GLAST Large Area Telescope

Instrument Flight Software
Quick Look Review
21 November 2003

Management Plan & Process

Presenting for the FSW group:
Gunther Haller
Stanford Linear Accelerator Center
Manager, Electronics, DAQ & FSW
LAT Chief Electronics Engineer

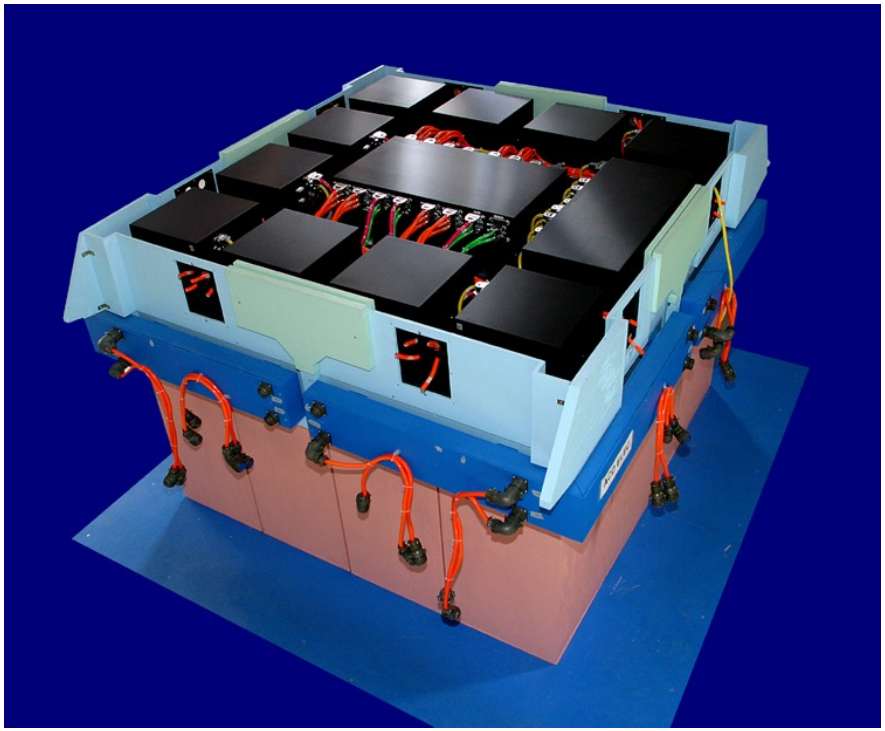
haller@slac.stanford.edu
(650) 926-4257

Content

- Overview of LAT
- Key Milestones
- Development Process
- Oversight/Assessment
- Organization
- Code Management/Configuration Control
- Problem Report and Tracking
- CDR/Peer-Review RFA's
- Accomplishments
- Remaining Effort

LAT Instrument

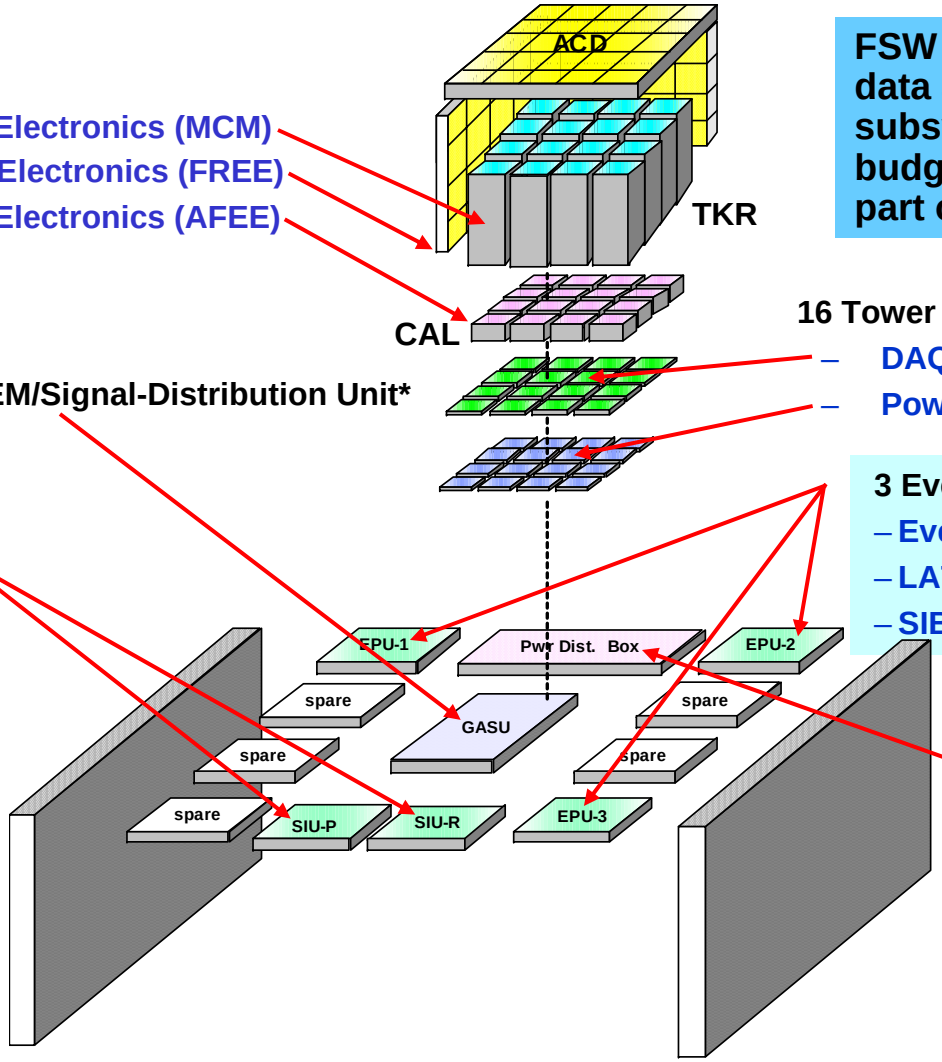
- ***Photograph of 1:1 scale LAT mock-up model (upside down view)***



LAT FSW – Part of DAQ Subsystem
FSW runs on SIU/EPU only

FSW is an integral part of the data acquisition (DAQ) subsystem and is managed, budgeted and scheduled as part of the DAQ subsystem

TKR Front-End Electronics (MCM)
ACD Front-End Electronics (FREE)
CAL Front-End Electronics (AFEE)



Global-Trigger/ACD-EM/Signal-Distribution Unit*

16 Tower Electronics Modules
- DAQ electronics module (DAQ-EM)
- Power-supplies for tower electronics

3 Event-Processor Units (2 + 1 spare)
- Event processing CPU
- LAT Communication Board
- SIB

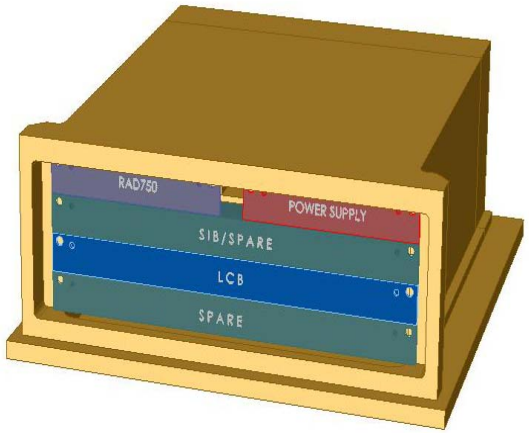
2 Spacecraft Interface Units (1 + 1 spare)
- Storage & Interface Board (SIB): Spacecraft interface, control & telemetry
- LAT control CPU
- LAT Communication Board (LCB): LAT command and data interface

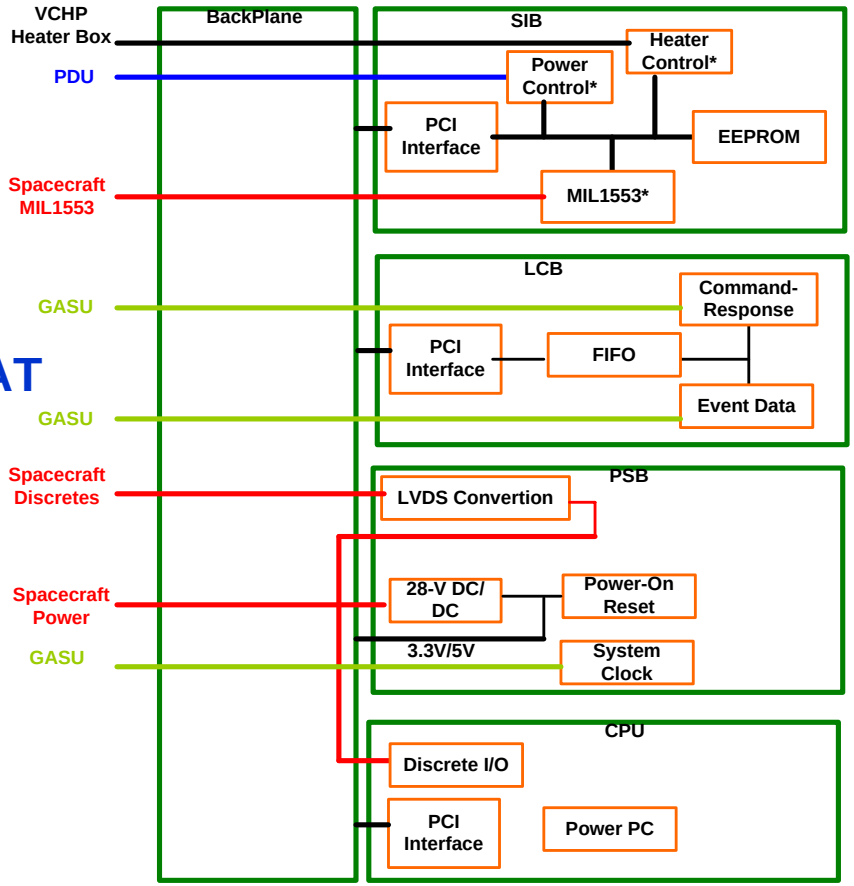
Power-Distribution Unit (PDU)*
- Spacecraft interface, power
- LAT power distribution
- LAT health monitoring

* Primary & Secondary Units shown in one chassis

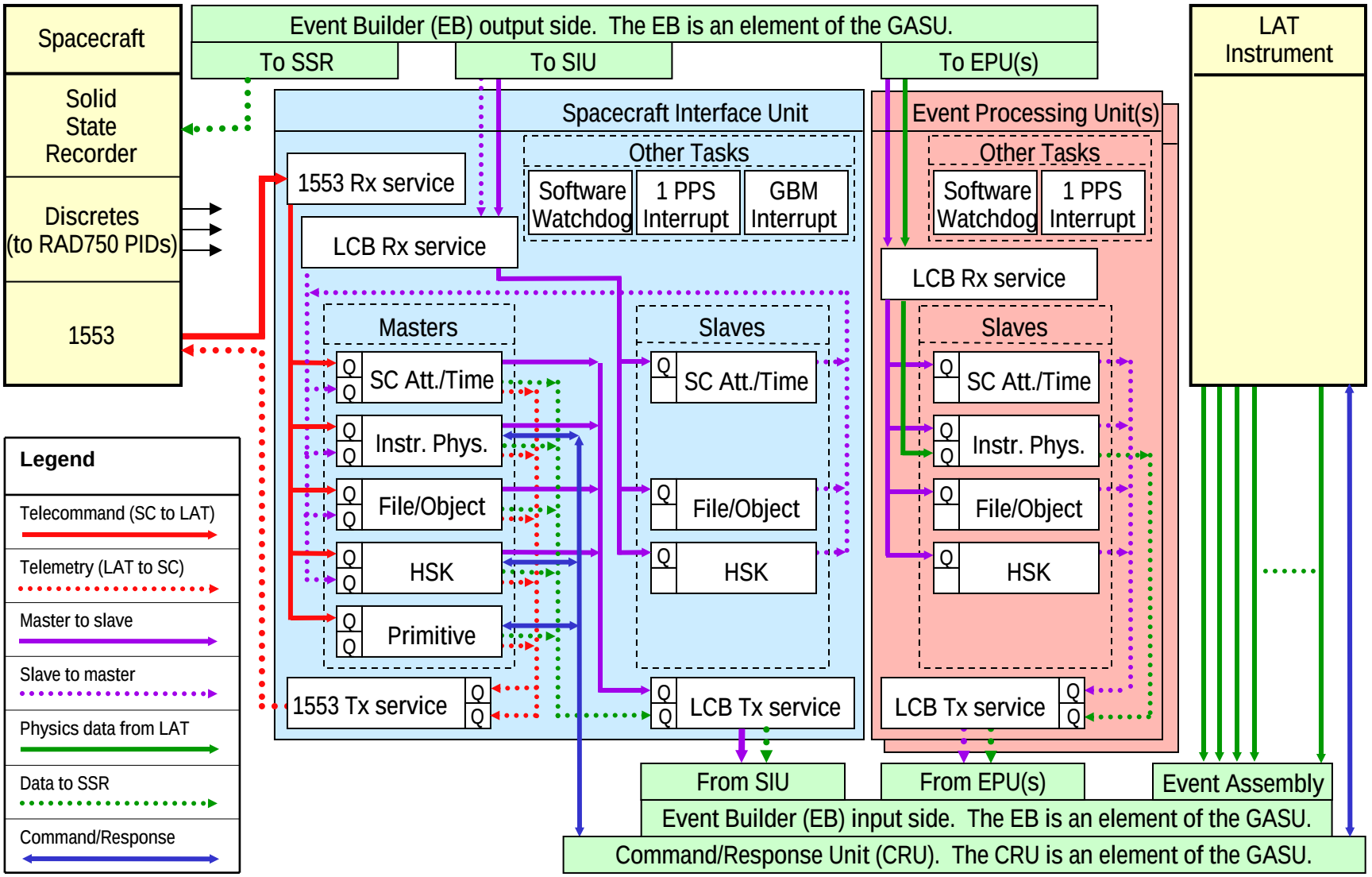
Software Runs in SIU/EPU Crate Processors

- Compact-PCI Crate consisting of
  - Storage & Interface Board (SIB)
    - EEPROM
    - MIL1553 Communication with spacecraft (SIU crate only)
  - LAT Communication Board (LCB)
    - Communication with rest of LAT
  - Power Supply Board (PSB)
  - BAE RAD750 CPU Board
  - cPCI Backplane (passive)





LAT FSW Architecture



Software Key Milestones for I&T/ISIS

- August 03
  - Tested Software to control/read-out single tower with Calorimeter and Tracker sub-system (done, EM1), delivered to I&T
- Jan 04
  - SW peer review
- June 04
  - I&T requires software to control/readout multi-tower (i.e. GASU) configuration (EM2)
- June 04
  - Instrument Spacecraft Interface Simulator (ISIS) to Spectrum Astro
- August 04
  - Demo to LAT system engineering on fully instrumented test-bed
- December 04
  - I&T requires tested software to control/readout full LAT
  - FU SW build to I&T
- February 05
  - I&T requires FU software release to operate/test (whole LAT is integrated)
  - Start of system testing
- May 05
  - End of system test
- May-July 05: float
- July 05
  - Ship LAT for instrument environmental testing
- Nov 05: float
- December 05
  - LAT RFI

LAT FSW Development Overview

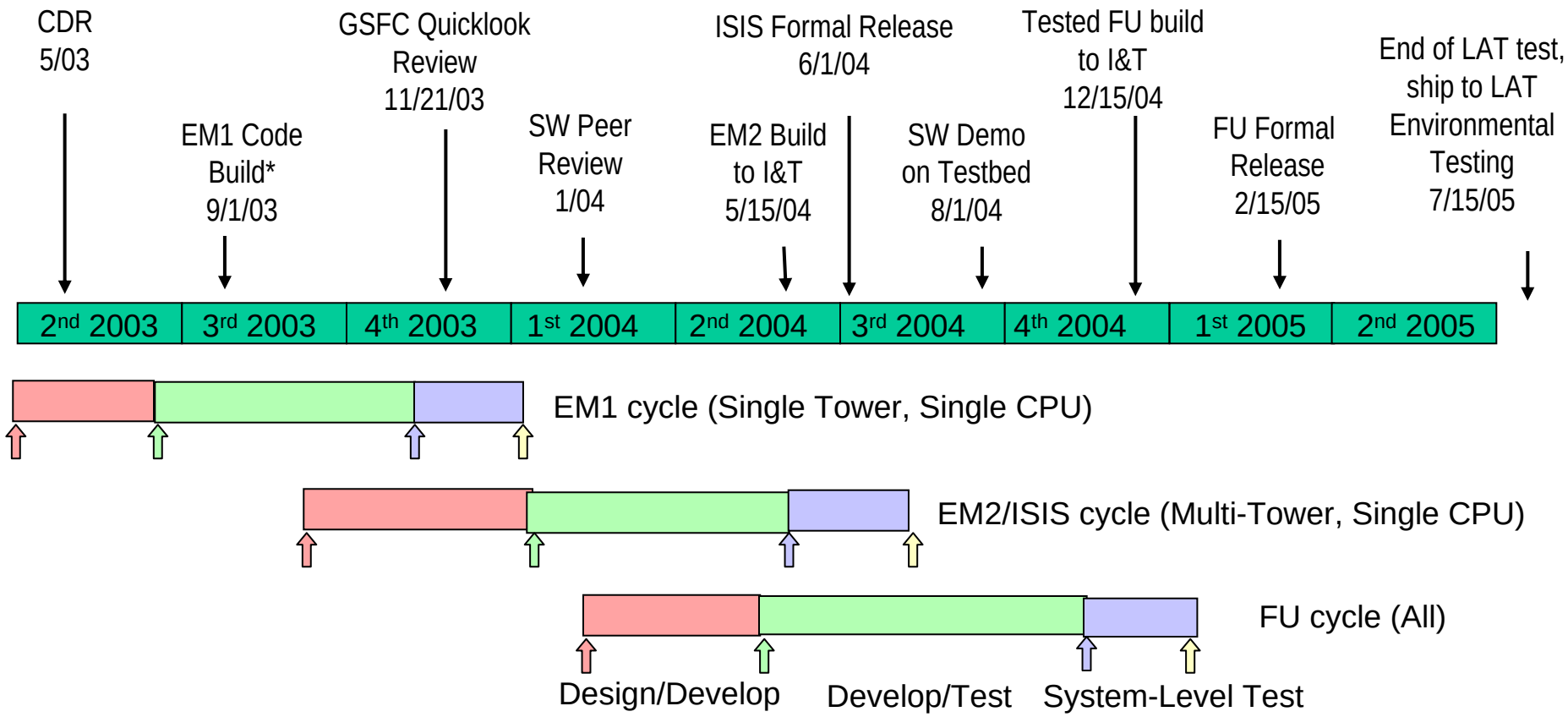
- FSW is an integral part of the data acquisition (DAQ) subsystem and is managed, budgeted and scheduled as part of the DAQ subsystem
  - > 3 million configuration bits to configure system and to take event data properly
  - Majority of software is to configure & setup hardware (boot, TKR, CAL, ACD, DAQ trigger, event-builder sub-system setup, etc)
  - Rest is filtering, data monitoring, health & safety, telemetry
    - Filter takes ~99% of non-idle CPU cycles during physics running
  - Once running, most is done in hardware
- FSW builds will therefore be coordinated with the DAQ hardware builds in both timing and content
- FSW development plan follows the spiral design model
- Hardware, C&DH software, and science software integrated in one team
- Software development continues after HW release

Major LAT FSW Builds

- Incremental FSW builds to coincide with the natural hardware builds as follows:
- Major Builds
  - Engineering Model 1
    - Run single tower, single CPU
      - Used for EGSE test-stands for hardware development (built, tested, done)
      - Used for LAT single-tower engineering unit by I&T group (built, tested, done)
  - Engineering Model 2
    - Multiple towers, GASU*, single CPU
      - Used for EGSE test-stands for hardware development (in progress)
      - Used as test-bed for hardware and software development & test (in progress)
- Releases
  - ISIS Build & Release
      - To be delivered to the Spacecraft vendor (Formal Release)
  - Full LAT Build & Release
    - Complete set of 16 towers, GASU*, full set of CPU's
      - Used as test-bed for hardware and software development & test
      - To be delivered to I&T for full-LAT testing (Formal Release)

* GASU includes LAT Global Trigger, LAT Event-Builder. Command-Response Unit, ACD Electronics Module

Breakdown of Development Cycles



Design/Develop: Start design, code small prototypes, no hardware available, only descriptions
Develop/Test: Code and test against real hardware, take snap-shot at end (i.e. define build)
System-Level test: Build Test

*: EM1 was built/tested/delivered, group is now integrating/testing another recently available piece of hardware for EM1, the LCB.

EM1 FSW Build

Goal: Demonstrate Single-Tower, Single-CPU Operation

- Hardware
  - 1 Partially populated tower with calorimeter and tracker sub-system instrumentation & detector sensors
  - 1 Tower Electronics Module
  - 1 COTS CPU (VME)
    - Ethernet
    - Serial port
    - LCB

Status:

Development and test completed against preproduction electronics with the exception of LCB support (using VME I/O communications boards instead).

Code tested and deployed to field in I&T test stands, and to single tower engineering unit test.

Used successfully by I&T to control/run single tower in clean room; took physics event data.

- Software
  - Interfaces (other than VxWorks)
    - LCB command/response
    - LCB event acquisition
  - TEM configuration setting and read-back
    - Read/write all TEM/TKR/CAL registers
  - Format and export event data from tower
  - Charge injection calibration
    - Inject a known charge signal directly into the (TKR, CAL) electronics, in lieu of the detector output
    - Read the resulting event data output
  - Collect TEM housekeeping and LRS data

- In Parallel
  - Filter development and testing
  - Boot, 1553 development

EM2 FSW Build

Goal: Demonstrate Multi-Tower, Single-CPU Operation with 1553 interface

- Hardware
  - Multiple towers (real detectors or sub-system Front-End Simulators, FESs)
  - Multiple TEMs
  - GASU
    - Command Response Unit (CRU)
    - Event Builder Module (EBM)
    - ACD Electronics Module (AEM)
    - Global Trigger Module (GEM)
  - 1 COTS “SIU/EPU” CPU (cPCI)
    - Ethernet
    - Serial port
    - SIB
    - LCB
- Software
  - All of EM1 functionality
  - Multiple tower capabilities
  - AEM configuration
  - AEM event acquisition
  - Capability to inject marker events into event streams to provide notice of filter parameter changes
  - LAT mode transitions
    - Engineering and safe modes
  - LAT spacecraft interface
    - 1553
    - Command and telemetry
  - File management system
  - Charge injection calibration
- In Parallel
  - Filter development and testing
  - Boot development and testing

Instrument Spacecraft Interface Simulator (ISIS) Formal Release

Goal: Meet requirements of ISIS delivery (ICD)

- Hardware
  - GASU
    - Command Response Unit (CRU)
    - Event Builder Module (EBM)
  - PDU
    - Monitoring
  - 1 cCPI SIU
    - Ethernet
    - SIB
    - LCB
    - BAE 750
- Software
  - Subset of EM2
  - Boot
  - LAT spacecraft interface
    - 1553
    - Command and telemetry
    - Science Interface

Requirements sign-off for ISIS Build & Formal Release including approved test-procedures and test-reports

Full LAT FSW Release

Goal: Demonstrate Full LAT Operation (Multi-Tower, Multi-CPU, SC interfaces)

- Hardware
  - All towers / FESs / TEMs
  - ACD FES
  - GASU
    - Command Response Unit (CRU)
    - Event Builder Module (EBM)
    - ACD Electronics Module (AEM)
    - Global Trigger Module (GEM)
  - Multiple engineering RAD750s
  - SIIS
- Software
  - All of EM2 functionality
  - Boot and startup operations
  - LAT hardware power control
  - Thermal control system
  - Multiple processor capabilities
    - CPU to CPU communications
    - Scatter/gather synchronization by SIU
    - EPU configuration by SIU
  - Spacecraft message processing
    - Attitude, time, ancillary data
  - Event filter operation
  - Transient detection and reporting

Requirements sign-off for FU Build & Formal Release including approved test procedures and test reports

Requirements (Example)

- **Requirements doc (SRS): LAT-SS-00399**
- **Reviewed by mission project IV&V**
- **Mapping of Requirements to packages/functions, see CDR slides**
- **SC Interface Requirements (SC-LAT ICD): formal test for ISIS release**
- **Selected requirements from the SRS: formal test for ISIS release**
- **Remaining SRS requirements tested during acceptance testing of flight-unit**

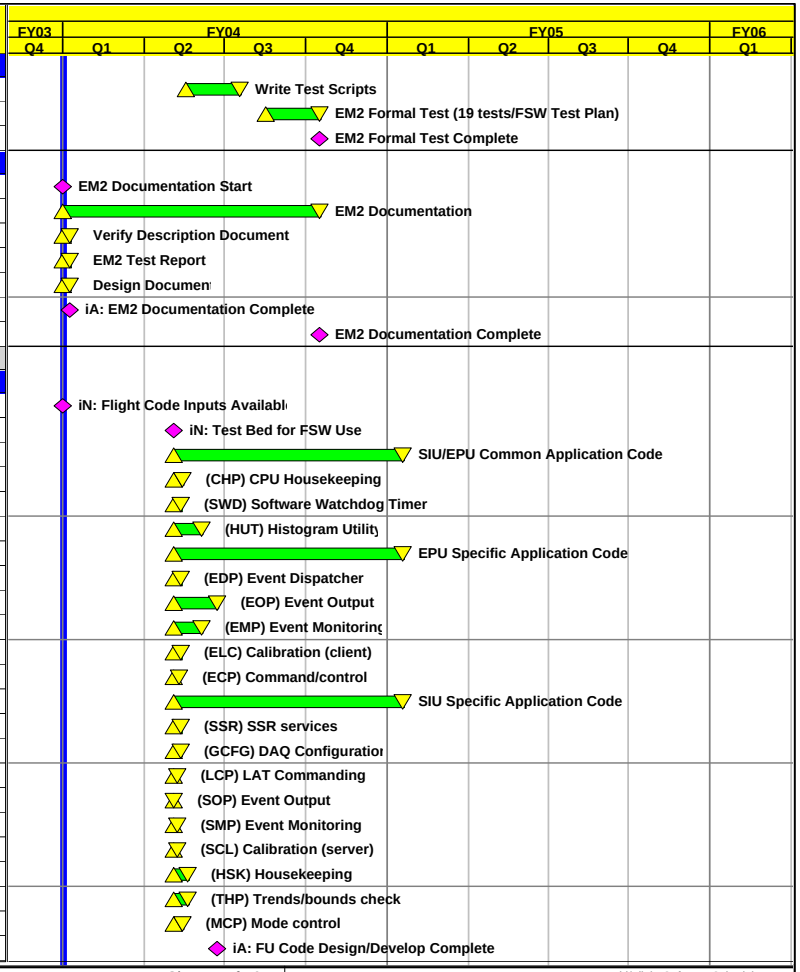
Requirement #	Title	Summary	Verif. Method
5.2.1.1	Interface To The SIU	The EPU FSW shall communicate with the SIU via a custom CPU-to-CPU serial message protocol described in [5].	Test
5.2.1.2	Interface To The EPU Watchdog	Once booting is complete, the EPU FSW shall provide a periodic heartbeat to a hardware watchdog. The watchdog shall re-initialize the EPU if the heartbeat is not received.	Test
5.2.1.3	Interface To The Event Builder	The EPU FSW shall receive fully assembled events from the Event Builder formatted according to the custom hardware and software protocols defined in [5]. The event data shall be placed directly in the EPU memory.	Test
5.2.2.1	Event Processor Boot	An EPU processor shall perform a minimal boot from non-writeable PROM with the hardware watchdog disabled. The minimal boot shall establish communications with the SIU and the secondary boot shall be directed by the SIU.	Test
5.2.2.2	Event Processor Reset	The EPU FSW shall perform a re-initialization on command from the SIU.	Test
5.2.2.3	Event Monitoring	The EPU FSW shall monitor event data for integrity and to track changes in event and detector statistics. The EPU FSW shall notify the SIU via CPU-to-CPU protocol in the event of an error or anomaly.	Test

Tracking Methods

- **Standard LAT project method of measuring monthly progress is Project Management & Control System (PMCS)**
  - **Lists all tasks (e.g. packages) to be done including start and end date**
  - **Each task is allocated a level of effort (i.e. number of man-hours)**
  - **Tasks started/completed status provided to PMCS system monthly and reviewed at LAT project management meeting**
  - **Example: FU section organized into**
    - **Design/Develop**
    - **Develop/Test**
    - **Unit Test**
    - **Formal Test**
    - **Documention**
- **Additionally SLAC is tracking LOC written/tested**

Example from PMCS Schedule (see web-page)

Activity ID	Activity Description	Early Start	Early Finish
4.1.7.9.4.F	EM2 FORMAL TEST		
7EN94F0050	Write Test Scripts	17FEB04*	16APR04
7EN94F1000	EM2 Formal Test (19 tests/FSW Test Plan)	17MAY04	15JUL04
7EN94F3100	EM2 Formal Test Complete		15JUL04
4.1.7.9.4.G	EM2 DOCUMENTATION		
7EN94G0000	EM2 Documentation Start	01OCT03*	
7EN94G1000	EM2 Documentation	01OCT03	15JUL04
7EN94G1010	Verify Description Document	01OCT03	07OCT03
7EN94G1020	EM2 Test Report	01OCT03	07OCT03
7EN94G1030	Design Document	01OCT03	07OCT03
7EN94G3100	iA: EM2 Documentation Complete		07OCT03
7EN94G3110	EM2 Documentation Complete		15JUL04
4.1.7.9.6	FLIGHT UNIT		
4.1.7.9.6.1	FU CODE DESIGN/DEVELOP		
7EN9610000	iN: Flight Code Inputs Available		30SEP03
7EN9610010	iN: Test Bed for FSW Use		02FEB04*
7EN9611000	SIU/EPU Common Application Code	03FEB04	19OCT04
7EN9611010	(CHP) CPU Housekeeping	03FEB04	13FEB04
7EN9611020	(SWD) Software Watchdog Timer	03FEB04	10FEB04
7EN9611030	(HUT) Histogram Utility	03FEB04	04MAR04
7EN9612000	EPU Specific Application Code	03FEB04	19OCT04
7EN9612010	(EDP) Event Dispatcher	03FEB04	10FEB04
7EN9612020	(EOP) Event Output	03FEB04	23MAR04
7EN9612030	(EMP) Event Monitoring	03FEB04	04MAR04
7EN9612040	(ELC) Calibration (client)	03FEB04	10FEB04
7EN9612050	(ECP) Command/control	03FEB04	09FEB04
7EN9613000	SIU Specific Application Code	03FEB04	19OCT04
7EN9613010	(SSR) SSR services	03FEB04	10FEB04
7EN9613020	(GCFG) DAQ Configuration	03FEB04	11FEB04
7EN9613030	(LCP) LAT Commanding	03FEB04	06FEB04
7EN9613040	(SOP) Event Output	03FEB04	03FEB04
7EN9613050	(SMP) Event Monitoring	03FEB04	06FEB04
7EN9613060	(SCL) Calibration (server)	03FEB04	06FEB04
7EN9613070	(HSK) Housekeeping	03FEB04	17FEB04
7EN9613080	(THP) Trends/bounds check	03FEB04	17FEB04
7EN9613090	(MCP) Mode control	03FEB04	12FEB04
7EN9614000	iA: FU Code Design/Develop Complete		23MAR04



Start Date 03APR00
Finish Date 29SEP06
Data Date 01OCT03
Run Date 14NOV03 10:23

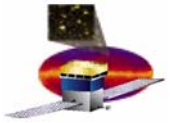
LAT4 - 7ELE

Sheet 5 of 10

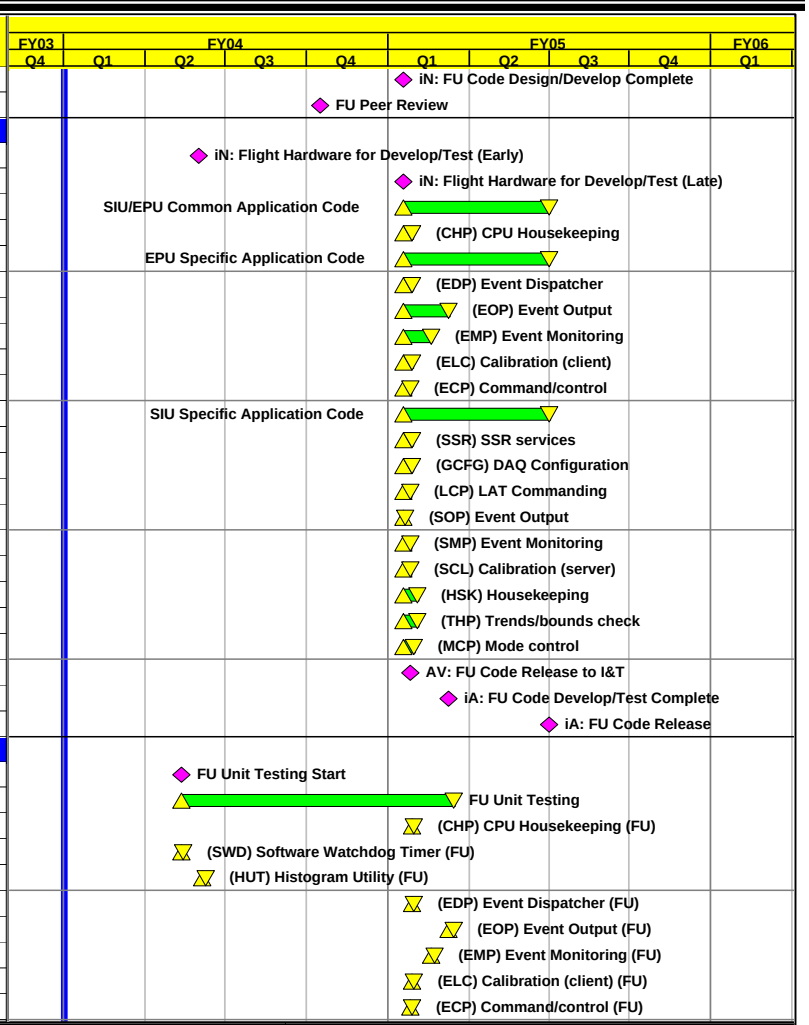
FSW Schedule

LT-DW: jd/Flight Software Schedule
FL-DW

*** LAT-wide project schedule is being rebaselined; updates and corrections are being made to the version shown in this print-out. Submitted to PMCS group but not processed yet.**



Activity ID	Activity Description	Early Start	Early Finish
7EN9614010	iN: FU Code Design/Develop Complete		19OCT04
7EN9614100	FU Peer Review		15JUL04
4.1.7.9.6.2	FU CODE DEVELOP/TEST		
7EN9620000	iN: Flight Hardware for Develop/Test (Early)		01MAR04*
7EN9620010	iN: Flight Hardware for Develop/Test (Late)		19OCT04*
7EN9621000	SIU/EPU Common Application Code	20OCT04	01APR05
7EN9621010	(CHP) CPU Housekeeping	20OCT04	27OCT04
7EN9622000	EPU Specific Application Code	20OCT04	01APR05
7EN9622010	(EDP) Event Dispatcher	20OCT04	27OCT04
7EN9622020	(EOP) Event Output	20OCT04	09DEC04
7EN9622030	(EMP) Event Monitoring	20OCT04	18NOV04
7EN9622040	(ELC) Calibration (client)	20OCT04	27OCT04
7EN9622050	(ECP) Command/control	20OCT04	26OCT04
7EN9623000	SIU Specific Application Code	20OCT04	01APR05
7EN9623010	(SSR) SSR services	20OCT04	27OCT04
7EN9623020	(GCFG) DAQ Configuration	20OCT04	28OCT04
7EN9623030	(LCP) LAT Commanding	20OCT04	25OCT04
7EN9623040	(SOP) Event Output	20OCT04	20OCT04
7EN9623050	(SMP) Event Monitoring	20OCT04	25OCT04
7EN9623060	(SCL) Calibration (server)	20OCT04	25OCT04
7EN9623070	(HSK) Housekeeping	20OCT04	02NOV04
7EN9623080	(THP) Trends/bounds check	20OCT04	02NOV04
7EN9623090	(MCP) Mode control	20OCT04	29OCT04
7EN9624000	AV: FU Code Release to I&T		25OCT04
7EN9624010	iA: FU Code Develop/Test Complete		09DEC04
7EN9624020	iA: FU Code Release		01APR05
4.1.7.9.6.3	FU UNIT TESTING		
7EN9630000	FU Unit Testing Start	11FEB04	
7EN9631000	FU Unit Testing	11FEB04	13DEC04
7EN9631020	(CHP) CPU Housekeeping (FU)	28OCT04	29OCT04
7EN9631030	(SWD) Software Watchdog Timer (FU)	11FEB04	12FEB04
7EN9631040	(HUT) Histogram Utility (FU)	05MAR04	08MAR04
7EN9631050	(EDP) Event Dispatcher (FU)	28OCT04	29OCT04
7EN9631060	(EOP) Event Output (FU)	10DEC04	13DEC04
7EN9631070	(EMP) Event Monitoring (FU)	19NOV04	22NOV04
7EN9631080	(ELC) Calibration (client) (FU)	28OCT04	29OCT04
7EN9631090	(ECP) Command/control (FU)	27OCT04	28OCT04



Start Date 03APR00
Finish Date 29SEP06
Data Date 01OCT03
Run Date 14NOV03 10:23

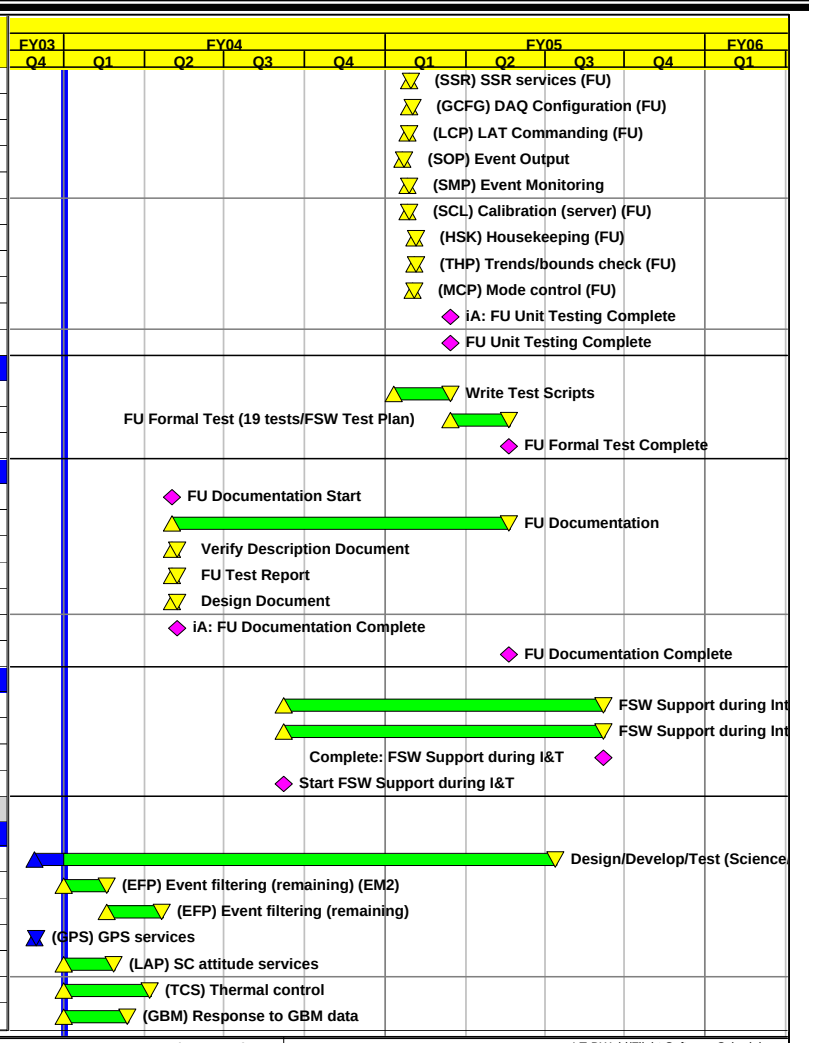
LAT4 - 7ELE

FSW Schedule

Sheet 6 of 10

LT-DW: jd/Flight Software Schedule
FL-DW

Activity ID	Activity Description	Early Start	Early Finish
7EN9631100	(SSR) SSR services (FU)	28OCT04	29OCT04
7EN9631110	(GCFG) DAQ Configuration (FU)	29OCT04	01NOV04
7EN9631120	(LCP) LAT Commanding (FU)	26OCT04	27OCT04
7EN9631130	(SOP) Event Output	21OCT04	22OCT04
7EN9631140	(SMP) Event Monitoring	26OCT04	27OCT04
7EN9631150	(SCL) Calibration (server) (FU)	26OCT04	27OCT04
7EN9631160	(HSK) Housekeeping (FU)	03NOV04	04NOV04
7EN9631170	(THP) Trends/bounds check (FU)	03NOV04	04NOV04
7EN9631180	(MCP) Mode control (FU)	01NOV04	02NOV04
7EN9633100	iA: FU Unit Testing Complete		13DEC04
7EN9633110	FU Unit Testing Complete		13DEC04
4.1.7.9.6.4 FU FORMAL TEST			
7EN9640050	Write Test Scripts	11OCT04*	13DEC04
7EN9641000	FU Formal Test (19 tests/FSW Test Plan)	14DEC04	18FEB05
7EN9643100	FU Formal Test Complete		18FEB05
4.1.7.9.6.5 FU DOCUMENTATION			
7EN9650000	FU Documentation Start	02FEB04*	
7EN9651000	FU Documentation	02FEB04	18FEB05
7EN9651010	Verify Description Document	02FEB04	06FEB04
7EN9651020	FU Test Report	02FEB04	06FEB04
7EN9651030	Design Document	02FEB04	06FEB04
7EN9653100	iA: FU Documentation Complete		06FEB04
7EN9653110	FU Documentation Complete		18FEB05
4.1.7.9.6.6 FSW SUPPORT DURING I&T			
7EN7000050	FSW Support during Integration/Testing (SLAC)	08JUN04	07JUN05
7EN7000060	FSW Support during Integration/Testing (NRL)	08JUN04	07JUN05
7EN7000070	Complete: FSW Support during I&T		07JUN05
7EN9660000	Start FSW Support during I&T	08JUN04	
4.1.7.9.7 SCIENCE/SPACECRAFT			
4.1.7.9.7.1 DESIGN/DEVELOP/TEST (SCI/S/C)			
7EN9700000	Design/Develop/Test (Science/Spacecraft)	29AUG03A	13APR05
7EN9700010	(EFP) Event filtering (remaining) (EM2)	01OCT03	18NOV03
7EN9700020	(EFP) Event filtering (remaining)	19NOV03	20JAN04
7EN9700030	(GPS) GPS services	29AUG03A	29AUG03A
7EN9700040	(LAP) SC attitude services	01OCT03	25NOV03
7EN9700050	(TCS) Thermal control	01OCT03	05JAN04
7EN9700060	(GBM) Response to GBM data	01OCT03	11DEC03



Start Date 03APR00
Finish Date 29SEP06
Data Date 01OCT03
Run Date 14NOV03 10:23

LAT4 - 7ELE

Sheet 7 of 10

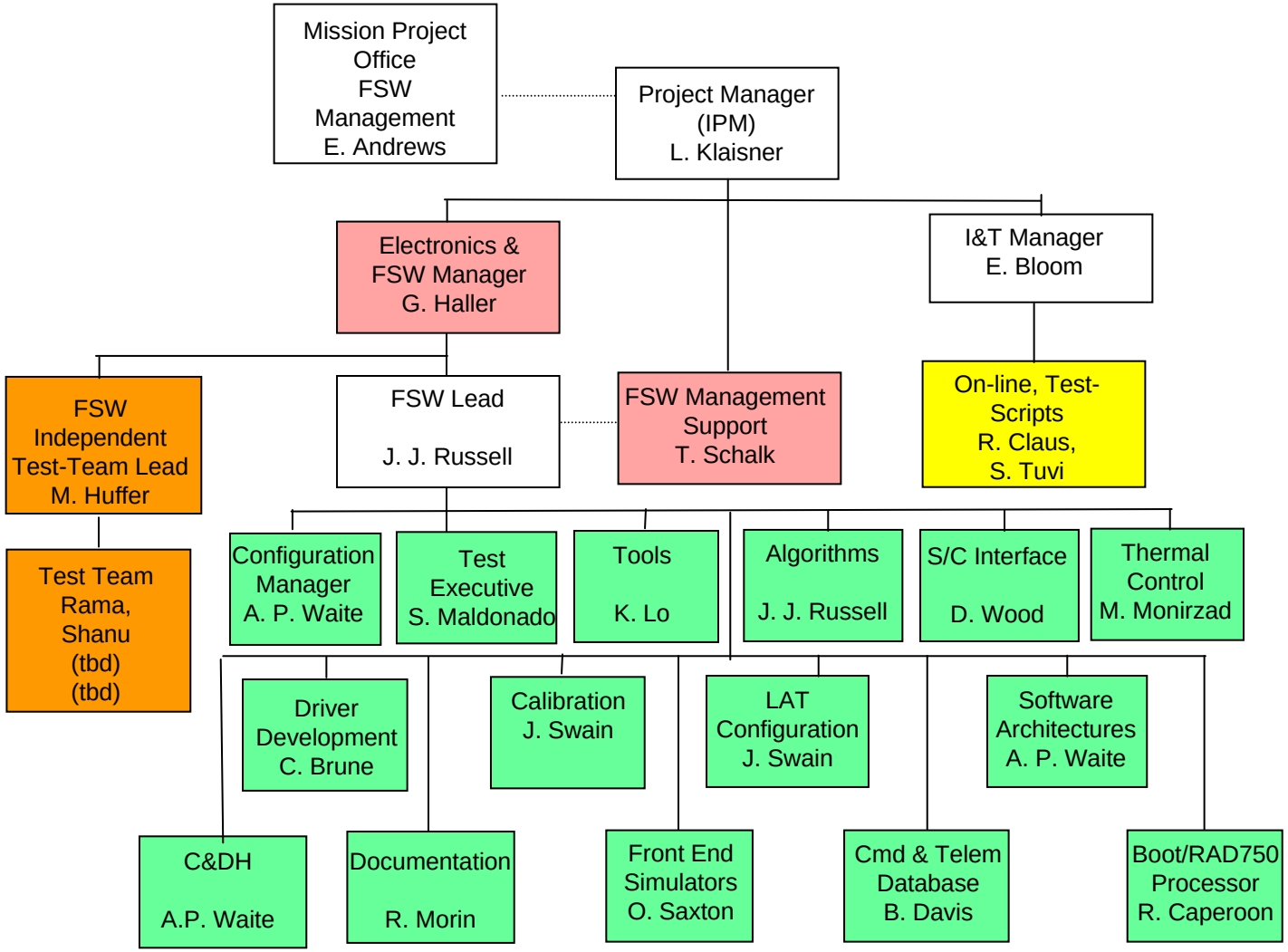
FSW Schedule

LT-DW: jd/Flight Software Schedule
FL-DW

Oversight/Reporting

- Monthly LAT-wide Face-to-Face sub-system leads meetings, with discussion of each sub-system including FSW
- LAT Project Weekly Report, including detailed reporting of FSW activities and tasks performed
- Monthly LAT-wide status reviews, with participation of GSFC management: system-specific past month's accomplishments, plans for following month, risk evaluation, cost and schedule review of last month's scheduled and budgeted versus actual accomplishments

FSW Organization Chart



LAT FSW Team Heritage

- Very experienced
  - DAQ SW
    - Russell: 30 years
    - Waite: 20 years
    - Most others: >15 years
- Successful track record
  - Architected, designed, implemented, tested and commissioned major large experiments
- Leads are developers
- Leads are scientists
- C&DH & Science SW designed, written, integrated, tested by same team

Experiment	# CPUs	Man-years	Time	LOC (C/C++)
SLD	> 500	12	4 years	150K
Babar	> 200	15	3 years	> 500K
BFEM	2	2.6	9 months	44K
LAT	3	20	In progress	100K

SLD: SLC Large Detector

BaBar: B-B Detector (Matter-Antimatter Exp.)

BFEM: GLAST LAT Balloon-Flight (proof-of principle for GLAST LAT detectors and DAQ)

SW Code Management

- Packages are the unit of management
- Packages are version controlled by CMX/CMT/CVS
- Packages exist at 3 levels
  - Test
    - "Sand-box" in the developer's private area
  - Development
    - Public area used to exercise code in a non-critical environment
  - Production
    - Public area used for official, tagged versions
    - A number of these can exist at a given time
      - One is declared the *current* production version
      - Back copies exist for comparison and other purposes
    - All production versions are tagged in CVS

Management & Configuration

- Version numbers follow strict naming conventions indicating:
  - Major: non-backwardly compatible interface changes
  - Minor: backwardly compatible interface changes
  - Patch: bug-fixes and performance enhancements
- A traditional build is a coherent collection of tagged packages
- Changes to builds delivered for formal testing (e.g. ISIS, FU), must be approved through configuration manager and CCB process
- Configuration management
  - Formal control through project management tools
    - LATDocs System
    - Non conformance reporting system

Code Organization

- FSW partitioned into functional blocks based on the Software Requirements Specification (SRS)
  - Functional blocks are then mapped into packages, the fundamental unit of the code management system
- Package code is (and has been) version/configuration controlled via Code Management System
  - Package structure includes
    - Source code
    - Documentation directory (manuals, developer guides, …)
    - Software Development Folder (a directory)
      - Development notes, version log, running log, to do lists, …
    - Package test directory
      - Pure test code
      - LTX test definitions/scripts
- Build: a collection of version tagged packages
  - For an example for EM1 build see
    - https://oraweb.slac.stanford.edu:8080/pls/slacquery/bbrdownload/FSW-EM1-release-VDD.pdf?P_FRAME=GLAST&P_DOC_ID=10444

Hardware/Software Integration

- Process is to exchange hardware & software as soon as either one is available (no formal testing at this stage, development)
  - Example
    - Hardware LCB engineer simulates board/FPGA
    - Software Engineer designs/codes driver
    - Both together get it to run, pass all tests
      - If problem is detected, fix
- Once build (HW & SW) is stable
  - Build declared and version tagged (HW and SW)
- Flight software is used to integrate and test hardware for EM1/EM2/ISIS/FU
- FSW team highly involved in
  - Debugging hardware
  - Writing scripts
  - Configuring test-stands

Problem Reporting & Tracking

- For development builds
  - Code is always code managed (tagged version content cannot be changed)
  - Snapshot builds are transferred (e.g. to I&T for EM1 test stand development)
  - Meanwhile code development goes on but does not affect the snapshot builds
  - If a problem is found or a new feature is required in a snapshot
    - Informal (office-to-office, email, FSW bulletin board) reporting, no official problem reports
    - Problem is fixed or feature is added, tested, new snapshot created and transferred
- For ISIS and FU releases
  - Once code/hardware is tested:
    - Code is bundled as a release and delivered to Spacecraft Vendor or I&T
      - Bundle contains version tagged and tested packages
      - Bundle is tested as a coherent set
      - Bundle is documented in version description document
    - If problem is found
      - Official non-conformance report with response
      - Problem is resolved, formally tested, delivered with documentation update

CDR Software RFA Status

RFA	Request	Reason	Response
1	Provide details of plans to assess the performance of the event filtering software on-orbit to maintain knowledge of the scientific responses of the LAT.	Any event filtering system runs the risk of removing signal at a rate that can vary with time. Proper scientific analysis requires proper knowledge of the event filtering mechanisms.	To be worked on with the science group.
36	Investigate options for the addition of engineering resources tasked with the responsibility of developing test procedures, maintaining the Software Test Plan, and defining a test procedure development schedule.	The development calls for an unrealistically high code production rate of approximately 25-30 verified lines of code per day per person. This rate is about 3 times higher than the industry standard. Clearly additional staffing will be required to allow the successful production of software and support of I&T.	3 additional software engineers were hired since (Monirzad, Lo, Morin) In process of adding additional dedicated test group people.
8	Complete any trade-offs for selecting a command and telemetry database meta-language and implement the database in the flight software test environment.	This selection is needed to allow progress in instrument I&T, the IOC, spacecraft I&T and mission operations.	XML with DTD was selected over MySQL. Use of an XML structure and DTD satisfies the project requirements for storing, accessing, and maintaining the command and telemetry information. A relational database, such as MySQL, is not required.
9	In the currently scheduled design reviews for EM2 and the FU builds, show detailed design information that includes the participation of independent reviewers, packages, algorithms and code walkthroughs.	Design materials presented to date have been high level and preliminary. With the use of a spiral development process, it is critical to have reviewers remain up to date with the latest design issues.	EM2 review was schedule for Nov 18, but was replaced by Quick Look review Nov 21. Need to reschedule EM2 review for Jan 04

EM1 Software Peer Review CDR's

- 16 RFA's
- 13 closed
- 3 open
  - Being worked on
    - One of them is test-team, being addressed now

FSW Resource Usage Current Estimates

Resource	Total Available	Anticipated Usage	Margin Factor
EPU Boot PROM	256 kB	128 kB	2
SIU Boot PROM	256 kB	128 kB	2
EPU EEPROM	6 MB	1.5 MB	4
SIU EEPROM	6 MB	1.5-2.5 MB	3
EPU CPU cycles	200% in 2 EPUs	30%	> 6
SIU CPU cycles	100% in 1 SIU	25%	4
EPU memory	128 MB	16-32 MB	4-8
SIU memory	128 MB	< 16 MB	8
Bandwidth – instrument to EBM	45 MB/sec	10 MB/sec	4.5
Bandwidth – EBM to CPU	20 MB/sec	5 MB/sec	4
Bandwidth – CPU to EBM	2.5 MB/sec	20 kB/sec	125
Bandwidth – EBM to SSR	5 MB/sec	40 kB/sec	125

Accomplished since CDR (1)

- Manpower available between May 16, 03 (CDR) and Nov 15, 03
  - 2 FTE at NRL (Wood, Caperoon/Davis 75%/25%)
  - 6 FTE's SLAC (Russell, Waite, Brune, Maldonado, Swain, Saxton)
- Line-of-Code written (C-language)
  - CDR: 6 K LOC for flight
  - Today: 21 K LOC for flight
  - Difference: 15 K LOC of flight
- Productivity
  - 6 people for 6 months
  - 21 LOC/person/day

Accomplished since CDR (2)

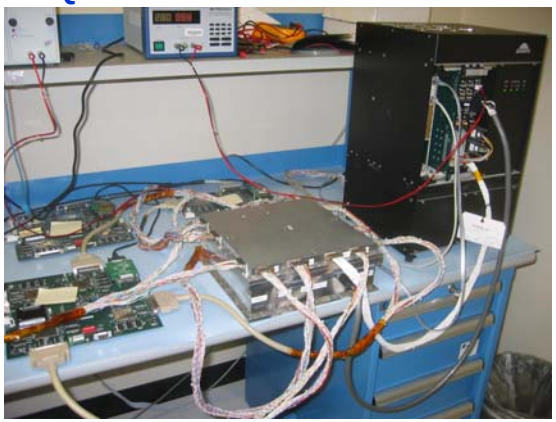
- Have driver level software
  - Have LCB driver software (in unit testing with target)
  - Have SIB Flash File System driver (unit tested with target)
  - Have SIB MIL1553 driver (unit tested with target)
- Have service level software
  - Can configure all elements currently available
    - Front end electronics (TKR, CAL, ACD)
    - DAQ electronics
      - TEMs
      - CRU/GEM/AEM/EBM on GASU
      - PDU
  - GASU/PDU services are part of EM2 software.
- Shown are examples of test-stands used by FSW team

GASU
(CRU)
(GEM)
(AEM)
(EBM)

LCB

CAL/TKR

DAQ TEM



Accomplished since CDR (3)

- Have written application level software
  - Filter
    - Key to sizing on-board resource margins
    - Must be verified against science requirements
      - Given to ground software organization where it is being used in their data challenge
  - Lossless data compression
    - Filter and compression taken together are the means to meet telemetry bandwidth requirements

- Also
  - A real-time toolbox providing queues, timers, interlocked operations, … (all unit tested)
  - Design documents for health/housekeeping, initial coding in progress
  - Generalized error reporting system (unit tested)

Accomplishments (4)

- **Provided EM1 software to I&T to run a single fully instrumented tower with DAQ tower electronics module, complete calorimeter sub-system, and TKR sub-system**
  - **This was the EM1 goal!**
- **I&T took full program of stimulated, cosmic ray and Van-de-Graf physics data with one tower**
  - **FSW performed flawlessly**
  - **Test reports being written**

Accomplished since CDR (5)

- Primary boot of RAD750 (from “internal” RAD750 SUROM)
- Secondary boot of RAD750 (from “external” SIB EEPROM)
- SIB EEPROM formatted, file system laid out
- Performed successful communication test with the Spacecraft Instrument Interface Simulator (SIIS) provided by Spectrum Astro
- Other tasks such as VxWorks upgrade, etc.

Remaining Effort

- Remaining
  - Flight Main Code: 77,000
- Available man-power (14 FTE's)
  - NRL: 2 FTE's (Wood, Caperoon)
  - SLAC: 9 FTE's (Russell, Brune, Waite, Lo, Morin, Monirzad, Maldonado, Swain, Saxton)
  - Plus R. Claus, S. Tuvi (both I&T) for overall run scripts writing/testing, allocate 25% each)
  - T. Schalk (50%)
  - Test group additions (in progress), 3-4 FTE
- Time available until First FU Build to I&T: 13 months (15 months to end of formal test)
- Result
  - Flight Main Code: 77,000/260/14= 21 LOC/man/day

Remaining Effort

- Includes added manpower to do separate build testing, formal testing of FSW (i.e. try to break the system) for ISIS, test-bed, and FU delivery
  - Planned:
    - M. Huffer: Head of Testing
      - Rama Chirayathumadom 50%
      - Kare Shantanu 50%
      - Getting 2 more people
- Short term tasks
  - Incorporate GASU/PDU/EPU code to complete software for test-bed
  - SIB thermal control/main power switch driver (minor, just register writes)
  - Service level software for EBM/AEM to be tested with hardware
  - Service level software for inter-task communication
  - Finish/test health/housekeeping code
  - Applications level software scheduled for EM2/FU
  - Testing

Backup

EM1 Goals vs Accomplished

- Goals
  - Exert full control over a single tower
    - Read/write all registers
    - Exercise all “dataless” commands (reset, failover, …)
  - Pull events from a single tower with various triggers
    - CPU demand trigger
    - External trigger (cosmic ray telescope)
    - Internal trigger (TKR three-in-a-row)
  - Pull housekeeping from a single tower
  - Provide I&T with a software platform for the test-stands
    - The goal was to allow sub-systems to test their electronics
- Accomplished
  - All of the above, except:
    - A remote procedure call layer to provide I&T access to the FSW written hardware interfaces
      - Was initially provided by I&T to get test stands up and running
      - I&T has gifted the code to FSW for further development
    - Housekeeping as a continuous data stream
      - Housekeeping was demand accessible from LATTE

Boot Code LOC

Boot Code			
Package Name	**Estimated**	**Written**	**Description**
PBC	500	300	Reset/exceptions + Memory Tests
	1000	50	Boot shell
	100	100	EEPROM driver
	200	100	Boot Utilities
	300	200	PCI driver
CCSDS	400	321	CCSDS formatter
FILE	1000		Upload parser
ZLIB	40	20	ZLIB integration
LCB (polled piece)	400		LCB driver (polled mode)
CTDB (polled piece)	400	*400*	1553 driver (polled mode)
Boot Total	**4340**	1491	

SIU/EPU Common LOC

Common Code			
Package Name	**Estimated**	**Written**	**Description**
(CBP) see "Boot"	3900		Common Boot, Primary
(CBS) see "Boot"	6900		Common Boot, Secondary
PBS	1800	**2189**	Processor Basic Services Code
FMP	1500		File Management Package
CHP	1000		CPU Housekeeping Package
SWD	1000		Software Watchdog Timer
MSG	*2500*	**993**	Generic Message Packaging
LCB	3000	1558	LAT Communication Board IO
Common Total	10800	4740	

EPU LOC

EPU Code			
Package Name	**Estimated**	**Written**	**Description**
(EBP) see "Boot"	1500		EPU Boot Primary
(EBS) see "Boot"	1000		SIU Boot Secondary
EDP	2100		Event Dispatch Package
EFP	10000	4443	Event Filtering Package
EOP	3750	903	Event Ouput Package
EMP	3500		Event Monitoring Package
CLB	4950		Calibration, Client Side Package
ECP	3400		Event Commanding and Control Package
EPU Total	27700	5346	

SIU LOC

SIU Code			
Package Name	**Estimated**	**Written**	**Description**
(SBP) see "Boot"	1500		SIU Boot Primary
(SBS) see "Boot"	8000		SIU Boot Secondary
DAB	*2500*	**918**	Data Acquistion Board (GASU)
DEM	*5000*	**2610**	Data Electronics Modules (replaces Gxxx)
CTDB	*5000*	**2489**	Command and Telemetry Data Bus (1553)
SSR	1000		Controls access to Solid State Recorder
TCS	2000		Thermal Control System
LATC	5850	**3180**	Configuration of front-end electronics
LCP	3600		LAT Commanding Package
GPS	800		Global Positioning System Package
LAP	1300		LAT/Spacecraft Attitude Information Package
EMP	3100		Event Monitoring Package
GBM	1550		GammaRay Burst Monitor
GRB	2150		GammaRay Burst and Transient Detection
CLB	3200		Calibration- Server Side
HSK	6350		Housekeeping and Low Rate Science
MCP	1300		Mode Control Package
SIU Total	54200	9176	

Grand Total LOC

Boot Total	4840	2491	Boot Grand Total
Common Total	10800	4740	Common Grand Total
EPU Total	27700	9176	EPU Grand Total
SIU Total	54200	5346	SIU Grand Total
Grand Total	**97540**	20753	