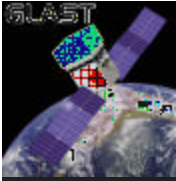


Quick Look Review: LAT FSW

Project Overview / Background



GLAST is an International Mission



NASA - DoE Partnership on LAT

LAT is being built by an international team

Si Tracker: Stanford, UCSC, Japan, Italy

CsI Calorimeter: NRL, France, Sweden

Anticoincidence: GSFC

Data Acquisition System: Stanford, NRL

GBM is being built by US and Germany

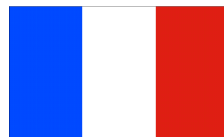
Detectors: MPE



Sweden



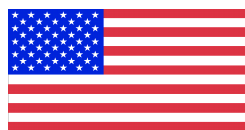
Italy



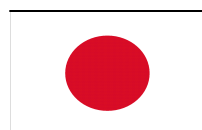
France



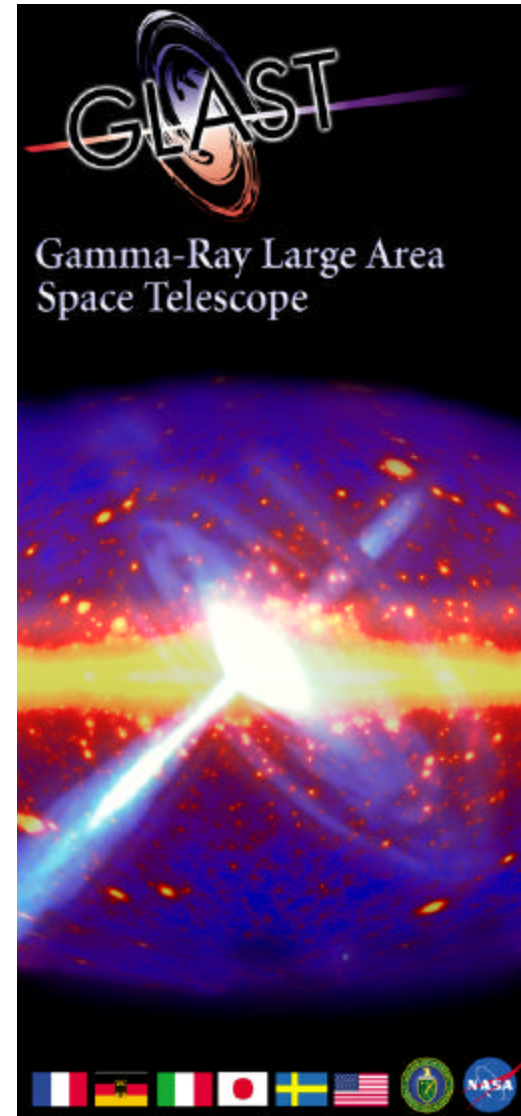
Germany

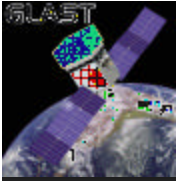


USA



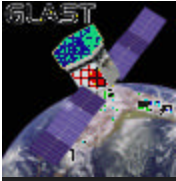
Japan





Agenda

- 1 **Introduction – K. Grady / S. Scott – 10 minutes**
- 1 **Project Overview & Programmatic – E. Andrews - 20 minutes**
 - *GLAST Introduction / Background*
 - *Requirements and Schedule*
 - *Project Office & IV&V support*
- 1 **LAT S/W Management Plan & Development Process – G. Haller - 90 Minutes**
 - *LAT FSW Milestones*
 - *FSW Phased Development Approach*
 - *Controls / Oversight*
 - *Staffing*
 - *H/W-S/W Integration Support*
- 1 **Test Approach and Status – A. Waite – 40 minutes**
 - *FSW Test Plan Status*
 - *FSW Test Bed(s) description*
 - *Unit/Package Test Approach*
 - *Build (EM-1, EM-2) testing*
 - *Release (ISIS, Flight) Test Planning*
- 1 **Risks / Summary / Actions – G. Haller - 15 minutes**



GLAST Science



GLAST will have a very broad menu that includes:

- ‡ ***Systems with supermassive black holes (Active Galactic Nuclei)***
- ‡ ***Gamma-ray bursts (GRBs)***
- ‡ ***Pulsars***
- ‡ ***Solar physics***
- ‡ ***Origin of Cosmic Rays***
- ‡ ***Probing the era of galaxy formation, optical-UV background light***
- ‡ ***Solving the mystery of the high-energy unidentified sources***
- ‡ ***Discovery! Particle Dark Matter? Other relics from the Big Bang? Testing Lorentz invariance. New source classes.***

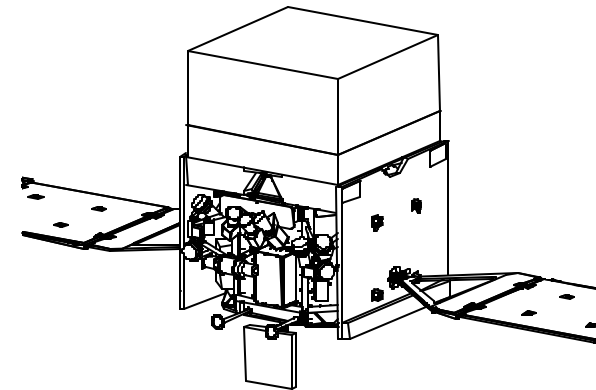
Huge increment in capabilities.

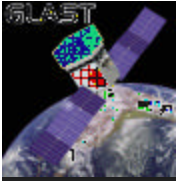
GLAST draws the interest of both the the High Energy Particle Physics and High Energy Astrophysics communities.



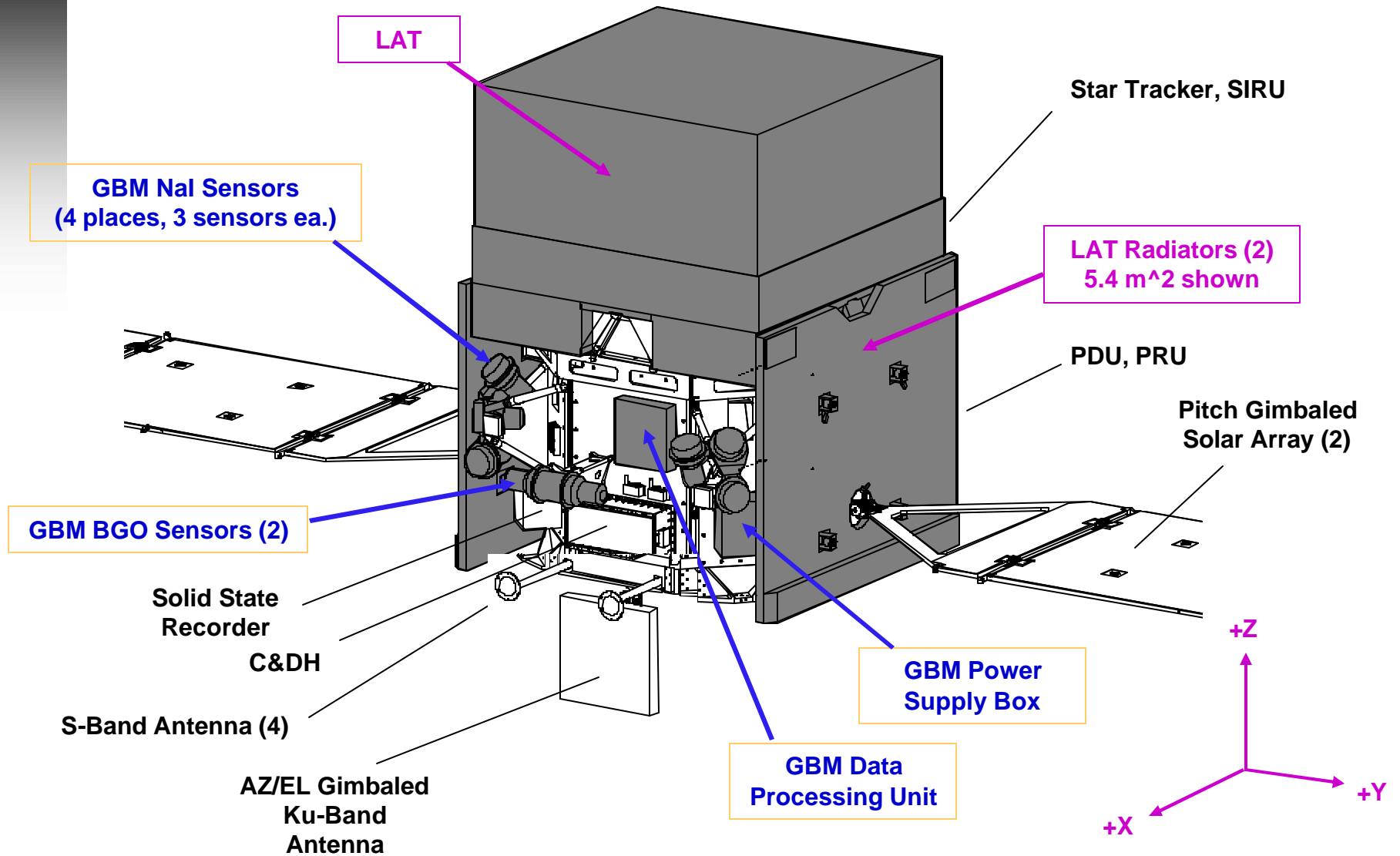
GLAST Mission Summary

- ‡ **GLAST:** *Gamma-Ray Large Area Space Telescope*
- ‡ **Objective:** *Larger field of view (FOV), higher sensitivity, and broader energy detection range than any previously flown gamma-ray mission. Affords scientists the unprecedented opportunity to sample the history of the universe, a variety of high energy astrophysical phenomena, and many of the little understood features of the sky*
- ‡ **Mission Duration:** *5 yrs (10 yr ops budget)*
- ‡ **Orbit:** *565 km Circ, 28.5° Inc.*
- ‡ **Launch Vehicle:** *Delta 7920H-10*
- ‡ **Launch Site:** *CCAS*
- ‡ **TDRSS (SN):** *S-Band Single Access or Multiple Access
Ku-Band Single Access*
- ‡ **GN Sites:** *S-Band to Wallops (backup)*
- ‡ **Launch Date:** *February 2007*





GLAST Observatory





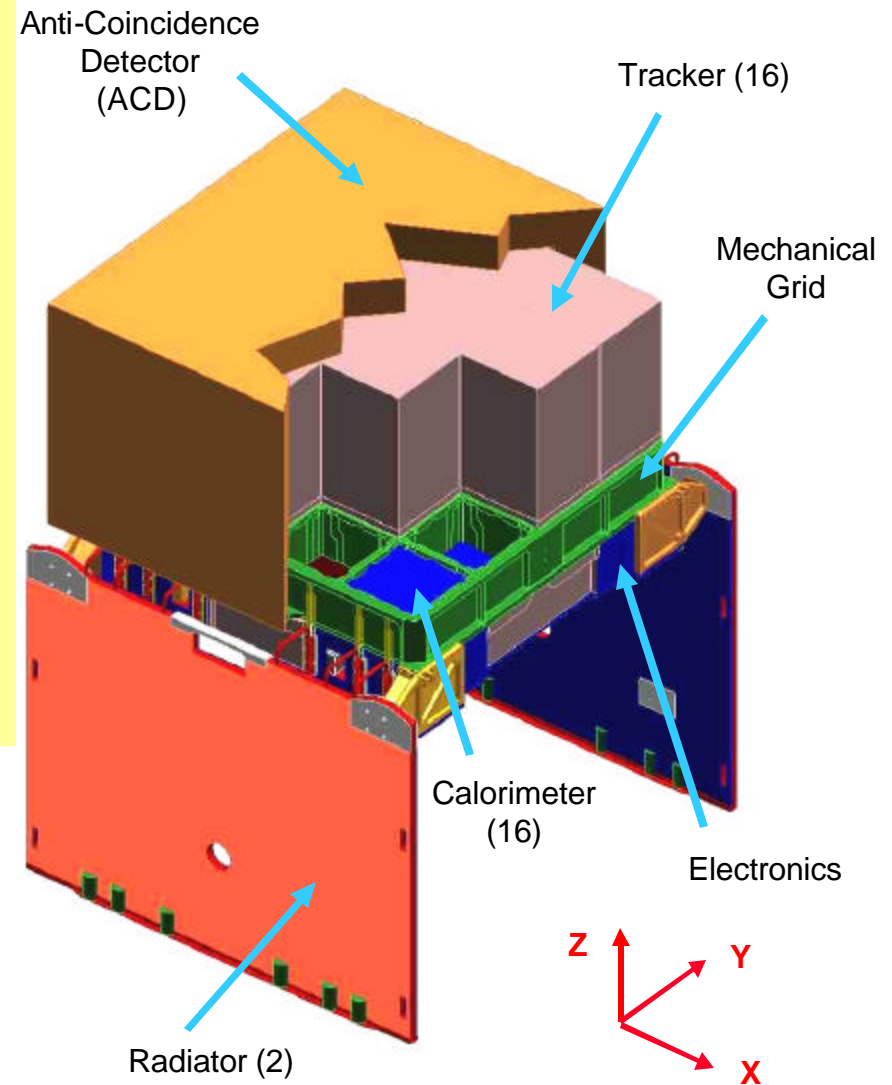
Large Area Telescope

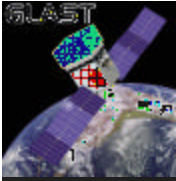


Mass: 3000 kg
Instrument Size: 180 x 180 x 280 cm (X-Y-Z)
Radiator Area: 2.83 m² each side
Science FOV: 2 π sr, +Z, above I/F plane
Mounting: 4-point mounting I/F at grid

Key LAT Accommodation Requirements:

Pointing Knowledge (10 arcsec, 1 σ -r)
Science Data I/F and Peak Rate (40 Mbps LVDS)
Operational Power (650 W OAP)
Clear Radiator FOV on +/- Y faces from LAT I/F Plane (LIP) to L/V Interface Plane (PAF)
Significant Mass Drives Observatory Axial CG

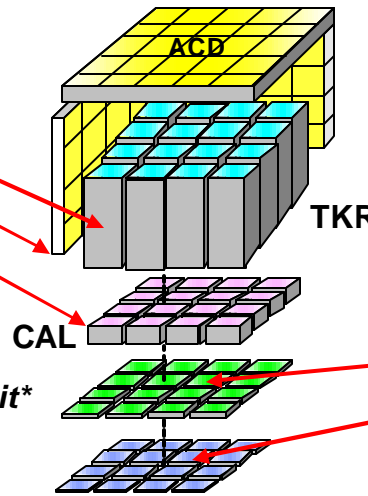




LAT FSW: executes on SIU and EPU

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)



16 Tower Electronics Modules

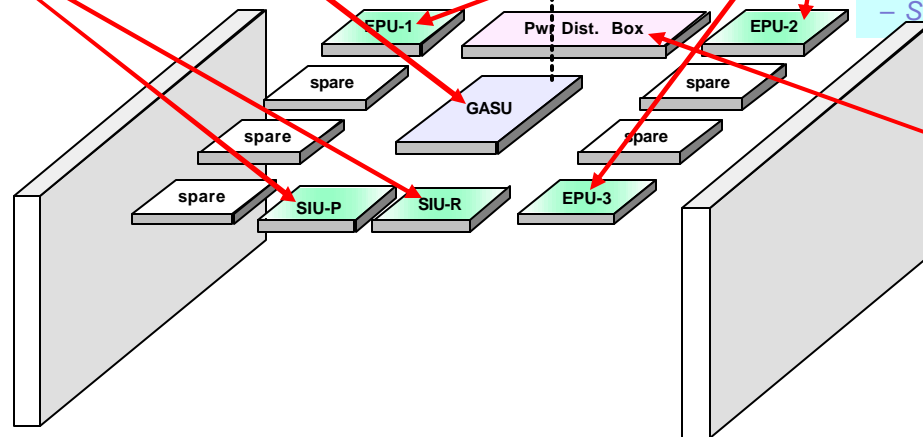
- DAQ electronics module (DAQ-EM)
- Power-supplies for tower electronics

3 Event-Processor Units (2 + 1 spare)

- Event processing CPU
- LAT Communication Board
- SIB

Spacecraft Interface Units

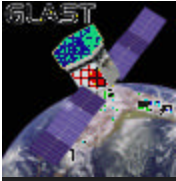
- Storage Interface Board (SIB): Spacecraft interface, control & telemetry
- LAT control CPU
- LAT Communication Board (LCB): LAT command and data interface



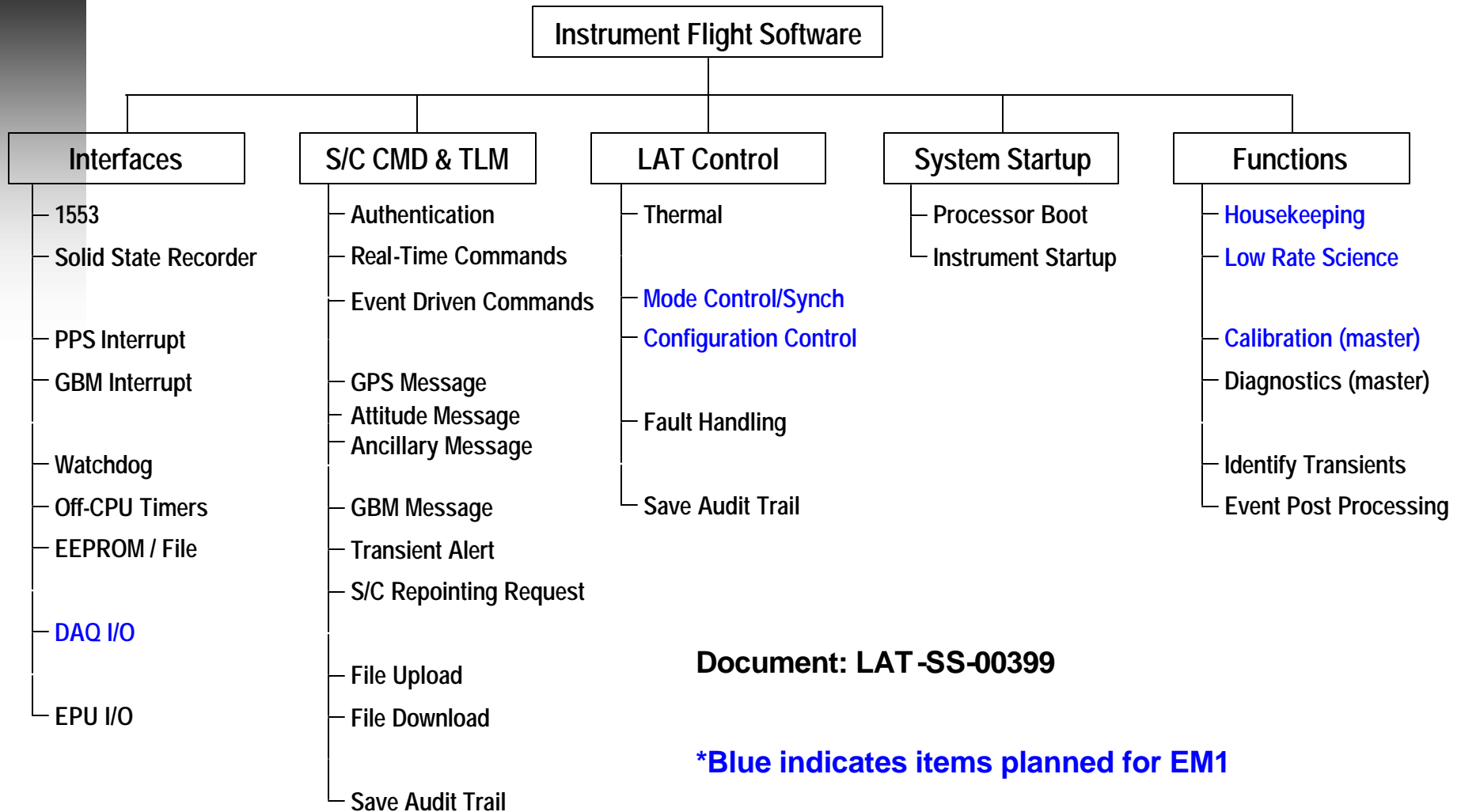
Power-Distribution Unit (PDU)*

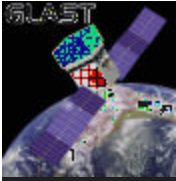
- Spacecraft interface, power
- LAT power distribution
- LAT health monitoring

* Primary & Secondary Units shown in one chassis

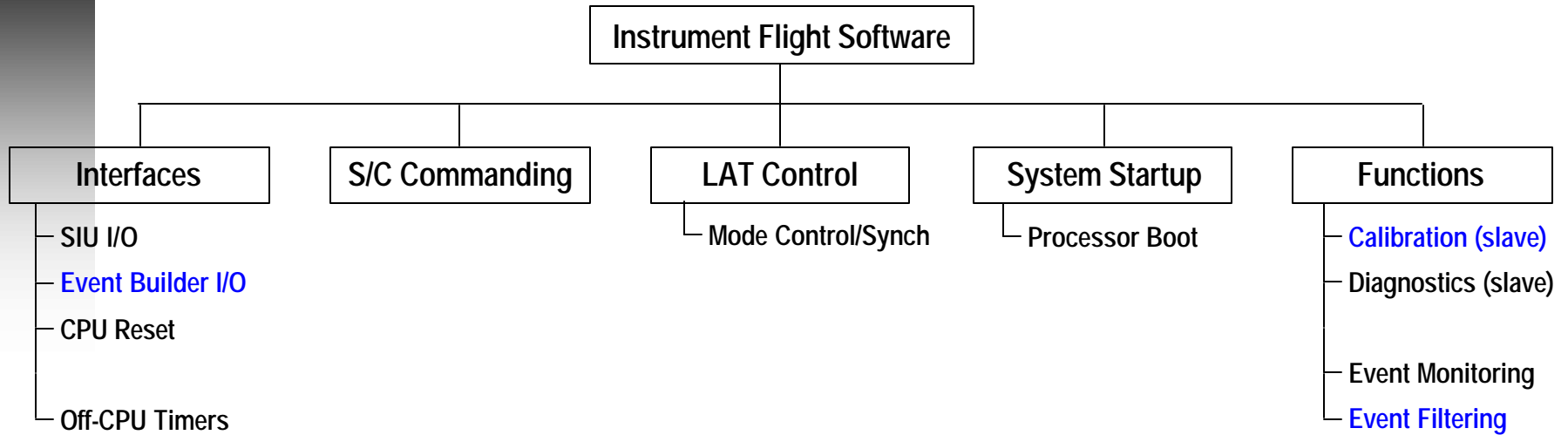


Derived Functional Requirements (SIU)



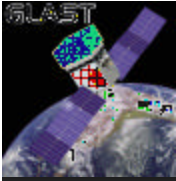


Derived Functional Requirements (EPU)



Document: LAT-SS-00399

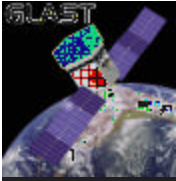
*Blue indicates items planned for EM1



Software CDRLs (Phase C/D)



- 1 *Software Management Plan*
 - *Phase A/B version available since PDR*
 - *Most recent release: July 2003*
 - *Update to reflect changes due to rebaseline and testing plan modifications.*
- 1 *Software Requirements Specification*
 - *Draft version delivered shortly after PDR (April 2002)*
 - *Peer Reviewed with SLAC, GSFC, Science Community (Dec 2002)*
 - *No Formal RFAs taken, minor modifications to Requirements made for clarity, testability*
 - *IV&V provided comments/questions on requirements analysis, traceability, and testability*
 - *Document update planned for Nov/Dec 2003 reflecting recommended and accepted changes per IVV comments*
- 1 *Software Test Plan/Procedures/Reports*
 - *Draft FSW Test Plan available shortly after PDR*
 - *FSW Test Plan approved Aug 2003*
 - *Recommend update to reflect modifications to the Test Strategy*
 - *IV&V provided comments, but no actions – favorable response*
- 1 *Software Design Document – iterated delivery*
 - *Version planned with each Release.*
- 1 *Version Description Document – iterated delivery*
 - *Version planned with each Release.*



LAT FSW Synopsis



Key science-related requirements – Filter, Filter, Filter

- Instrument receives ~4000 - 5000 events/sec (Peak: 10K ev/sec). (Average one every 200- 250 usec)
 - At ~ 1 KB of data per event, data reduction of >99% is required to meet 300kbps orbit average data rate.
- FSW uses multiple algorithms and compression to reduce this to ~ 30 – 60 ev/sec to be recorded.
- Current prototyping of algorithms reduces data to ~ 130 events / second.
 - Currently consumes 14 usecs/event to do this amount of data reduction
- Further algorithm development / implementation to reduce final data set to required levels. *

Peer Review and LAT CDR completed

- Sixteen RFAs generated at EM-1 FSW Peer Review – 13 closed, 3 others in work
- Four RFAs generated at CDR – being worked (will be covered later)

Project Office involved in software process efforts early

- Provided modified templates for FSW Management Plan and FSW Maintenance Plans
- Emphasis on thorough testing for Instrument FSW

SLAC Software Process – in place, but different than NASA standard

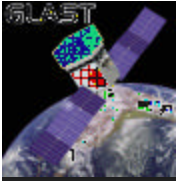
- Detailed design phase is iterated with the code development, and unit/build tests.
- Builds (EM-1, EM-2) to support Subsystem (Electronics and Tower) Integration and Testing.
- Formal ‘Releases’ to support deliveries (ISIS to Spectrum, Flight to I & T)

Integrated, Experienced Software Team

- High Energy Physicists with 20+ years experience in Data Acquisition Systems – h/w and s/w
- Experienced Boot, Communications, C&DH and Infrastructure FSW team from NRL.

Build	Supports	Date
EM1	Single Tower Event Proc	10/1/03
EM2	Multiple Towers / GASU	6/16/04

Release	Supports	Date
ISIS	Instrument-Spacecraft Interface Simulator	6/15/04
Flight	Instr Integration & Test	12/00/04; 2/1/05

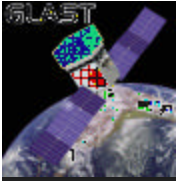


Independent Verification & Validation



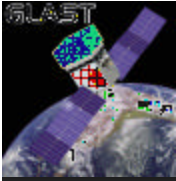
↓ **Large Area Telescope**

- *MOA for LAT FSW Assessment Phase signed in May 2002*
- *IV&V is focused on critical software functionality.*
 - *1553 Interface Software*
 - *Boot and Instrument Safety Software*
- **LAT IV&V Tasks**
 - *Software Processes Review*
 - *Software Requirements Analysis*
 - *29 Issues Identified; 27 'Closed' or 'Resolved' to date*
 - *Software Requirements Traceability Analysis*
 - *19 Issues Identified; 16 'Closed' or 'Resolved' to date*
 - *Interface Requirements Analysis*
 - *3 Issues Identified; 3 'Resolved' to date*
 - *Test Program Analysis*
 - *No Issues identified; Comments provided to the FSW Test Plan*



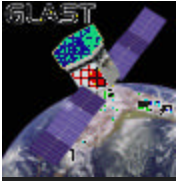
Recent Risk Mitigation Actions

- 1 **Continued working with SLAC management to supplement the FSW development team.**
 - *Added FSW Management Support (T. Schalk)*
 - *Added three (1 developer, 1 tools expert, 1 tech doc writer) to FSW Staff*
 - *Added Dedicated Test Team of four engineers led by Mike Huffer*
 - *Tasked with writing test scripts and running test procedures – both formally and informally*
 - *Front End Simulator and Software Test Bed also have added staff.*
- 1 **Continue support for the NRL FSW team by providing boot and S/C Interface (Mil-Std-1553) test fixtures to them.**
- 1 **Distinguished between 'Build' and 'Release' for formality and requirements sell-off purposes.**
 - *EM-1, EM-2: Builds*
 - *ISIS, Flight Unit: Releases*
- 1 **Evaluate opportunities to reduce the LAT filtering requirements by increasing the bandwidth to the SSR.**
- 1 **Participate in weekly telecons to maintain current status & concerns lists.**
- 1 **Tracked metrics to evaluate performance through EM-1 Build and checkout.**
 - *FSW SLOC authored during this development/unit test phase ~20-25 / day. Not unexpected during this phase of the project.*
 - *Estimated productivity for remaining SLOCs: ~25/day (to be covered later)*



Related LAT FSW & Project Milestones

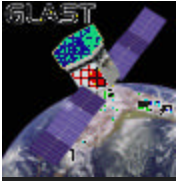
- ‡ **March 2003 – EM-1 FSW Peer Review**
- ‡ **May 2003 – Instrument CDR**
- ‡ **Sept/Oct 2003 – EM-1 FSW Build Integrates with Single Tower**
- ‡ **Jan 2004 – FSW Peer Review**
- ‡ **April 2004 – FSW Test Team begins testing ISIS FSW Release**
- ‡ **June 2004 – Instrument-Spacecraft Interface Simulator software release and delivery to Spectrum Astro.**
- ‡ **July 2004 – EM2 FSW Build Integrates with Multiple Towers**
- ‡ **December 2004 – Flight Release of FSW enters Acceptance Testing**
- ‡ **February 2005 – Flight Release delivered to I&T for Instrument System Testing**
- ‡ **July 2005 – Instrument Environmental Testing Begins at NRL**
- ‡ **December 2005 – Instrument delivered to Spectrum Astro for Observatory I&T**
- ‡ **October 2006 – Observatory delivered to launch site.**
- ‡ **February 2007 – Launch.**



Backup



- ↳ ***Mission Level 1 Requirements***
- ↳ ***LAT Level 1 Requirements***
- ↳ ***Mission Elements***



Level 1 Requirements

- ‡ ***Mission Life: design – 5 years, minimum – 2 years***
- ‡ ***Full mission success***
 - *One year sky survey; four years of observations of selected investigations*
- ‡ ***Minimum mission success***
 - *One year sky survey; one year of observations of selected investigations*
- ‡ ***GLAST Science Level 1 Requirements***
 - *Effective area, energy range, source location*
- ‡ ***Reliability: no credible single point failure***
- ‡ ***Science planning, data processing and reduction, archiving and distribution of data products***
- ‡ ***Launch on an MELV***
- ‡ ***Execute a national-scale Education and Public Outreach program***



LAT Requirements Summary



LAT science performance will meet or exceed requirements in GLAST Science Requirements Document (433-SRD-0001)

<i>Parameter</i>	<i>SRD Value</i>	<i>LAT Performance</i>
Peak Effective Area (in range 1-10 GeV)	>8000 cm²	10,000 cm² at 10 GeV
Energy Resolution 100 MeV on-axis	<10%	9%
Energy Resolution 10 GeV on-axis	<10%	8%
Energy Resolution 10-300 GeV on-axis	<20%	<15%
Energy Resolution 10-300 GeV off-axis (>60°)	<6%	<4.5%
PSF 68% 100 MeV on-axis	<3.5°	3.37° (front), 4.64° (total)
PSF 68% 10 GeV on-axis	<0.15°	0.086° (front), 0.115° (total)
PSF 95/68 ratio	<3	2.1 front, 2.6 back (100 MeV)
PSF 55%/normal ratio	<1.7	1.6
Field of View	>2sr	2.4 sr
Background rejection (E>100 MeV)	<10% diffuse	6% diffuse (adjustable)
Point Source Sensitivity(>100MeV)	<6x10⁻⁹ cm⁻²s⁻¹	3x10⁻⁹ cm⁻²s⁻¹
Source Location Determination	<0.5 arcmin	<0.4 arcmin (ignoring BACK info)
GRB localization	<10 arcmin	5 arcmin (ignoring BACK info)

GLAST MISSION ELEMENTS

