GLAST Large Area Telescope: I & T Peer Review

Integration, Facilities, Configuration

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Subsystem Manager

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Outline

- Facility Overview
- Assembly & Integration
  - Overview
  - Readiness to install
  - Verification of proper Installation/Inspection Process
  - Assembly plan and flow
  - Alignment
    - Optical
    - Muons
- GSE movement
Documentation

• LAT Integration and Test Plan (LAT-MD-01376)
• LAT Assembly Sequence (LAT-MD-00676)
• MGSE Development Plan (LAT-MD-01462)
• Electrical Performance Test Plan (LAT-MD-01055)
• LAT Mock-Up, Building 33 SLAC
• LAT I&T Survey and Alignment (LAT-MD-01586)
• LAT I&T Traveler Specification (LAT-TD-xxxx)
GASU = Global trigger, ACD electronics, Signal distribution Unit
PDU = Power Distribution Unit
EPU = Event Processor Unit
SIU = Spacecraft Interface Unit

View from Bottom of LAT
LAT I&T, Verification, and Calibration Flow

**I & T Responsibility**

- **Calibration Unit - CU**
  - I&T: Beam test CU – 4 towers
    - Acc, Survey, Cal
  - TKR/CAL: F1,2 from CU

- **Flight LAT - FU**
  - I&T: LAT Tower Assembly, Test
    - Acc, Survey, Cal
  - I&T: LAT Debug, Test, Ship to NRL
    - Acc, Survey, Cal, End-to-End (on airplane)
  - I&T: LAT Environmental Tests
    - Acc, Cal, Survey, EMI, Vibe, Ac, T-B, T-V

**Deliver to Spectrum Astro**

**Responsibility**

- **TKR: QU FS from TKR fab**
- **TKR: F1-2 from TKR fab**
- **CAL: QU- FS from CAL fab**
- **CAL: F1-2 from CAL fab**
- **ELX: EM2 Elect. Modules**
- **Mech: Flt Grid from Mech**
- **TKR: F3-16 from TKR fab**
- **CAL: F3-16 from CAL fab**
- **ELX: Flt Elec. Mod. to LAT I&T**
- **ELX: GASU, PDU, SIU, EPU**
- **ACD: ACD to LAT I&T**
- **Mech: X-LAT Plate, Thermal Switch Boxes**
- **Mech: Flt Rad’s fit check**

**Legend**

- Calibration unit I&T
- Flight unit/spares I&T

**Tests**

- Vibe sine sweep
- Ac Acoustic
- T-B Thermal Balance in vacuum
- T-V Thermal-vacuum cycle test
- EMI Electro-magnetic interference test
- EM Engineering Model
- TM Thermal model
- CU Calibration Unit
- FU Flight Unit
- Cal Calibration

**Symbols**

- Acc Acceptance test level
- QU Qualification Unit
- FS Flight Spare
Readiness to Install

Instrument Integration Readiness Review (IRR)

The IRR will be held prior to delivery of flight hardware to I&T. Successful completion of the IRR shall result in concurrence by the LAT IPO that flight hardware performance is adequate for delivery and acceptance by I&T and hence the beginning of the LAT integration activities. The following information shall be presented and reviewed prior to flight hardware delivery:

- The specification for the acceptance data packages for each subsystem.
- MGSE and EGSE functionality.
- Resolution plans for all failures, anomalies, and malfunctions encountered during component and system testing.
- Remaining open integration issues and their proposed resolution.
- Readiness to perform LAT integration (e.g. staffing, facilities, GSE, procedures, resources, etc.).
- I&T software readiness and verification status.
- FSW development and verification status.
- Risk Status.
- Plans to proceed to pre environmental review (tests, activities, facilities, resources, schedule, flow).

Instrument Integration will proceed upon successful disposition (closure or acceptable action plan) of RFAs resulting from the IRR.
Verification of proper Installation/Inspection Process

- **Acceptance Test Data Package (ATDP, LAT-MD-00408)**
  Successful completion of subsystem testing, as well as other data, is documented in an ATDP provided with the component upon delivery to the Responsible Engineer Authority (REA). QA and I&T sign-off of the ATDP is required before the flight hardware/software is accepted for integration into the LAT. I&T will perform a suite of functional tests specified in the ATDP and using subsystem test scripts running on I&T EGSE. The flight hardware/software must pass this suite of functional tests before being accepted for integration into the LAT.

- **Process documentation**
  - Electronic Operations log (Web Based)
  - I&T Hardware/Software Database (Web Based)
    - Electronic Mate – demate log
    - Electronic Configuration log
    - Hardware/firmware Configuration log
    - Software Configuration log
  - Hard Copy Traveler
  - Non Conformance Report (NCR)
### GLAST Shift Logbook

**Index**

<table>
<thead>
<tr>
<th>GLAST Home</th>
<th>Help</th>
<th>Shift Index</th>
<th>List Runs</th>
<th>Shift Schedule</th>
</tr>
</thead>
</table>

**Other Indices:** ACD TKR CAL General

#### March 2003

<table>
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<th>M</th>
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[2002] [Jan] [Feb] [Mar] [Apr] [May] [Jun] [Jul] [Aug] [Sep] [Oct] [Nov] [Dec] [2004]
GLAST Shift Logbook
Day Shift for Thu, 2003-03-13 08:00:00

You are logged in as Xin

Shift Takers:
   TAKER1: Xin Chen

General Note:

   another test

Runs:

<table>
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<tr>
<th>Run</th>
<th>TestName</th>
<th>StartTime</th>
<th>EndTime</th>
<th>ElapsedTime</th>
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## Summary info for run 1

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<td>2003-03-05 03:54:46</td>
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<td>2003-03-13 13</td>
<td>2003-03-13 13</td>
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<td></td>
<td></td>
<td></td>
<td>13:54:17</td>
<td>13:54:46</td>
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### Operators:
- Selin

### Schema config file:
- simpleAemSchema.xml

### Version data:
- ('gGroup': '1.13', 'versions': '1.11', 'FSM': '1.1', 'testAppAcc': '1.10', 'xml.parsers.expat': '1.1', 'gAttr': '1.13', 'gEGU': '1.3', 'RunControlManGUILmpl': '1.15', '_man__': '1.6', 'XBRD': '0.0.2.0', 'GTEM': '1.3.1.0', 'smath': '1.0', 'MSGLogGUILmpl': '1.11', 'xml': '0.8.1', 'RunControlFSM': '1.2', 'GAEM': '2.0.1.0', 'Python': '[2, 2, 2, final, 0]', 'gLAT': '1.19', 'GNAT': '1.0.17.0', 'urllib': '1.15', 'GGLT_FW': '3.1', 'gutil': '1.10', 'cmdCLI': '1.27', 'gSchemaConfig': '1.21', 'evtScr': '1.39', 'GGLT_FW': '1.1', 'cPickle': '1.77', 'multarray': '0.30', 'xml.parsers.expat': '2.64', 'urllib2': '2.0a1', 'xml.parsers': '0.8.1', 'cmdScr': '1.42', 'RunControlMan': '1.13', 'RunControlCommon': '1.6', 'logging': '0.4.7', 'gNode': '1.19', 'Numeric': '21.0', 'rcReportGen': '1.2', 'gRule': '1.3', 'rcArchiver': '1.9', 'sre': '2.2.1', 'rcTransitions': '1.25', 'GAEM_HW': '1.1', 'GAEM_FW': '3.1', 'gConstraint': '1.5', 'rcPreferencesGUILmpl': '1.9', 'pickle': '1.56.4.4', 'cvtCli': '1.34', 'GGLT': '1.3.1.0')

### Archive file:
- eb030305025413.arch

### Log file:
- msg030305035250.log

### FTTS file:
### GLAST Shift Logbook

**Shift Run Info**

- **Run Range:**
  - (e.g. 2500-2550 2567)

- **Date Range:**
  - taken from [ ] to [ ] (use format YYYY-MM-DD)

- **Accelerator Type:**
  - Beam

- **Secondary Particle Type:**
  - Positron

**Additional query conditions:**

- [ ] list runs
GLAST Shift Logbook
GLAST Shifts from 2003-3-10 to 2003-3-24

You are logged in as
- Click on a shift number to sign up for that series of shifts.
- Shifts with names instead of numbers are already taken.
- Click on a name only if you wish to change shifts with that person.

Show schedule beginning: [2003-3-25 MM-DD]

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<th>printable</th>
<th>show later dates &gt;&gt;</th>
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<td>2003-3-10</td>
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## LAT Modules

Enter query criteria

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**Status:**

[Find]  [Clear]  [New]

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Records 51 to 60 of 111

[First]  [Previous]  [Next]  [Last]
• I&T manages, schedules, and is responsible for LAT Assembly Operations.
• Electronics subsystem supplies electronics flight hardware, and supports LAT Assembly Operations.
  – Electronics hires and pays for Electronic shift technicians (4).
  – Electronic shift technicians are supervised by Brian Grist with technical input from ELX Cognizant Engineer.
• QA (Darren Marsh) is responsible for quality assurance as his team determines, and supports QA activities during LAT Assembly Operations.
  – Larry Wai coordinates scheduling of inspection activities during LAT Assembly Operations with QA.

* Experienced in I&T of flight hardware/software.
Assembly Sequence, Start with Bay 9 Installation

Step 1: Crane lifts and positions TKR tower over grid bay 9, lowers into position (see slide 6 for detail). TKR fasteners are torqued.

Step 2: Crane connects to GPR, lifts, moves, and lowers LAT into inverted orientation (see slide 7 for detail).

Step 3: Crane lifts and positions CAL/TEM assembly over grid bay 9, lowers into position (see slide 8 for detail). CAL fasteners are torqued.
Tracker Installation
LAT Inversion (Schematic)
Electronics Mockup (Understand Cable Plant)
Bays 8, 9 Installation/TEM-Level test Sequence

Step 1: Install Bay 9 TKR, CAL+TEM/PSU. TEM connector savers already on at delivery. Install TEM-level test cables and perform Bay 9 TEM-level test.

Step 2: Remove Bay 9 connector savers, remove TEM-level test cables. Install Bay 8 TKR, CAL+TEM/PSU. Bay 8 TEM connectors savers already on at delivery. Install TEM-level test cables and perform Bay 8 TEM-level test.

All TEM-PSU positions w/o an Electronic Module have EMPTY Boxes mounted to them.

28V EM-PDU Power Cable
GASU-level Test Cable

+Y
+Z
+X
Bays 8+9 System Level Test

Step 1: Complete installation of Bays 8, 9, intervening cable tray, and TEM flight cables

Step 2: Temporarily fasten EM PDU+EM GASU+power/test cables and perform Bays 8,9 Multi-Tower test.

Step 3: Remove EM PDU, EM GASU, power/test cables
**First 8 Bays Installation/Test Sequence**

**Step 1:** Complete installation and test of Pair 1 (Bays 8, 9, intervening cable tray, and TEM flight cables)

**Step 2:** Complete installation and test of Pair 2. EM PDU now remains in place until installation of flight PDU

**Step 3:** Complete installation and test of Pair 3

**Step 4:** Complete installation and test of Pair 4. EM GASU now remains in place until installation of flight GASU
**Last 8 Bays Installation/Test Sequence**

**Step 1:** Complete installation and test of Pair 5

**Step 2:** Installation of +/-X cable trays, fasten flight cables. System level test.

**Step 3:** Installation/test of Pair 6, install +/- X cable trays, fasten flight cables. System level test.

**Step 4:** Installation/test of Pair 7, install +/-X cable trays, fasten flight cables. System level test.

**Step 5:** Installation/test of Pair 8, install +/-X cable trays, fasten flight cables. System level test.
All TEM-PSU positions w/o an Electronic Module have EMPTY Boxes mounted to them.
System Level Electronics Installation Sequence

Step 1: Remove EM GASU, install test instrumentation on grid, install flight GASU, remove connector savers and perform flight mates. System level test.

Step 2: Remove EM PDU, install flight PDU, PDU-GASU cable, and perform flight mates. System level test.

Step 3: Install EPU, EPU-PDU cable, and EPU-GASU cable. System level test. Repeat for all 3 units.

Step 4: Install SIU, SIU-PDU cable, SIU-GASU cable. System level test. Repeat for both units.

Step 5: Install EMI skirt, Bulkhead feed through panels/cables (see slide 20 for detail). System level test. ACD FREE simulator test.
Grid, Corner brackets, EMI Skirt
After all 16 Bays Have Been Loaded, Lower Grid Assy

Precision Crane Op ACD into position and Torque
Assembly Test Summary Chart

- **Blue** = TEM-level test
- **Green** = GASU-level test
- **Red** = Spacecraft Interface Simulator test
- **White Circle** = Optical survey test

Legend:

- LAT w/o ACD
- LAT w/ ACD
- TKR+CAL+GASU+PDU+EPU
- TKR+CAL+GASU

Bays:

- Bays 0-11
- Bays 0-13
- Bays 4,5,8-11
- Bays 8,9
- Bays 4,5,8,9
- Bays 4,5,8,9
- Bays 0,1,4-11
- Bays 4,5,8,9

Document: LAT-PR-01779-01
Open Issues

- X-LAT plate assembly process
  - Require installation after ACD.
  - Require ability to install X-LAT plate with the LAT on edge (+Z horizontal).
1. **LAT Survey ACCURACY GROUND TESTS**
   There is currently a requirement on the knowledge of pointing accuracy to be better than 7 arcsec. From the geometry of the Tracker this corresponds to a survey precision of 20 micron or better. The strategy for determining the survey accuracy on the ground is as follows:

   - **GROUND TRAY MISALIGNMENT TEST**
     - Determine SSD deformation within a tray and tray-to-tray misalignment within a tower using muon survey, cross-checked by simulation and TKR subsystem manufacturing data.

   - **GROUND TOWER MISALIGNMENT TEST**
     - Determine tower-to-tower misalignment using muon survey, cross-checked by optical survey, feeler gauge data, and simulation.

   - **GROUND GRID MISALIGNMENT TEST**
     - Determine tower-to-grid misalignment using optical survey.

   - **GROUND SPACECRAFT MISALIGNMENT TEST**
     - Determine Grid to Spacecraft misalignment using optical survey. Tray-to-tray and tower-to-tower misalignments will be cross-checked by on-orbit cosmic ray surveys. The tower-to-grid and grid-to-spacecraft misalignment will be cross-checked by an on-orbit survey using celestial point sources.
LAT MGSE Used at SC Vendor

- Transport Container
  - Transport Container Cover Lift Fixture

- LAT Lift Fixture
  - Remove LAT from Transport Container
  - Attach LAT to SC

- GPR and Brackets to LAT
  - Lifted Up and Over LAT After Installation onto SC and Brackets Removed

- Radiator Transport Container
  - Radiator Lift Fixture (for removal from shipping container)

- Tilt Over Stands
  - LAT can be placed on Stacked Stands (35” x 2 = 70” to GPR)
  - Stacked Stands may allow side by side testing with SC prior to integration

- Thermal / Humidity Control Cart (TBD)
LAT MGSE Used at Launch Site

• Flight Preparation Operations in Florida
  – Nominal Operations
    • No LAT MGSE Foreseen
    • EGSE may be required to check out LAT prior to Fueling
  – Off-Nominal Operations – TBD to None
  – Thermal / Humidity Control Cart (TBD)

• Operations at Canaveral AFS
  – None Anticipated for SC to LV Mate
LAT Contamination Control at SC Vendor

- Conform to LAT Contamination Control Plan, LAT-MD-00404
  - Class 100,000 Clean Room and Operations Protocol
  - Helium Monitoring
    - Protects ACD
    - Concern about Helium use at SC Integration Halls (to Counter Act Gravity During Deployment Checks)
  - Humidity Control, 30 to 45 % RH
    - Protects Calorimeter
    - Desiccant Cartridges while in Transport Container
    - Connected to Dry Air, or N₂, Purge Upon Removal from Transport Container
      - SC Vendor Provides Purge (TBR)
      - Thermal / Humidity Control Cart (TBD)
LAT Contamination Control at Launch Site

- Conform to LAT Contamination Control Plan, LAT-MD-00404
  - Class 100,000 Clean Room and Operations Protocol
  - Helium Monitoring
    - Protects ACD
    - Helium is typically used as Pressurant for LV & SC Fuel Tanks
  - Humidity Control, 30 to 45 % RH
    - Protects Calorimeter
    - SC Vendor Responsible for Transport
    - Connected to Dry Air or N₂ Purge Upon Removal from Boeing Provided Transport Container
      - SC Vendor Provides Purge (TBR)
      - Thermal / Humidity Control Cart (TBD)
  - LAT Requires Continuous Dry N₂ Purge up to Launch (TBR)
    - Avoids Problems if Air Conditioned Air Source (Provided by Launch Site) Goes Down
LAT Access Points at Observatory Level

• SC Vendor
  – LAT Test Point prior to Installation onto SC
  – LAT Test Point for Off-Nominal Check Outs After Integration onto SC
  – Radiator Installation Access TBD
  – LAT to SC Interface Bracket Access TBD
  – LAT Environmental Test Sensor Connections

• Launch Site, Astro Tech
  – LAT Test Point for Off-Nominal Check Outs
  – Close of LAT Test Point before launch (Green Tag).

• Launch Site, Canaveral Air Force Station
  – None
EXTRA SLIDES
LAT Structural Design Overview

<table>
<thead>
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<th>LAT Structural Design Parameters</th>
<th>Design</th>
<th>Spec</th>
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<tbody>
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<td>Mass</td>
<td>2679.4 kg</td>
<td>&lt;3000 kg</td>
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<tr>
<td>Center of Gravity</td>
<td>149.3 mm</td>
<td>&lt;185 mm</td>
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<tr>
<td>Width</td>
<td>1796 mm</td>
<td>&lt;1800 mm</td>
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<tr>
<td>Height</td>
<td>1047 mm</td>
<td>1100 mm</td>
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**Tracker (TKR)**
- Mass: 504.9 kg
- Materials: GrEp, CC structures, Silicon, Tungsten
- Size: 372 mm sq x 640 h
- Interfaces: Grid Ti flexure mount

**Calorimeter (CAL)**
- Mass: 1375.8 kg
- Materials: CFC support shell, alum structure, CsI
- Size: 364 mm sq x 224 mm h
- Interfaces: Grid bolted friction joint

**LAT Mass Budget and Current Estimates (kg)**

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<th>Estimate</th>
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<tr>
<td>LAT Total</td>
<td>2679.4</td>
<td>3000</td>
</tr>
</tbody>
</table>

Source: LAT-TD-00564-6 “LAT Mass Status”

**LAT Structural Performance**

<table>
<thead>
<tr>
<th>Component</th>
<th>Design</th>
<th>Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAT First Mode Freq.</td>
<td>55.5 Hz</td>
<td>&gt;50 Hz</td>
</tr>
<tr>
<td>LAT Drumhead Freq.</td>
<td>60.2 Hz</td>
<td>&gt;50 Hz</td>
</tr>
<tr>
<td>Radiator First Mode Freq.</td>
<td>65.1 Hz</td>
<td>&gt;50 Hz</td>
</tr>
<tr>
<td>Deflection at Grid Center</td>
<td>0.49 mm</td>
<td>---</td>
</tr>
</tbody>
</table>

**Anticoincidence Detector (ACD)**
- Mass: 270.1 kg
- Materials: CFC honeycomb, alum base frame, MLI/ Micrometeorite Shield
- Size: 1796 mm w x 1015 mm h
- Interfaces: Grid bolted joint, shear pins

**Grid/X-LAT Plate/Radiators**
- Mass: 329.3 kg
- Materials: Aluminum, heat pipes, alum honeycomb plates
- Size: 1566 mm sq x 236 mm h
- Interfaces: Four-point mount to SC flexures

**Electronics**
- Mass: 199.3 kg
- Materials: Aluminum
- Size: mm sq x mm h
- Interfaces: Flexure mount to CAL; bolted friction joint to X-LAT Plate

Document: LAT-PR-01779-01