Quick Look Review: LAT FSW

Project Overview / Background

Erik Andrews
Software Systems Manager

GLAST is an International Mission

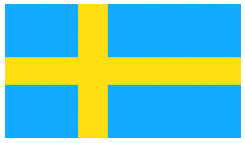
NASA - DoE Partnership on LAT

LAT is being built by an international team

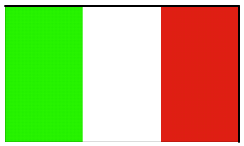
- *Si Tracker: Stanford, UCSC, Japan, Italy*
- *CsI Calorimeter: NRL, France, Sweden*
- *Anticoincidence: GSFC*
- *Data Acquisition System: Stanford, NRL*

GBM is being built by US and Germany

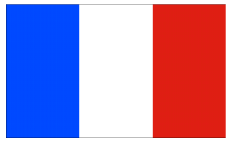
- *Detectors: MPE*



Sweden

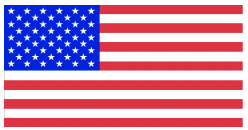


Italy

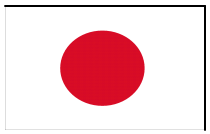


France

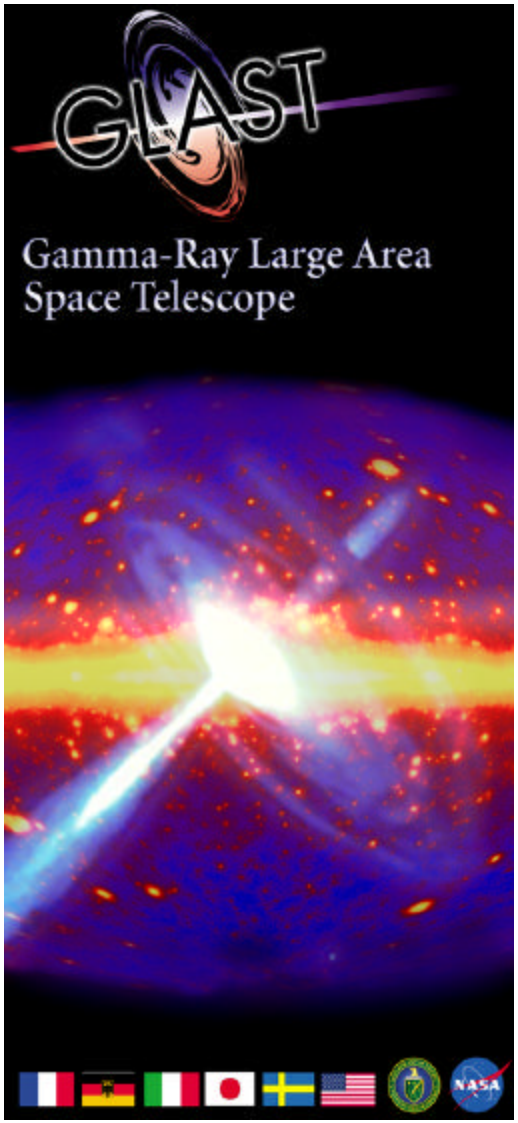
Germany



USA



Japan



Agenda

- ***Introduction – K. Grady / S. Scott – 10 minutes***
- ***Project Overview & Programmatics – E. Andrews - 20 minutes***
  - *GLAST Introduction / Background*
  - *Requirements and Schedule*
  - *Project Office & IV&V support*
- ***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*
- ***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*
- ***Risks / Summary / Actions – G. Haller - 15 minutes***

GLAST Science

GLAST will have a very broad menu that includes:

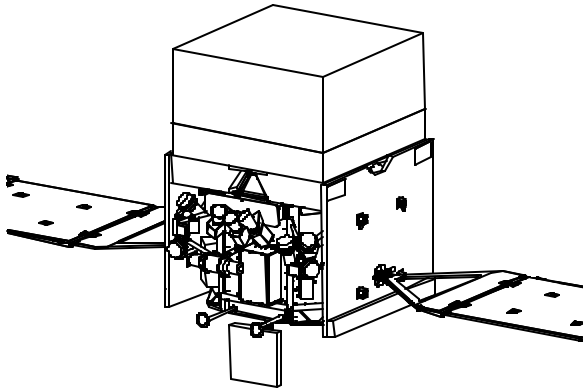
- ***Systems with supermassive black holes (Active Galactic Nuclei)***
- ***Gamma-ray bursts (GRBs)***
- ***Pulsars***
- ***Solar physics***
- ***Origin of Cosmic Rays***
- ***Probing the era of galaxy formation, optical-UV background light***
- ***Solving the mystery of the high-energy unidentified 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

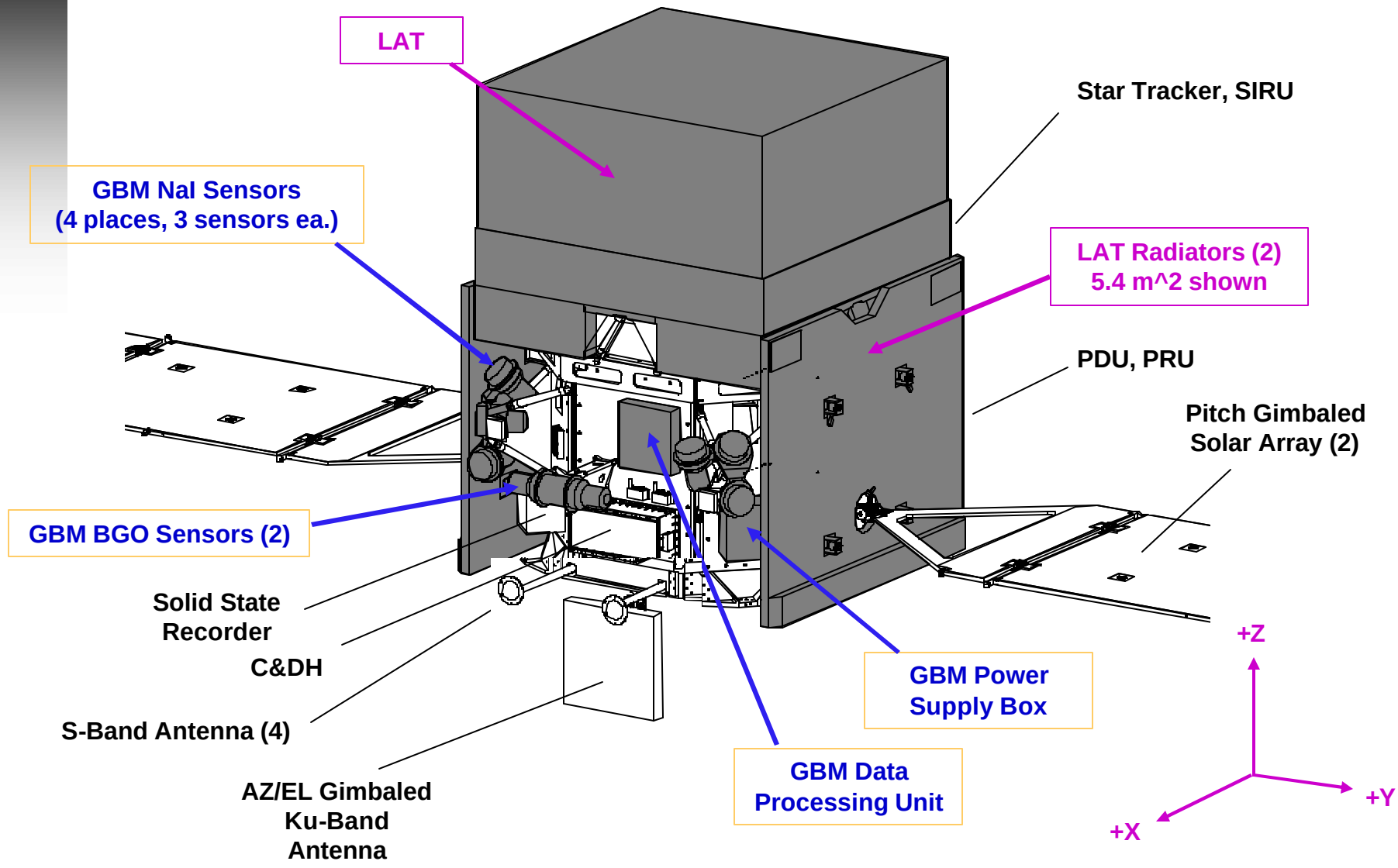
- ***GLAST:*** ***Gamma-Ray Large Area Space Telescope***
- ***Objective:*** ***Larger field of view (FOV), higher sensitivity, and broader energy detection range than any previously flown gamma-ray mission. Affords scientists the unprecedented opportunity to sample the history of the universe, a variety 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:*** ***May 2007 LRD (earliest possible February 2007)***

GLAST Observatory

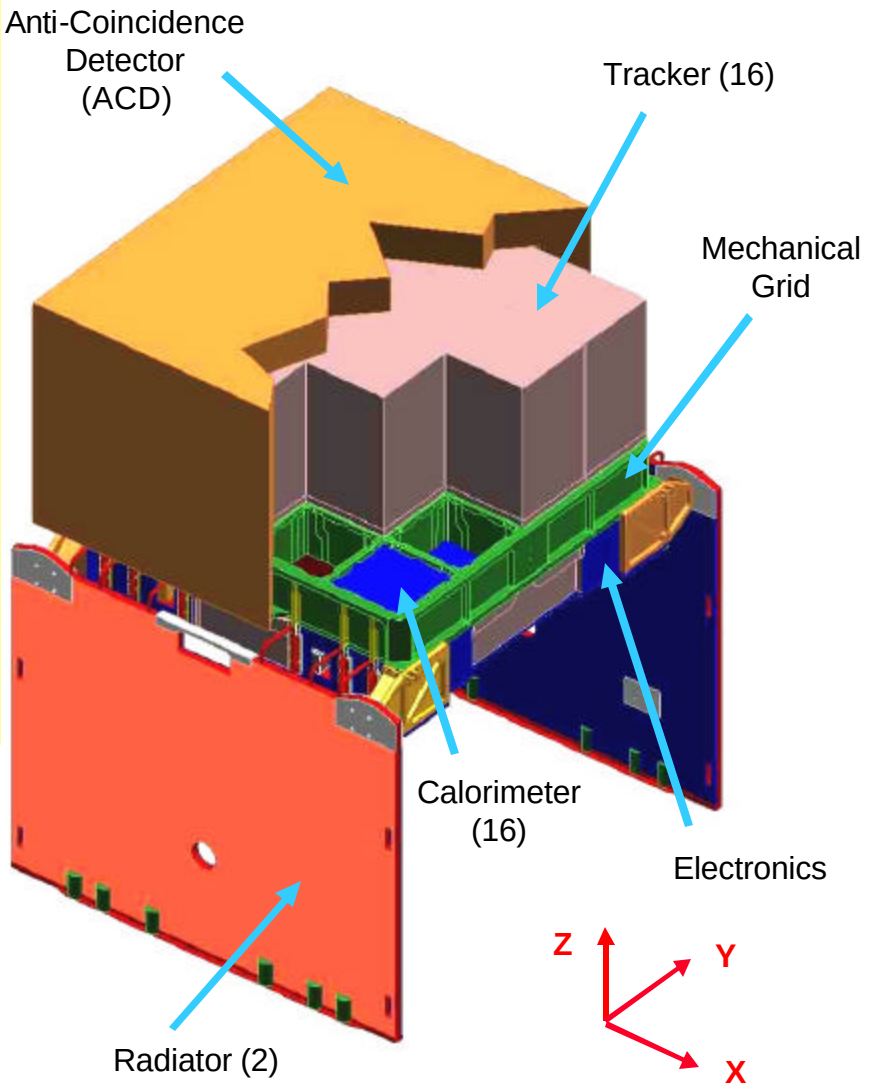


Large Area Telescope

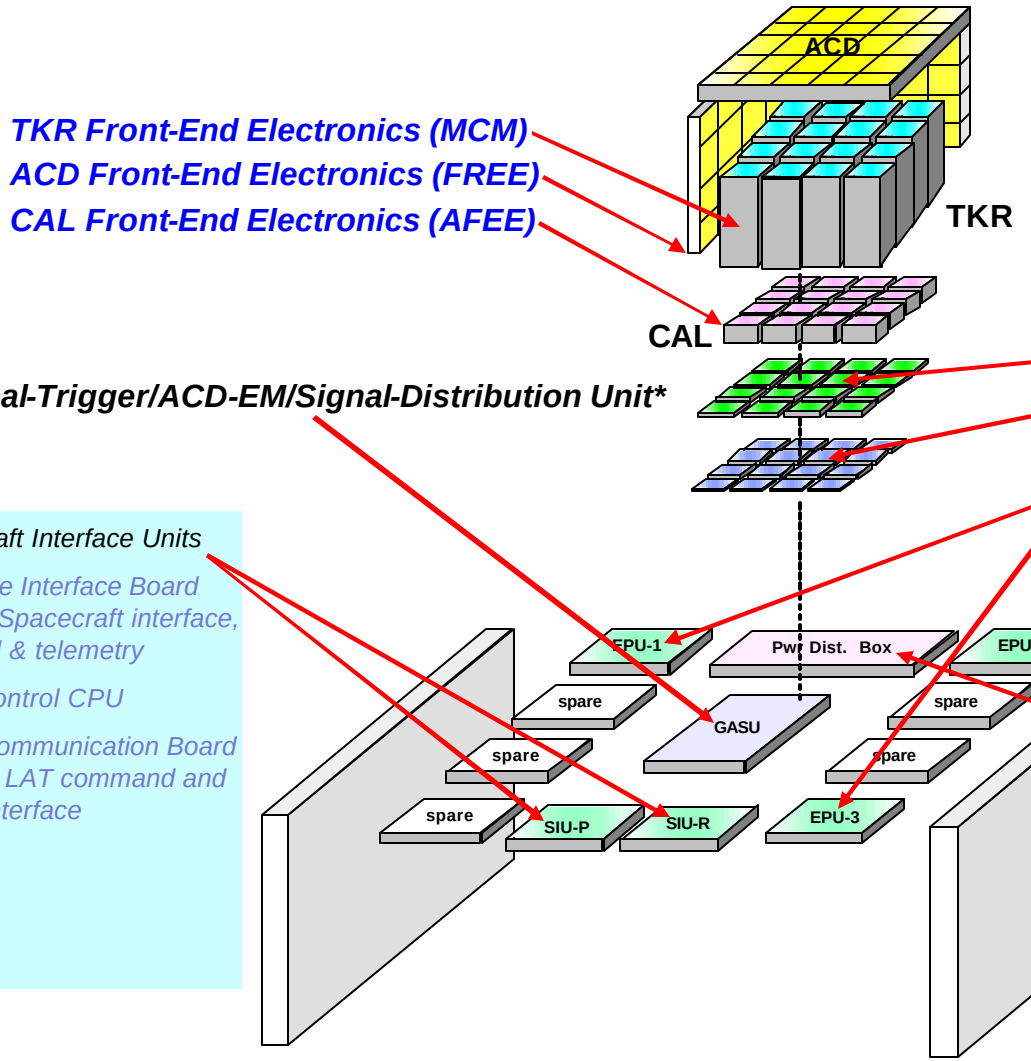
Mass:	**3000 kg**
Instrument Size:	**180 x 180 x 280 cm (X-Y-Z)**
Radiator Area:	**2.83 m^2 each side**
Science FOV:	**2? sr, +Z, above I/F plane**
Mounting:	**4-point mounting I/F at grid**

Key LAT Accommodation Requirements:

- **Pointing Knowledge (10 arcsec, 1?-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

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)

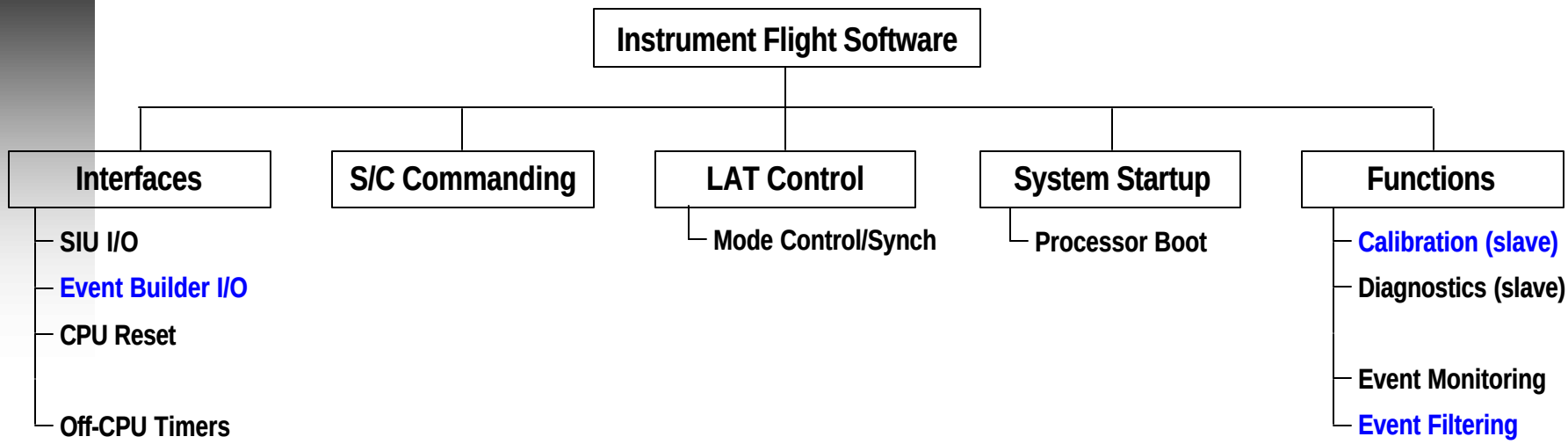
Instrument Flight Software

- **Interfaces**
  - 1553
  - Solid State Recorder
  - PPS Interrupt
  - GBM Interrupt
  - Watchdog
  - Off-CPU Timers
  - EEPROM / File
  - DAQ I/O
  - EPU I/O
- **S/C CMD & TLM**
  - Authentication
  - Real-Time Commands
  - Event Driven Commands
  - GPS Message
  - Attitude Message
  - Ancillary Message
  - GBM Message
  - Transient Alert
  - S/C Repointing Request
  - File Upload
  - File Download
  - Save Audit Trail
- **LAT Control**
  - Thermal
  - Mode Control/Synch
  - Configuration Control
  - Fault Handling
  - Save Audit Trail
- **System Startup**
  - Processor Boot
  - Instrument Startup
- **Functions**
  - Housekeeping
  - Low Rate Science
  - Calibration (master)
  - Diagnostics (master)
  - Identify Transients
  - Event Post Processing

Document: LAT-SS-00399

***Blue indicates items planned for EM1**

Derived Functional Requirements (EPU)



Document: LAT-SS-00399

***Blue indicates items planned for EM1**

Software CDRLs (Phase C/D)

- *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.***
- *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***
- *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***
- *Software Design Document – iterated delivery*
  - ***Version planned with each Release.***
- *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

- ***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.*
- ***Continue support for the NRL FSW team by providing boot and S/C Interface (Mil-Std-1553) test fixtures to them.***
- ***Distinguished between 'Build' and 'Release' for formality and requirements sell-off purposes.***
  - *EM-1, EM-2: Builds*
  - *ISIS, Flight Unit: Releases*
- ***Evaluate opportunities to reduce the LAT filtering requirements by increasing the bandwidth to the SSR.***
- ***Participate in weekly telecons to maintain current status & concerns lists.***
- ***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***

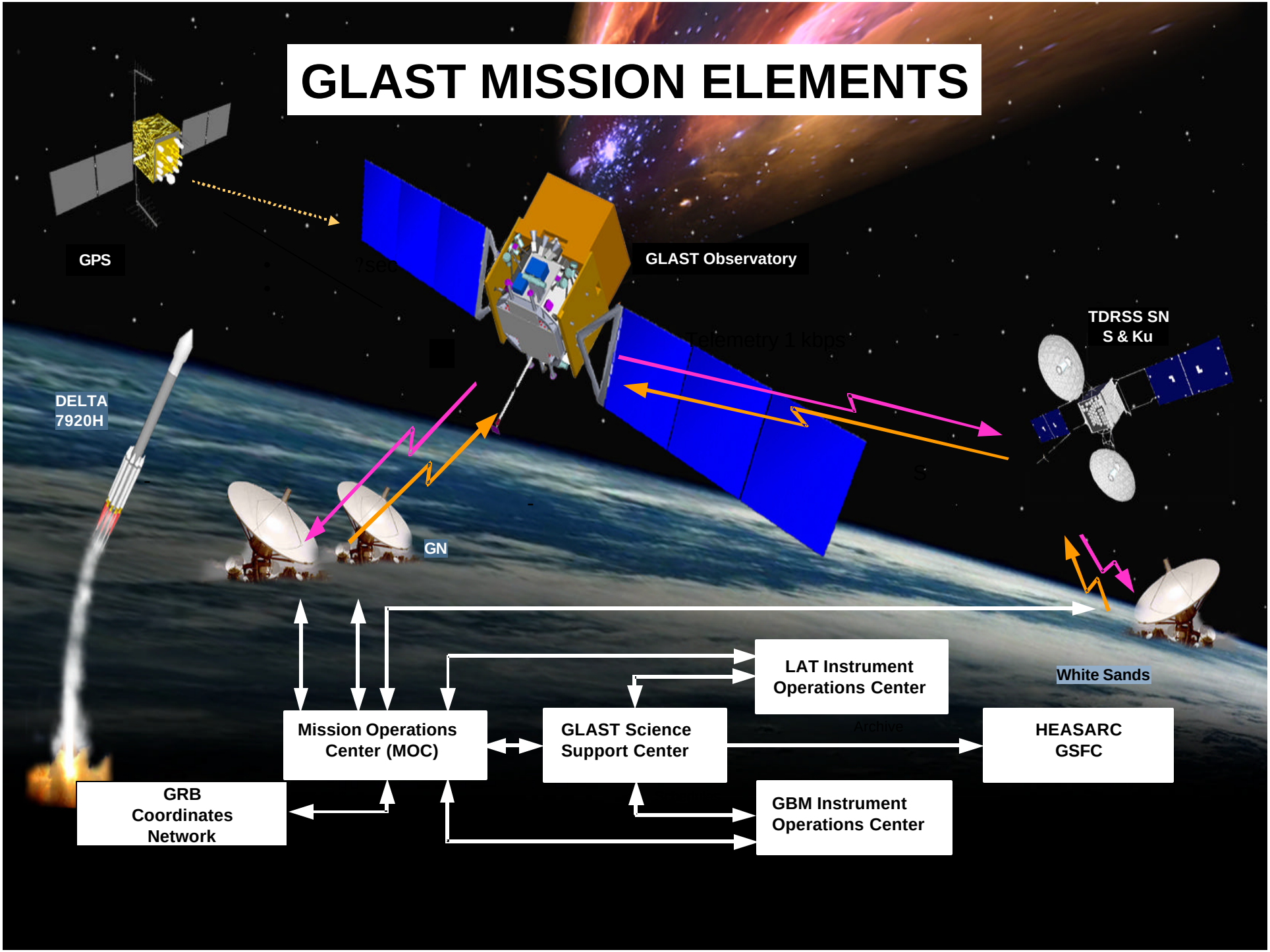
Level 1 Requirements

- ***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)

Parameter	*SRD Value*	*LAT Performance*
Peak Effective Area (in range 1-10 GeV)	***>8000 cm^2***	***10,000 cm^2 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 (>60º)	***<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 55º/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)	***<$6x10^{-9}$ $cm^{-2}s^{-1}$***	***$3x10^{-9}$ $cm^{-2}s^{-1}$***
Source Location Determination	***<0.5 arcmin***	***<0.4 arcmin (ignoring BACK info)***
GRB localization	***<10 arcmin***	***5 arcmin (ignoring BACK info)***


GLAST MISSION ELEMENTS
GPS
GLAST Observatory
TDRSS SN
S & Ku
DELTA
7920H
GN
White Sands
LAT Instrument
Operations Center
Mission Operations
Center (MOC)
GLAST Science
Support Center
HEASARC
GSFC
GRB
Coordinates
Network
GBM Instrument
Operations Center