8.1	Observatory Testing	
4.1.B.8.2	Ground Systems Testing	
4.1.B.8.3	Training Simulations	
4.1.B.8.4	Launch & Early Operations Support	
4.1.B.8.5	MSI&T Travel	
4.1.B.9	Mission Operations & Data Analysis	Williams
4.1.B.9.1	MO&DA Management	
4.1.B.9.2	Science Operations	
4.1.B.9.3	LAT Operations	
4.1.B.9.4	LOF Systems Support	
4.1.B.9.5	LAT Testbed	
4.1.B.9.6	LAT Engineering Support	

WBS Organization



WBS Interfaces



Development

- Resources constrained in FY02/03
- IOC CDR in 12/03

Key IOC Milestones

• IOC Requirements Review	05/01
• IOC Peer Design Review	08/01
• IOC Pre PDR	10/01
• LAT Instrument PDR	01/02
• Online System Specification from I&T	05/02
• LAT Instrument CDR	08/02
• IOC CDR (TBR)	12/03
• LOF S/W Release 1	06/04
• Environmental Test Database Release	06/04
• LOF-DPF Interface Test	06/04
• LOF Development Model Complete	12/04
• Observatory I&T Database Release	12/04
• LOF S/W Release 2	02/05
• LOF-DPF-MOC-SSC Interface Test 1	02/05
• LOF-DPF-MOC-SSC Interface Test 2	06/05
• LOF Validation & Verification Complete	07/05

GLAST Project milestones in blue

Key IOC Milestones

• LOF S/W Release 3	09/05
• Ground Systems Compatibility Test (TBR)	09/05
• Operations Simulation 1 (TBR)	10/05
• Mission Sequence Test (TBR)	10/05
• LOF Operations Model Complete, Flight DB Release	11/05
• Operations Simulation 2 (TBR)	12/05
• IOC Readiness Review	01/06
• LOF S/W Release 4	01/06
• End-to-end Test (TBR)	01/06
• LAT Flight Readiness Review (FRR)	02/06
• Operations Simulation 3 (TBR)	02/06
• Launch	03/06
• LAT Operations Readiness Review	L+3d
• LAT Activation and Checkout Complete	L+30d
• LAT Instrument Commissioning Complete	L+60d
• LAT Verification Phase Complete	L+14m

Documentation Plan

Level II

LAT IOC Specification LAT-SS-00015	Ground System I/F Reqs Doc
9/00	TBD

Level III

LOF Functional Specification LAT-SS-00021	LOF-DPF ICD LAT-TD-00nnn	LAT Operations Plan LAT-TD-00nnn	LAT Instrument Ops Manual LAT-TD-00nnn	LAT CMD & TLM Database LAT-TD-00nnn
11/01	LAT CDR	LAT CDR	LAT PSR	LAT PSR

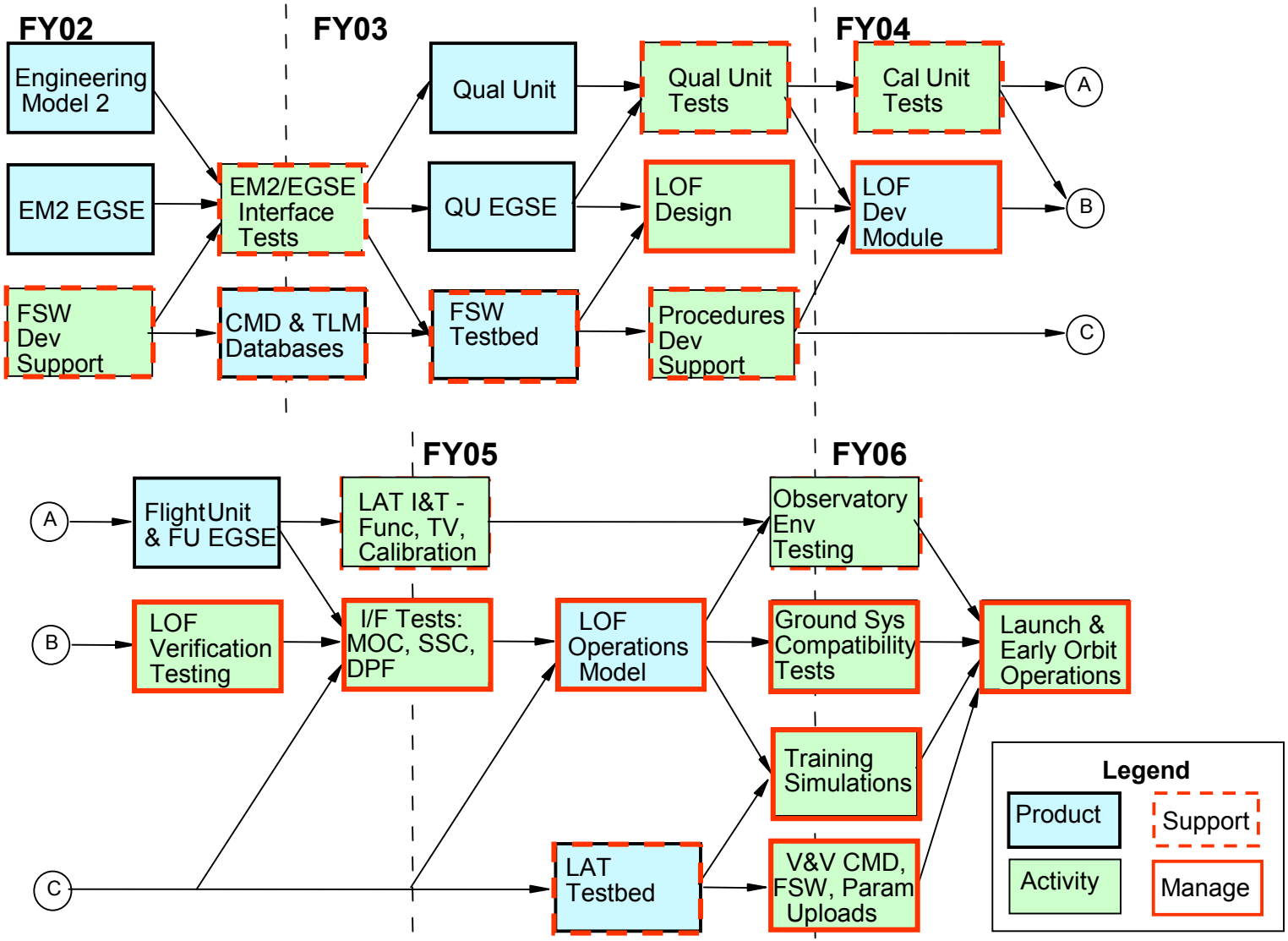
LAT LEO Ops Plan LAT-TD-00nnn
LAT PSR

Level IV

LAT IOC PDR Report LAT-SS-00428	LOF Operations Concept LAT-SS-00nnn	LOF Performance Specification LAT-SS-00nnn	LOF Verification Plan LAT-TD-00nnn	LOF Software Mgmt Plan LAT-TD-00nnn
12/01	LAT CDR	LAT CDR	LAT CDR	LAT CDR

LOF Crew Res Mgmt Plan LAT-TD-00nnn	LOF Facility Specification LAT-DS-00nnn	LOF Computer Procurement Spec LAT-DS-00nnn	LOF S/W Procurement Spec LAT-DS-00nnn	LOF Operations Manual LAT-TD-00nnn
LOF CDR	LOF CDR	LOF CDR	LOF CDR	LOF PSR

Development Flow



IOC Development Staffing

Manager - S. Williams

Technical management, reporting, mission planning, concept and requirements development, command & telemetry database, operations procedures and documentation, I&T support planning, crew resource management.

Scientist - D. Lauben

LAT performance verification, calibration support, analysis and display prototyping, science planning and ops tools, LAT Testbed support, SSC interface (inst. scheduling), DPF interface (level 0 data & performance metrics).

Scientist – TBD, late FY05

LAT performance verification, calibration support, analysis and display prototyping, science analysis tools, SSC and DPF interface (analysis tools).

Engineer - TBD2, mid-FY03

LOF development, operations S/W development, distributed monitoring, procedure and upload verification & validation, MOC interface (data flow).

Engineer - TBD1, FY04

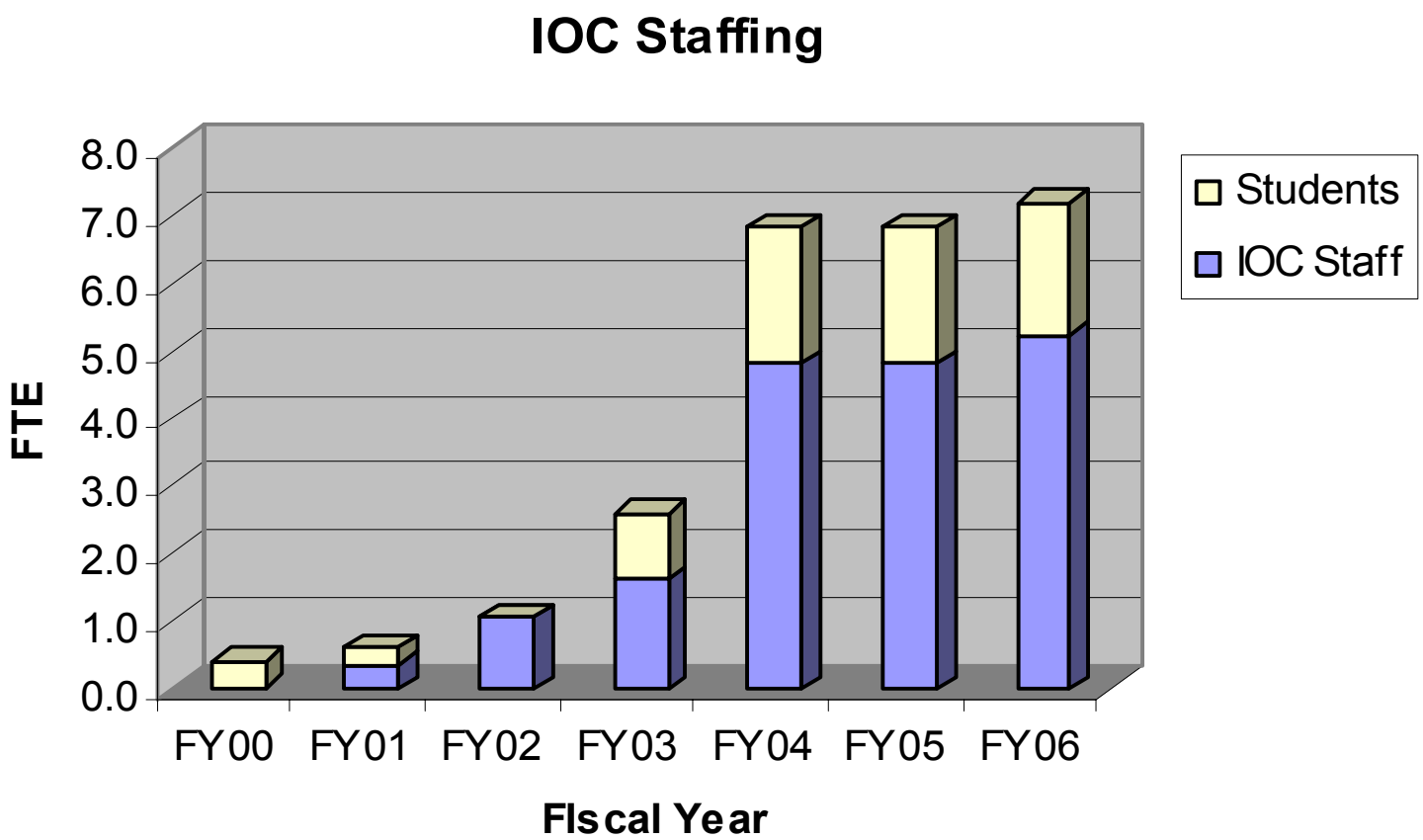
Verification and QA support, test planning, command & telemetry database, operations procedures and documentation, I&T interface, MOC interface (commanding & databases).

Programmer - TBD3, FY04

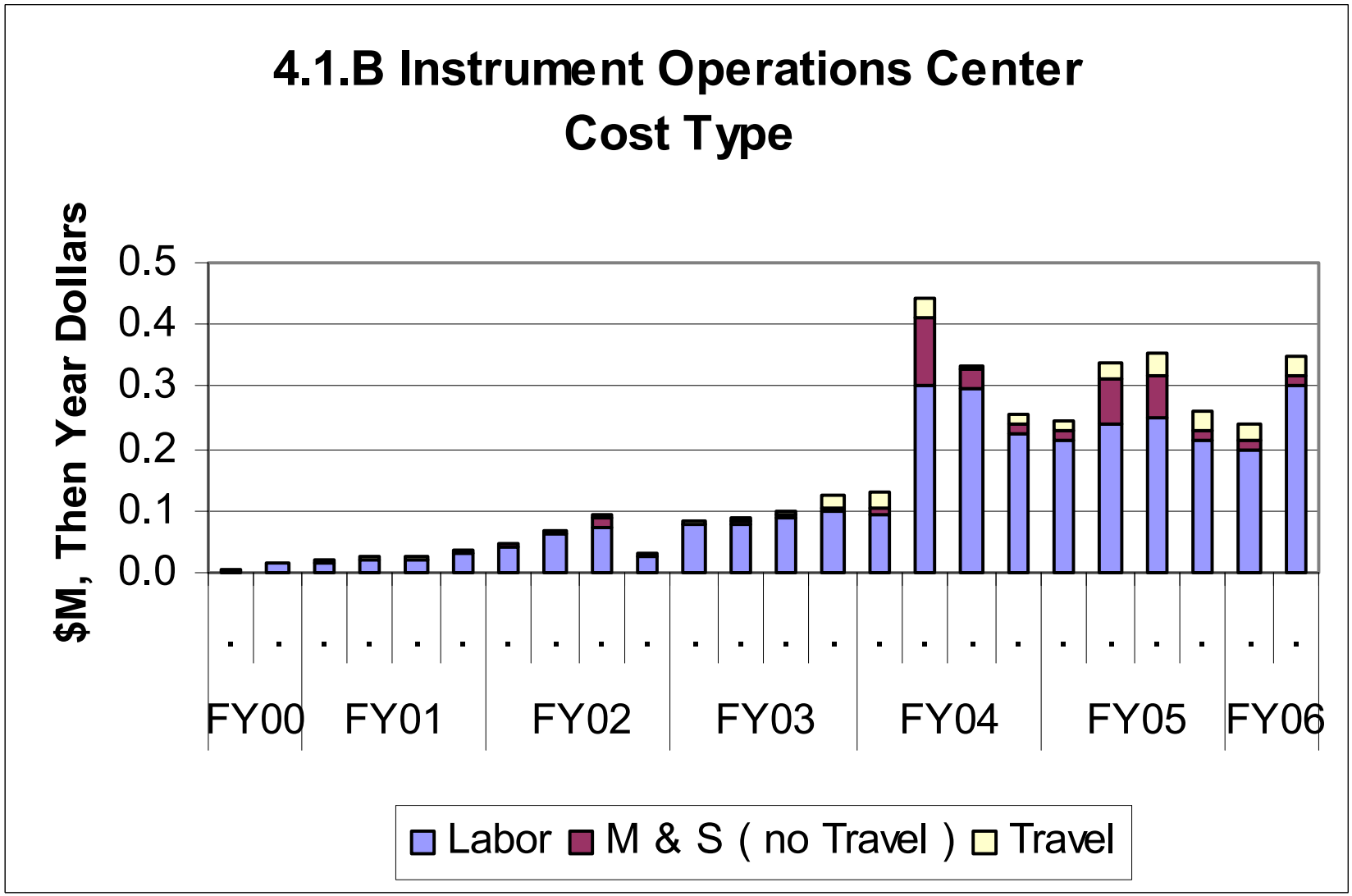
Computer systems management, data processing S/W, operations S/W, LAT Testbed support, LAT Testbed, FSW interface.

Development Labor Plan

Staffing for IOC includes hiring profile of 1 FTE staff in FY03 (TBD2) and 2 FTE in FY04 (TBD1, TBD3) to stabilize at 5 FTEs plus students.



IOC Cost Profile



MO&DA

- Launch Data – March 2006
- Phase 0 - Launch & early orbit: up to 60 days
  - S/C configuration and checkout: 10 days
  - LAT turn-on, configuration, and checkout: 20 days
    - Subsystem checks
    - Initial in-orbit calibration and alignment
  - LAT commissioning – 30 days
    - Initial science observations
    - Instrument Response Functions understood
- Phase 1 – Verification and Sky Survey: 12 months
  - LAT science verification
  - up to 20% of observing time for LAT calibration and test
- Phase 2 – Science Observations: minimum 4 years
  - Peer review driven investigations
  - 5% observing time for LAT calibrations and maintenance

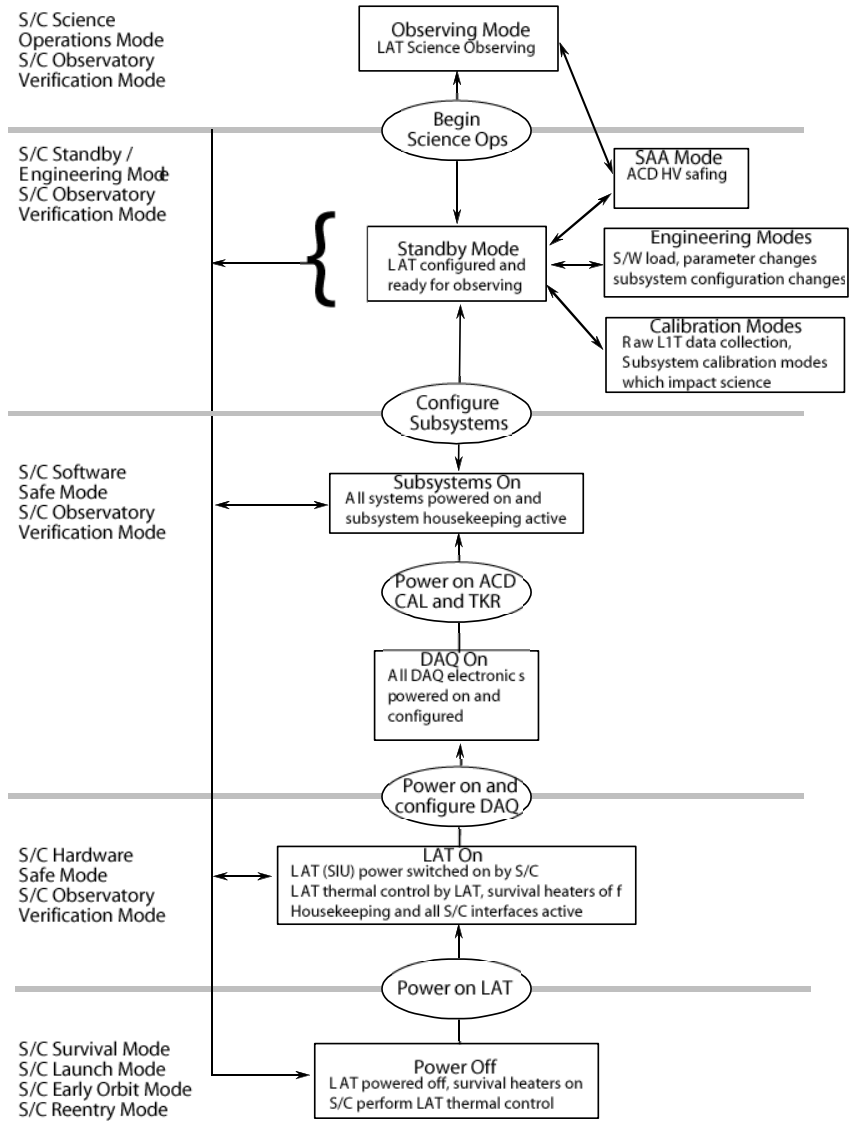
LAT Operating Modes

- **Science observing modes**
  - **Standard, Solar Flare, and GRB (TBR), distinguished by trigger criteria and post-trigger rejection cuts (possibly on the ground) for charged particles**
  - **Each science mode will have well-characterized (and monitored) instrument response functions**
- **Engineering-related modes**

Standby	All subsystems configured and ready for transition to nominal observing
Engineering	Used for flight software update, parameter changes, subsystem configuration changes
Calibration	Raw L1T data downlink, other subsystem calibration modes which impact science observing
SAA Mode	Safing of ACD photomultiplier tubes for high ambient charged particle density environments like the South Atlantic Anomaly
Sensors On	All sensor subsystems powered on and housekeeping active
DAQ On	All nodes of LAT DAQ powered on and configured, housekeeping active

LAT Operating Modes (2)

- **Calibration mode**
  - **E.g. no event filtering, verify FSW and check for rate-dependent effects in LAT response**
- **Other mode**
  - **Survival - LAT off (survival heaters turned on)**



MO&DA Roles

Observer

Scientist managing science planning and instrument operations, verifying data quality, and interfacing with the DPF/SSC. Consists of two 50% staff positions with lead responsibility on alternating weeks. Off week reserved for science analysis and primary backup. Cross trained with operators. Also filled by collaboration volunteers.

Operator

Engineers monitoring data acquisition, monitoring LAT health & status, performing daily trend analyses, managing uploads, interfacing to the MOC, scheduling instrument activity. Two fulltime positions with offset shift times to expand coverage. Cross trained with Observers. Also filled by collaboration volunteers.

Monitor

Staff and collaboration volunteers providing LAT data quality and acquisition monitoring and LAT configuration and performance monitoring during MOC and LOF off-shift periods.

Monitoring

- Purpose
  - to ensure integrity of IOC data acquisition and processing
  - to support lights out MOC in monitoring LAT status
- Exploit worldwide GLAST collaboration to provide distributed monitoring during lights out operations. Monitoring schedule filled weekly by LOF staff and collaboration volunteers.
- Provide web form with embedded data on data acquisition status, housekeeping, command status, science plan, LAT operations plan, recent data products, S/C alerts, and trend plots. One session requires about 15 minutes with inputs automatically entered in operations log.
- Provide abundant help and guidance/procedures for anomalies including pager/cell phone of responsible off-shift staff

Time	IOC	GSFC/NRL	France/Italy	Japan
UT	PST	EST	Europe	Japan
1-3	17-19	20-22	2-4	9-11
5-7	21-23	0-2	6-8	13-15
9-11	1-3	4-6	10-12	17-19
13-15	5-7	8-10	14-16	21-23
17-19	9-11	12-14	18-20	1-3
21-23	13-15	16-18	22-24	5-7

Concept weekend monitoring schedule with target monitoring periods
Primary Monitor
Backup Monitor

MO&DA Staffing

Manager - S. Williams

Technical management, reporting, mission planning, crew resource management, data analysis, Observer/Operator.

Science Observer - D. Lauben

LAT science operations, data analysis, calibration support, science planning and operations tools, LAT testbed support, DPF interface.

Science Observer – S. Digel

LAT science operations, data analysis, calibration support, science analysis tools, SSC interface.

Instrument Operator - TBD1

LOF management, operations S/W maintenance, LAT testbed support, distributed monitoring management, MOC interface for data acquisition.

Instrument Operator - TBD2

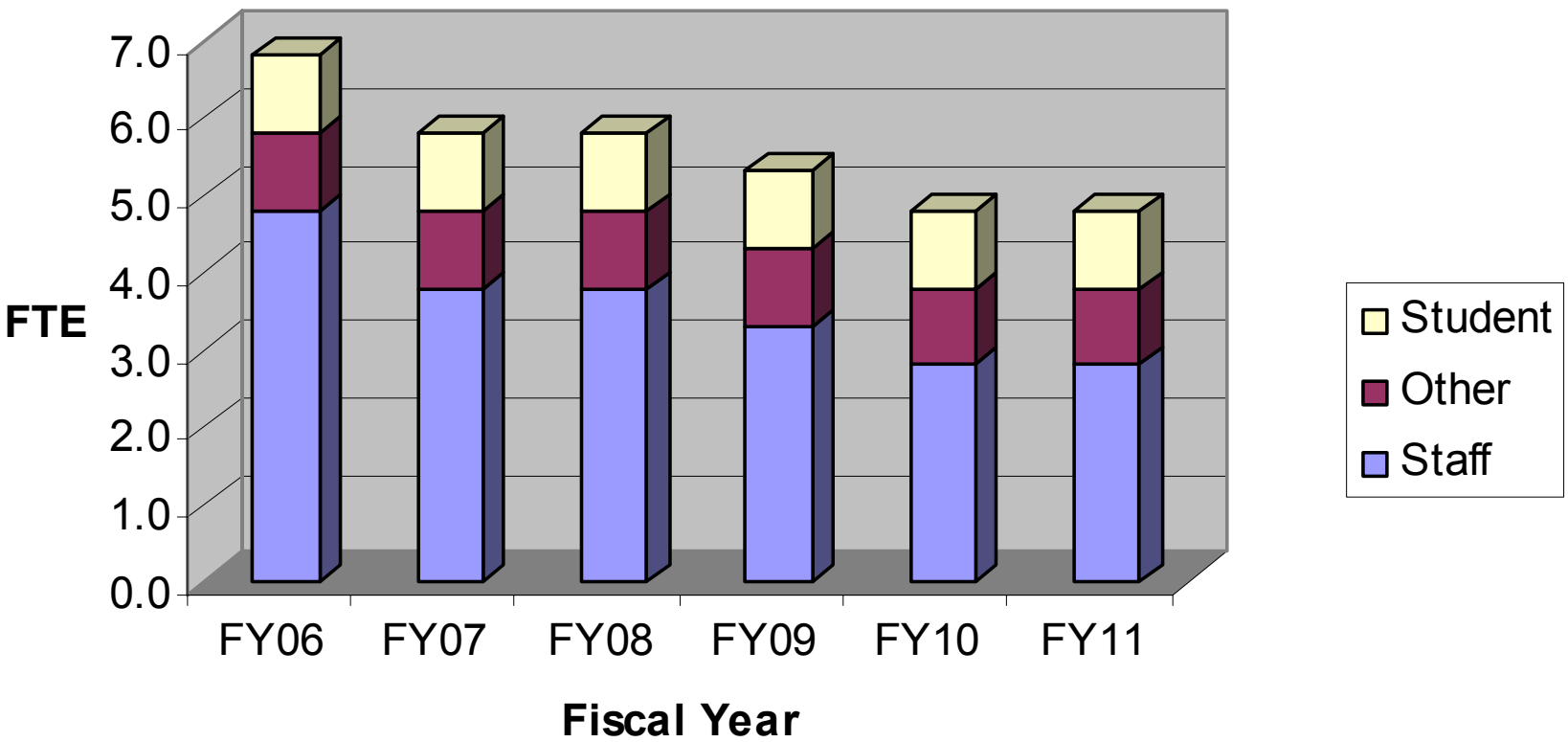
Configuration management, verification and QA support, command & telemetry database, operations procedures and documentation, MOC I/F for databases

LOF Systems Support - TBD

Ground Systems Engineer, instrument operator, computer systems management, data processing & operations S/W maintenance, FSW interface.

MO&DA Labor Plan

Single FTE labeled other represents Monitor contribution from collaboration members.



Balloon Flight

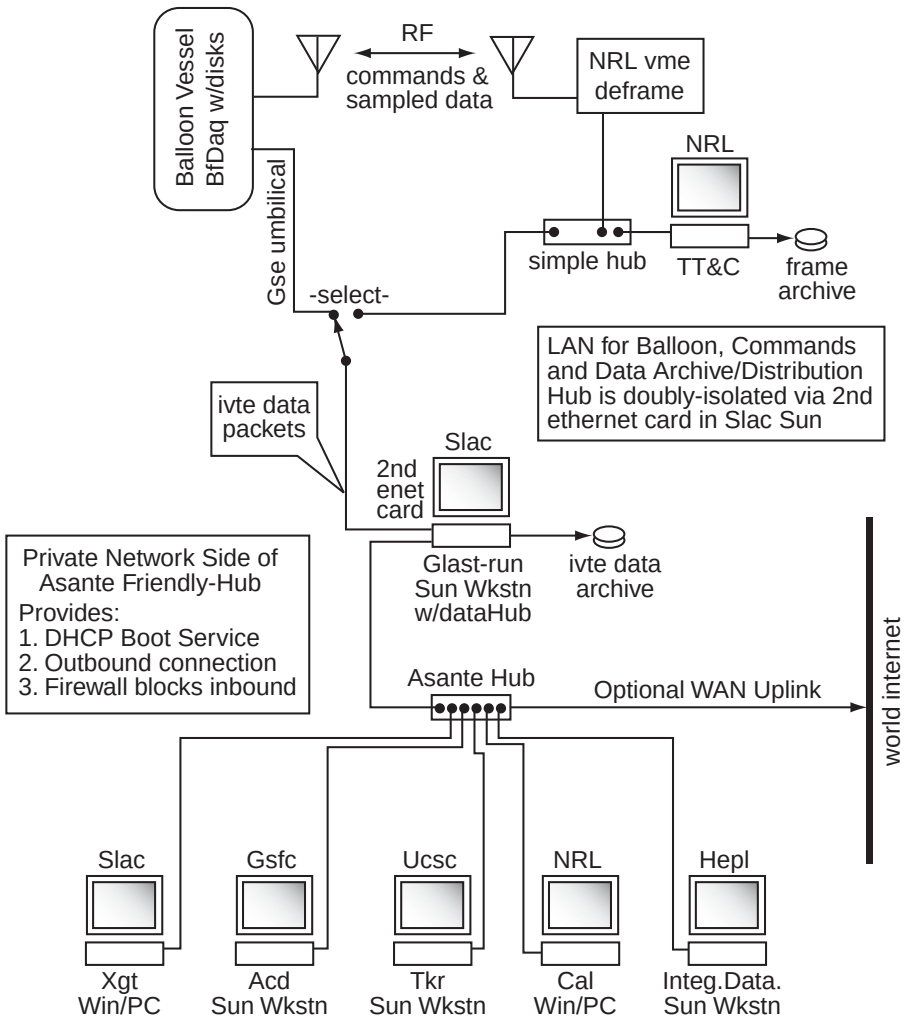
- Successful one-day flight in August 2001 from Palestine, Texas
- BFEM Objective 4 - Demonstrate an efficient data analysis chain that meets the requirement for the future IOC.
  - Demonstrate GSE capable of supporting data acquisition, archive and display from the BFEM and commanding of the BFEM
  - Acquire and display ground test and flight BFEM data for verification of BFEM status
  - Prototype IOC functions in support of flight IOC development
- Finding 1 - Rapid prototyping and development of new displays and quicklook analysis tools should be supported.
  - facilitates ID and resolution of anomalies, verification of integrated performance, and inclusion of revisions developed by other subsystems
- Finding 2 - heterogeneous h/w and s/w environment should be supported by using packetized ethernet distribution of data.
  - Allows the re-use of subsystem test s/w and display tools
  - Allows easy augmentation or replacement of hardware functions with available resources

BFEM "IOC" for Balloon Flight

Balloon, telemetry, disk read

Archive, dataHub

Gse clients, private net

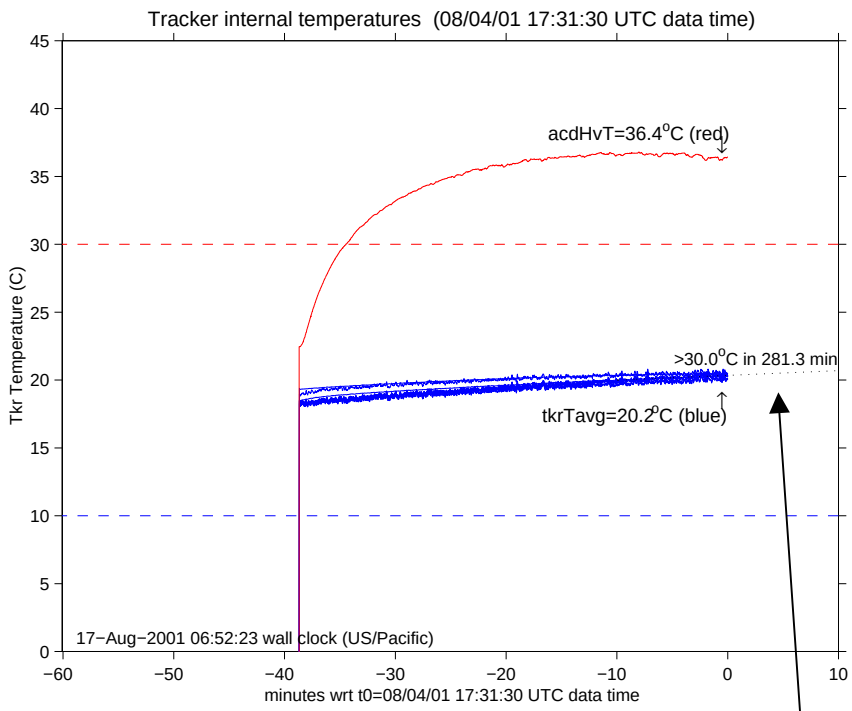


Single command console for flight

Outbound internet access via firewall router

Balloon Flight Housekeeping Display

- **Simple tabular text, line plots**
- **Forward trend extrapolation**



Tkr temp trend

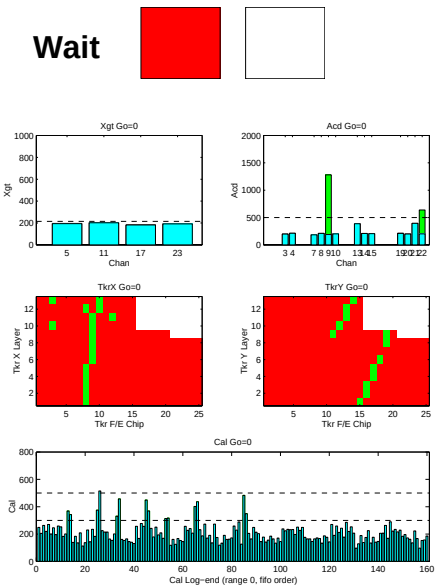
```
Daq Housekeeping (VSAM)
08/04/01 17:31:30 UTCBFEM GPS Time
17-Aug-2001 06:52:22 US/Pacific (wall clock)
ch     raw      calib      name
 0    1.204     0.72 A     tkr2i
 1    2.417     2.30 V     tkr2v
 2    1.791     1.07 A     tkr3i
 3    3.530     3.35 V     tkr3v
 4    1.024     0.61 A     tkr5i
 5    2.027     3.04 V     tkr5v     <4.8
 6    3.351   117.27 V     tkrHvV
 7    4.964   496.35 uA    tkrHvI
 8    0.299    25.79 C     tkrPsT
 9    3.431     5.15 V     cal5v
10    0.923     0.55 A     cal5i
11    0.299    25.69 C     calPsT
12    0.016     0.02 N/C   deadChan
13    2.484     4.97 V     acdDig5v
14   -0.030     1.01 A     acdDig5i
15    2.461     4.92 V     acdAna5v
16   -0.039     1.29 A     acdAna5i
17    7.978    28.08 V     acd28v
18   -0.016   549.65 mA    acd28i
19    0.298    25.46 T     acdPsT
20    3.094    36.45 T     acdHvT
21    6.151    12.30 V     xgt12v
22   -0.008   281.31 mA    xgt12i
23    2.922    19.15 C     calTopT
24    1.992   497.97 V     xgtHv0
25    1.876   469.10 V     xgtHv1
26    1.944   485.99 V     xgtHv2
27    1.985   496.17 V     xgtHv2
28    3.235     0.18 g     magRoll
29    3.415     0.22 g     magPitch
30   50.000     0.90 Psi   ExtPr
31    3.142     7.72 Psi   IntPr     <10.0
```

underpressure alarm

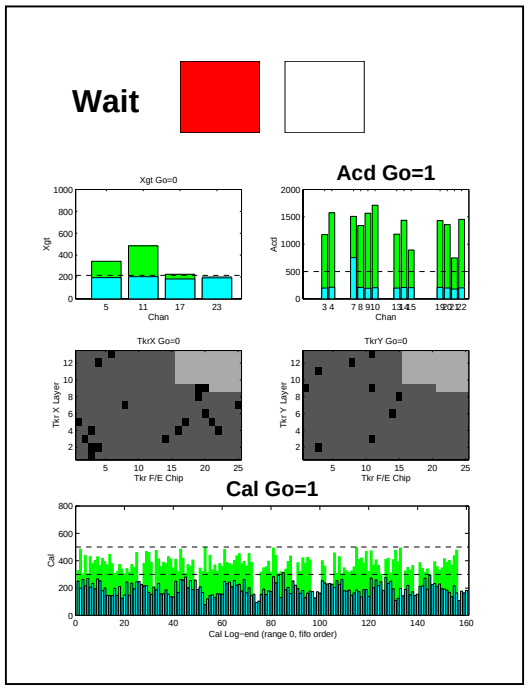
Balloon Flight Go/NoGo

With infrastructure in place, this display took only ~1 hour to create…

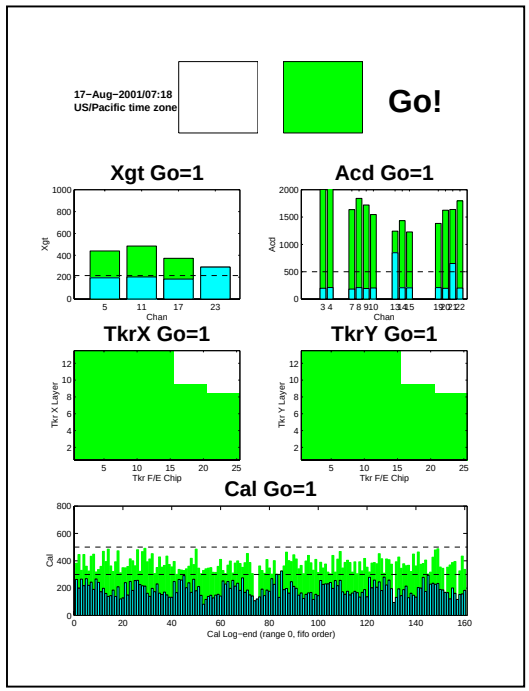
reset… …wait… …launch!



t = 0+



t = ~5 min



t = ~15 min

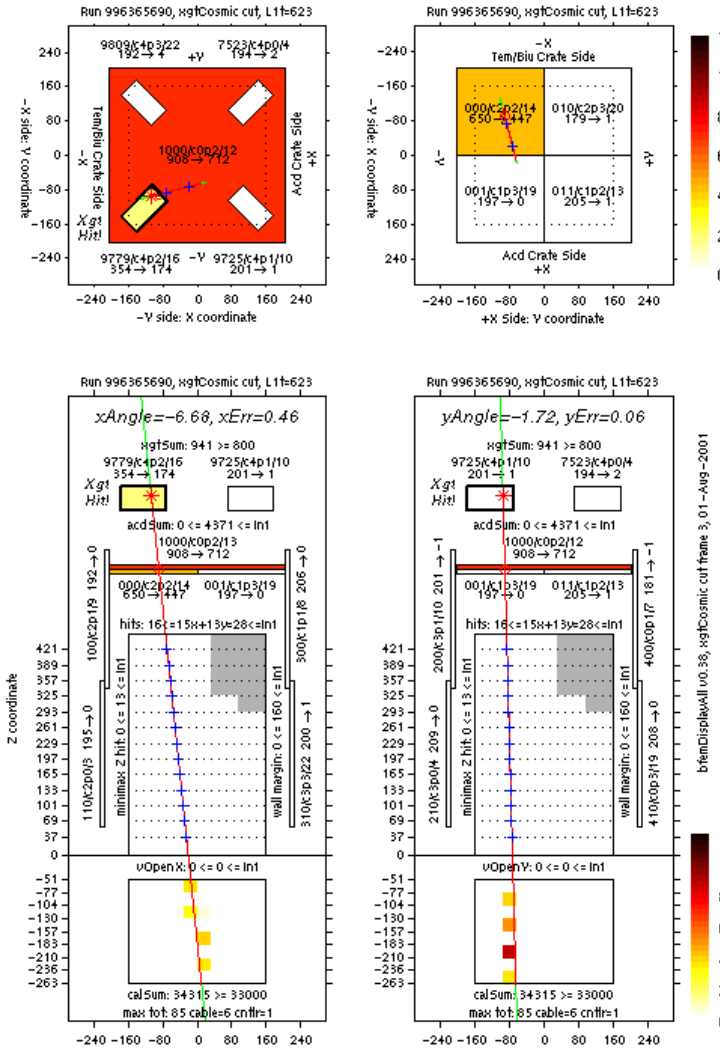
Balloon Flight Raw Event Display

Primitive Display:

- Shows sample events in real time, has optional display filters (cuts)
- Minimal calibration/algorithms
- No event reconstruction

Straight Track Cut (Muons):

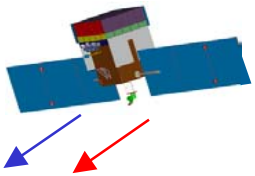
- Verify geometry model and alignment between Tracker, Calorimeter, and Acd tiles
- Verify event synchronization



Trade Studies

- Several trade studies will be completed prior to IOC PDR
  - Command management and control (or test executive) software
  - Wide area network interface to GLAST ground segment
  - Location of LAT Operations Facility at Stanford
  - Command and telemetry database software
  - Data analysis and visualization software
  - Data management and realtime display software
  - LOF workstation hardware and operating system
- Resources are constrained in FY02/03
  - Leverage I&T online system development by participating in development and planning for evolution to meet IOC requirements.

LAT Data Path



Realtime data: 32 kbps S-band
SSR dump: 10 to 150 Mbps X-band

Prime - 2 Mbps Intelsat

Backup - 500 kbps

ASINet Central Node Fucino, Italy

32 Mbps

JSC Houston

Realtime S-Band Data and SSR Data

NISN or ASINet

MOC (TBD)

NISN or Internet 2 via JPL

NISN or Internet 2 via ARC

LAT IOC Stanford

Malindi gets ~35 Gbits per day from GLAST and 26 Gbits From Swift, and AGILE

Equivalent to ~400 kbps continuous

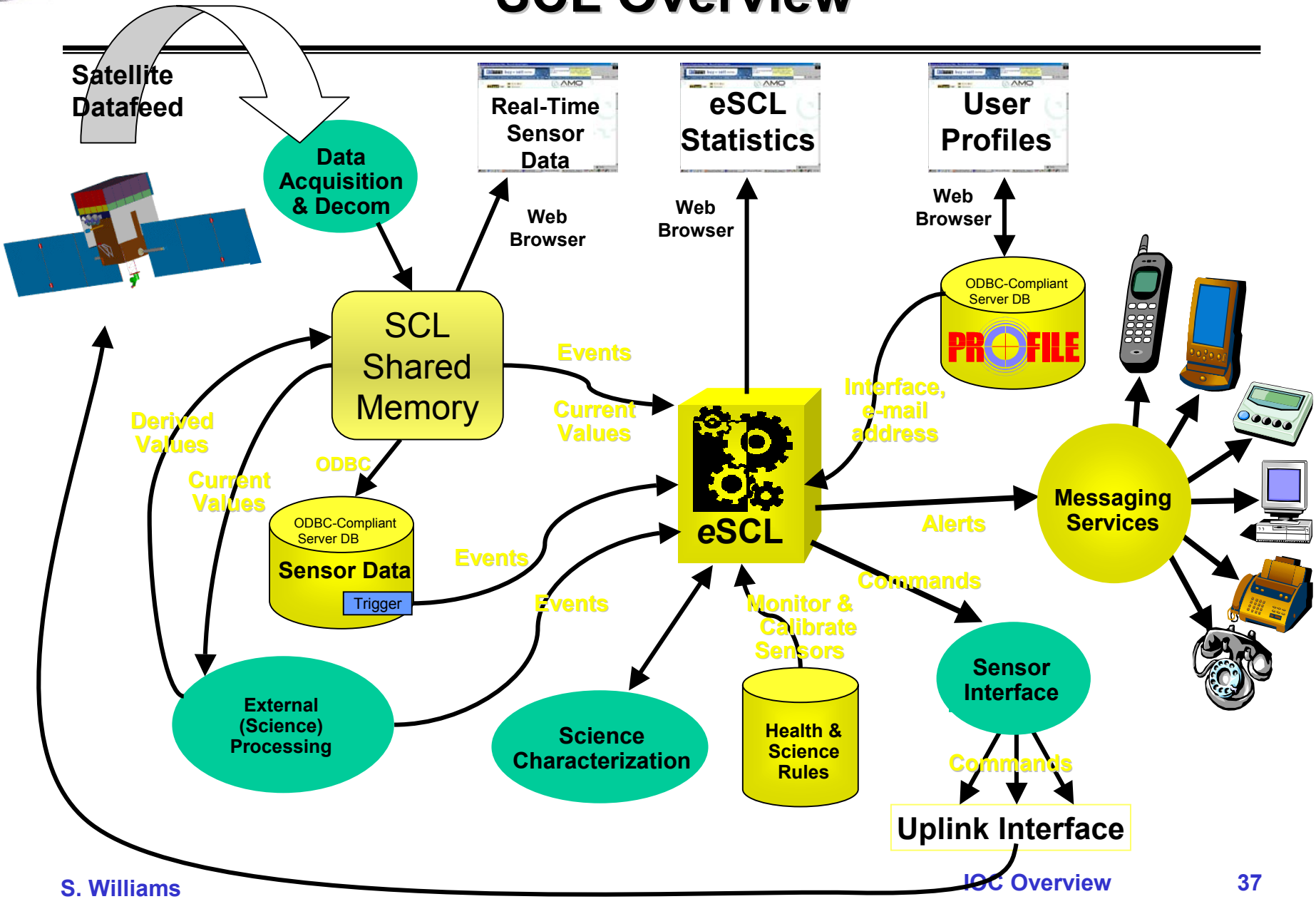
NISN should support whatever rates we deem necessary for the desired latency Another option is Internet 2

Realtime S/C and LAT HSK Data
Followed by processed Level 0 Data

Test Executive Trade Study

Company: Product Name	Contact and phone #	Open Source	Supported Platforms	Export Control	Upfront Cost	website
Colorado U/LASP: OASIS	Randy Davis 1-303-492-6867; Michelle Kelly 303-492-4624	Source is free, but not "open source"- ADA	Solaris 2.5.1 Ulatrasparc	No		http://lasp.colorado.edu/oasis/oasis.html
Harris Corp: OS - Comet	Trip Carter 303-738-9122, Cell 303-884-8495, wcarte08@harris.com	No-C	Unix	yes		http://www.sticomet.com/products.asp
Interface ControlSystems: SCL	Brian Buckley 321-723-0399, buckley@interfacecontrol.com	Yes- C, C++, Java	NT, Solaris VX, Redhat Linux+Realtime Extensions	no		http://www.interfacecontrol.com/aerospace.htm
Talarian: Smart Sockets (formally RT - Works	Abraham Glazer, 650-695-8050x104,abraham.glazer@talarian.com	No - C	NT, Solaris, Linux	no		http://www.talarian.com/
GSFC: ITOS	Bill Mocarsky, William.L.Mocarsky.1@gsfc.nasa.gov	No - C	Linux, Solaris, Free BSD	yes		http://itos.gsfc.nasa.gov/
GSFC: ASSIST	Bill Mocarsky, William.L.Mocarsky.1@gsfc.nasa.gov	No-C	Linux, IBM AIX	yes		None found.

SCL Overview



Issues & Mitigations

Uncertainty in GLAST operations concept for downlink rate, downlinks per day, and downlink margin complicates IOC planning.

- Participate in GLAST Ops Working Group
- Provide flexibility in LOF support via global monitoring concept

The development schedule for the Mission Operations Center (MOC), Spacecraft, and ground communications segment lags the LAT schedule by approximately 12 months.

- Performed detailed ground systems functional allocation study and developed level II requirements document.
- Hold IOC PDR with LAT but allow IOC CDR to match schedule with remainder of ground segment.

Resources in FY02/03 are limited.

- Leverage I&T online system development by participating in development and planning for evolution to meet IOC requirements.
- Use Systems Engineering resources to support systems level planning and design integration.
- Exploit balloon flight experience in display prototyping and data visualization.

Conclusions

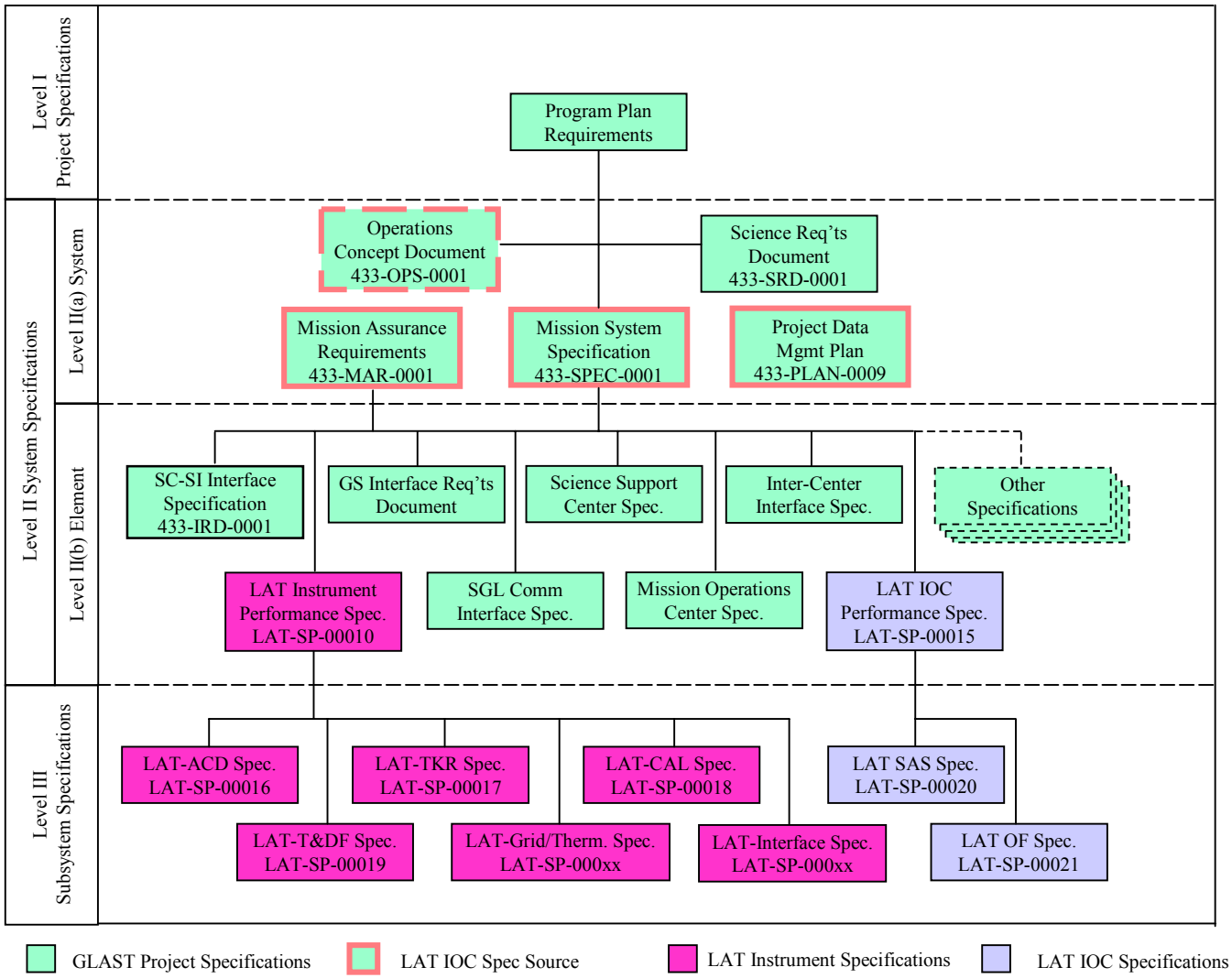
- IOC plan is captured in PMCS and ready for baselining
  - Established cost plan fits available funding
  - Schedule meets program requirements
  - Contingency (24% overall, but 31% on LOF) is adequate
  - Delay in IOC CDR preserves flexibility to accommodate program level changes
- Requirements flowdown from GLAST Operations Concept must be completed
  - Updates needed for MSS, PDMP, LAT IOC Level II Spec.
- MOC and S/C selections in spring 2002 is eagerly anticipated
  - Allow development of LOF interface requirements

Background Material

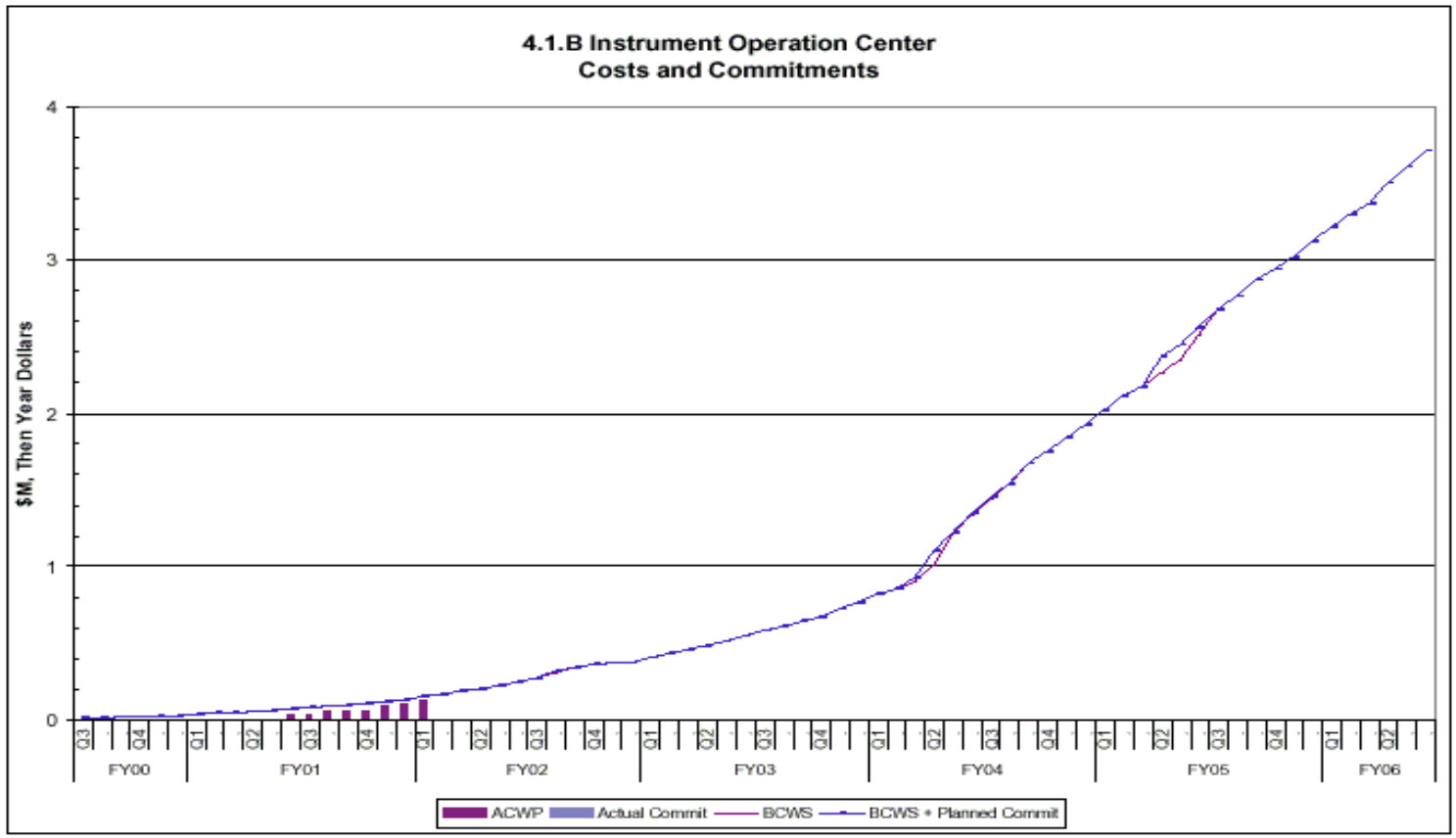
Definitions

- **Level 0 Processing - Space-to-ground artifact removal**
  - Processing of raw instrument data. Level 0 data processing consists of time-ordering packets, removing corrupted, incomplete, or duplicate packets, annotating quality, and can include separating housekeeping, calibration, science, and engineering data streams.
- **Level 1 Processing**
  - Processing of level 0 data into level 1 data. Level 1 data processing consists of creating a database of reconstructed gamma-ray photons and cosmic-rays which includes energy, direction of arrival, quality parameters, and associated exposure maps.
- **Higher Level Science Processing**
  - Processing of level 1 data into derived science products. Science data processing includes detecting sources, measuring spectra, determining time histories, and locating potential counterparts in other astronomical catalogs.

Requirements Traceability

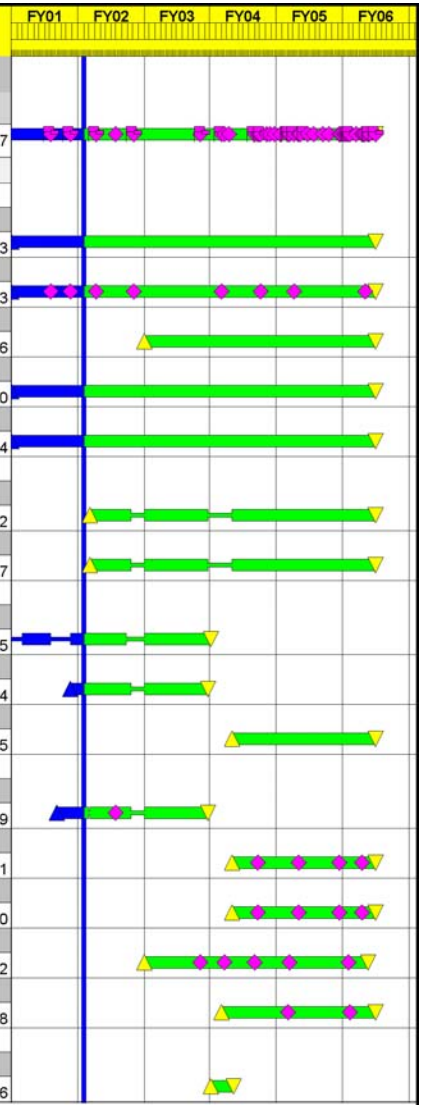


IOC Cost & Commitments



Schedule

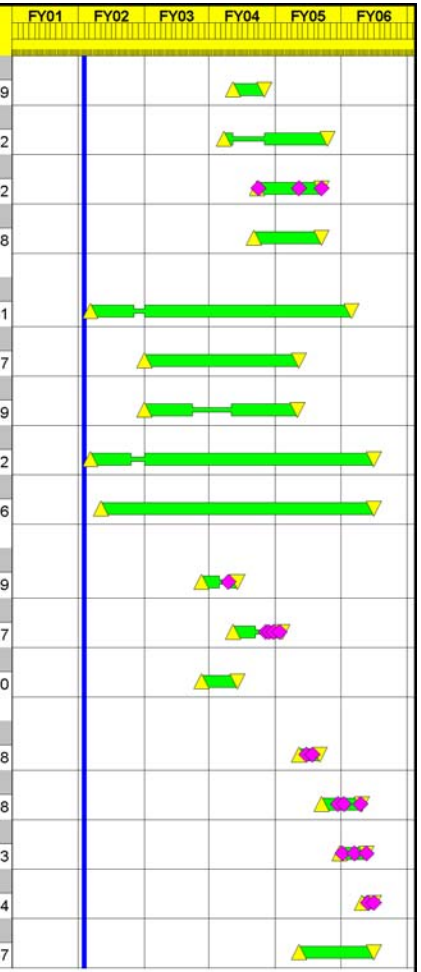
Activity ID	Activity Description	Orig Dur	PMT	% Comp	Early Start	Early Finish	Total Float	Budgeted Cost
4 GLAST INSTRUMENTS								
4.1 GLAST LAT PROJECT (DRAFT)								
Subtotal		1,483		4	04APR00A	31MAR06	191	3,843,942.17
4.1.B LAT INSTRUMENT OPERATIONS CENTER								
4.1.B.1 PROJECT MANAGEMENT								
+ 4.1.B.1.1 PROJECT ADMINISTRATION								
		1,357		27	02OCT00A	31MAR06	191	158,974.03
+ 4.1.B.1.2 MEETINGS & REVIEWS								
		1,357		9	02OCT00A	31MAR06	191	158,930.63
+ 4.1.B.1.3 LOGISTICS MANAGEMENT								
		863		0	01OCT02	31MAR06	191	144,637.16
+ 4.1.B.1.4 TRAVEL								
		1,357	A	16	02OCT00A	31MAR06	191	109,280.60
+ 4.1.B.1.5 PROJECT SUPPORT								
		1,357	A	5	02OCT00A	31MAR06	191	116,995.84
4.1.B.2 PERFORMANCE ASSURANCE								
+ 4.1.B.2.1 IOC PERFORMANCE ASSURANCE								
		1,061		0	11DEC01	31MAR06	191	54,893.42
+ 4.1.B.2.2 IOC VERIFICATION								
		1,061		0	11DEC01	31MAR06	191	72,417.37
4.1.B.3 MISSION & OPERATIONS PLANNING								
+ 4.1.B.3.1 OPERATIONS CONCEPT DEVELOPMENT								
		870		54	04APR00A	03OCT03	32	94,033.85
+ 4.1.B.3.2 INTEGRATION & TEST PLANNING								
		516	A	7	20AUG01A	19SEP03	42	40,103.14
+ 4.1.B.3.3 MISSION OPERATIONS PLANNING								
		541	A	0	28JAN04	31MAR06	191	172,573.25
4.1.B.4 LAT OPERATIONS FACILITY								
+ 4.1.B.4.1 SYSTEM CONCEPTUAL DESIGN								
		570		8	04JUN01A	19SEP03	42	114,410.89
+ 4.1.B.4.2 DATA ACQUISITION S/W DEVELOPMENT								
		541		0	28JAN04	31MAR06	191	260,340.91
+ 4.1.B.4.3 OPERATIONS S/W DEVELOPMENT								
		541		0	28JAN04	31MAR06	191	477,614.50
+ 4.1.B.4.4 COMMAND & TELEMETRY DEVELOPMENT								
		835		0	01OCT02	21FEB06	195	224,051.12
+ 4.1.B.4.5 IOC SYSTEM DEVELOPMENT								
		571		0	05DEC03	31MAR06	191	307,092.58
4.1.B.5 IOC TEST								
+ 4.1.B.5.1 TEST PLANNING								
		80	E	0	06OCT03	06FEB04	364	14,917.56



Sheet 1 of 2

Schedule

Activity ID	Activity Description	Orig Dur	PMT	% Comp	Early Start	Early Finish	Total Float	Budgeted Cost
+ 4.1.B.5.2	TEST DEVELOPMENT	120	E	0	09FEB04	28JUL04	364	75,157.39
+ 4.1.B.5.3	VERIFICATION TESTING	390		0	17DEC03	18JUL05	364	55,878.32
+ 4.1.B.5.4	IOC INTERFACE TESTS	242		0	18JUN04	09JUN05	390	54,211.02
+ 4.1.B.5.5	LOF I&T TRAVEL	255*		0	01JUN04	09JUN05	149	34,030.88
4.1.B.6	LAT PERFORMANCE VERIFICATION							
+ 4.1.B.6.1	PERFORMANCE VERIFICATION TESTING	980		0	11DEC01	28NOV05	49	69,049.81
+ 4.1.B.6.2	ANALYSIS SOFTWARE	580		0	01OCT02	09FEB05	44	45,408.27
+ 4.1.B.6.3	DISPLAY SOFTWARE	572		0	01OCT02	28JAN05	52	44,775.19
+ 4.1.B.6.4	LAT CALIBRATION SUPPORT	1,061		0	11DEC01	31MAR06	191	47,804.12
+ 4.1.B.6.5	LAT TESTBED SUPPORT	1,028		0	06FEB02	31MAR06	191	144,426.96
4.1.B.7	LAT INTEGRATION & TEST							
+ 4.1.B.7.1	QUALIFICATION UNIT TEST SUPPORT	129		0	18AUG03	01MAR04	68	62,929.99
+ 4.1.B.7.2	FLIGHT UNIT TEST SUPPORT	193		0	09FEB04	09NOV04	101	136,341.77
+ 4.1.B.7.3	LAT I&T TRAVEL	129*		0	18AUG03	01MAR04	68	60,745.00
4.1.B.8	MISSION SYSTEMS INTEGRATION & TEST							
+ 4.1.B.8.1	OBSERVATORY TESTING	79		0	10FEB05	02JUN05	30	98,148.48
+ 4.1.B.8.2	GROUND SYSTEMS COMPATIBILITY TESTS	147		0	17JUN05	24JAN06	25	71,274.98
+ 4.1.B.8.3	TRAINING SIMULATIONS	101		0	19SEP05	17FEB06	220	74,436.13
+ 4.1.B.8.4	LAUNCH & EARLY OPERATIONS SUPPORT	47		0	25JAN06	31MAR06	191	139,955.64
+ 4.1.B.8.5	MSI&T TRAVEL	283*		0	10FEB05	31MAR06	191	108,101.37



Sheet 2 of 2

Key Level III Milestones

IOC Requirements Review	05/03/01
IOC PDR	08/17/01
Online System Spec from I&T to IOC	05/01/02
IOC CDR	12/04/03
Calibration Unit Beam Test from I&T to IOC	01/15/04
LAT EMI/EMC Test from I&T to IOC	08/09/04
LAT Vib/Acoustic Test from I&T to IOC	08/30/04
LAT Thermal Test from I&T to IOC	09/21/04
LAT Performance Test from I&T to IOC	10/26/04
LAT Observatory TV Test from SCO to IOC	04/20/05
Ground System Interface Test from SCO to IOC	09/16/05
Mission Sequence Test from SCO to IOC	10/17/05
IOC Readiness Review	01/10/06
End-to-End Test from SCO to IOC	01/17/06

Key Level IV Milestones

Calibration Unit Database Release	08/07/03
I&T Database Release	12/16/03
Environmental Test Database Release	06/01/04
Data Acquistion S/W Development Release 1	06/17/04
Operations S/W Development Release 1	06/17/04
IOC S/W Release 1	06/17/04
IOC I/F Test A Complete	06/24/04
Development Model Complete	12/06/04
Observatory Integration Database Release	12/13/04
Data Acquistion S/W Development Release 2	01/28/05
Operations S/W Development Release 2	01/28/05
IOC I/F Test 1 Complete	02/04/05

Key Level IV Milestones

IOC S/W Release 2	02/07/05
IOC I/F Test 2 Complete	06/09/05
LAT Ops Factility Validation & Verification Comp	07/18/05
IOC S/W Release 3	09/15/05
Data Acquistion S/W Development Release 3	09/15/05
Operations S/W Development Release 3	09/15/05
Ground Systems Compatibility Test (TBR) Complete	09/23/05
Simulation 1 Complete	10/07/05
Mission Sequence Test (TBR) Complete	10/24/05
Flight Database Release	11/01/05
Operational Model Complete	11/08/05
Simulation 2 Complete	12/09/05

Key Level IV Milestones

IOC S/W Release 4	01/18/06
Data Acquistion S/W Development Release 4	01/18/06
Operations S/W Development Release 4	01/18/06
End-to-end Test (TBR) Complete	01/24/06
Flight Readiness Review (FRR)	02/01/06
Training Simulations Complete	02/17/06
Simulation 3 Complete	02/17/06
LAT Activation & Checkout Complete	03/31/06

Mission Operations Overview

- **Launch Date:** March 2006
- **Mission Life:** 5 year required with 10 year goal
- **Orbit:** 470 to 550 km circular orbit, 28.5° inclination.
- **Spacecraft:** RSDO spacecraft, to be selected ~spring 2002.
- **Mission Operations Center:** TBD, to be selected ~spring 2002.
- **Ground Link:** Ground Station (Malindi) – Two contacts per day (TBR) to dump the bulk science data. Data volume is 28 Gbits per day. Downlink rate is 150 Mbps (TBR) over an X-band link. S-band used for real time housekeeping telemetry and commanding.
- **Space Link:** Space Network – Demand Access System (DAS) used for gamma-ray burst alerts, health and safety alerts, and other science and housekeeping functions. Single Access Service (SAS) used for large command uploads and early orbital operations. Multiple Access Service (MAS) used for TOO commanding.
- **Operations Constraints:** Earth limb avoidance, radiator, and solar panel pointing constraints. Spacecraft may autonomously adjust its operation (including its pointing) in response to a gamma-ray burst.

WBS Interfaces