GLAST Large Area Telescope: Integration & Test

Elliott Bloom  
SU-SLAC  
I&T Manager

elliott@slac.stanford.edu  
650-926-2469
Organization of I&T – Overview

Integration Facilities Configuration and Test (IFCT)

Mechanical Ground Support Equipment (MGSE)

Electrical Ground Support Equipment (EGSE) / Online Software

Particle Test

Science Verification Analysis and Calibration (SVAC)

Integration, Test, and Calibration

Management
Scope of I&T Presentation

- Preparation for LAT integration
  - Integration, Facilities, Configuration and Test (IFCT)
  - Electrical Ground Support Equipment (EGSE)/Online
  - Mechanical Ground Support Equipment (MGSE)
  - Particle Test
  - Science Verification, Analysis, and Calibration (SVAC)
  - Management
    - Peer Reviews of I&T departments 6/14/04 - 6/18/04
    - Integration Readiness Review – 7/8/04
- Installation of one tower and testing begins – 8/13/04
- Installation of two towers and testing begins – 9/04
- Two Tower CPT begins – 10/04
- Two Tower CPT complete – 11/04
Integration and Test Sequence Through Two Towers (LAT-MD-00676)

1. Receive Grid
   - Integrate Grid onto Rotation Stand
   - Grid Optical Survey

2. Receive Calorimeter, TEM/TEM PS Flight Units A
   - Install in Metrology Bay for Shimming & Assembly
   - Test CAL A & TEM/TEM PS A

3. Receive Tracker Flight Unit A
   - Install tower in Single Bay
   - Test Single Bay Tower
   - De-Install Tower from EM single bay

4. Receive Calorimeter, TEM/TEM PS Flight Units B
   - Install in Metrology Bay for Shimming & Assembly
   - Test CAL B & TEM/TEM PS B

5. Receive Tracker Flight Unit B
   - Install tower in Single Bay
   - Test Single Bay Tower
   - De-Install Tower from EM single bay

6. Integrate Tracker A into Grid
7. Integrate Cal/TEM/TE M-PS A into Grid
8. Single Tower Test in Grid
9. Optical Survey
10. Integrate Tracker B into Grid
11. Integrate Cal/TEM/TE M-PS B into Grid
12. Single Tower Test in Grid
13. Two Tower CPT
I&T Overview to Start of Integration

- Requirements LAT-MD-02730 6/10/04 *
- I&T Plan LAT-MD-01376 5/1/04
- Survey Plan 5/1/04 draft 5/31/04 final

Integration Procedures
Mechanical and Electrical 6/18/04

Training & Procedure Verification 6/18/04

Electronics Test-Bed 5/04

I&T Mockup 4/1/04

LATTE v.3.0 4/1/04
EGSE Hwr Deliveries 6/1/04

I&T Functional Test Scripts 6/1/04

Training & Script Verification 6/1/04 – 7/1/04

Integration Readiness Review 7/8/04

Bldg 33 Cert 6/18/04
Particle Test Equipment 6/18/04

Receive Flight Hardware Start Integration

- LATTE v.3.n V & V 5/8/04 – 7/8/04

- LAT-MD-02730 6/10/04 *

- Final though two tower CPT, releases to support integration procedure development
Recent Accomplishments

- MGSE Review – February 5th and February 24th.
- Held an Integration Kick-off Meeting – March 9th.
- Assembly plan under review for release (Design Engineering document) – March 12th.
- Hired 6 of 10 open I&T positions as of March 25th.
- Training Mockup ready for use March 31st.
- Initial Online software for integration of LAT, LATTE v.3.0 released – April 1st.
Integration, Facilities, Configuration, and Test (IFCT) Flow

Procedure Writing
(March – June)

Mockup Preparation
(March)

Mockup Training
(April – June)

Facility Preparation
(March – May)

Facility Training
(May – June)

Integration Readiness Review
7/8/04

Testbed Preparation
(March – April)

Testbed Training
(May – June)
Integration, Facilities, Configuration, and Test (IFCT) - Procedures for Single and Two Towers

- Single bay procedures (12 total)
  - 9 procedures partially or fully tested in EM1 test series
  - 3 procedures never exercised yet: Tracker installation, Optical survey, TEM/PSU shimming
  - Includes critical operations and facility procedures.
  - 7 complete by 4/9/04, 3 complete by 4/19/04, 1 by 5/19/04, and 1 by 6/18/04.

- Two-bay procedures (6 total)
  - Top concern: GASU/PDU test procedures; will be sending IFCT personnel to ELX test lab to develop and exercise procedures.
  - 3 complete by 4/9/04 and 3 by 6/18/04 including two tower comprehensive performance test.

- Related MGSE procedures (13 total)
  - Use and proof test procedures ready by the IRR.
Example of monitoring system data:

- Cleanroom typically operating within limits 99.7% of time
- Hardware bag with nitrogen purge covered remaining 0.3% of time
IFCT - Facility Project Schedules

- Cleanroom air conditioning hot water back-up boiler - new issue as of 3/25 (SLAC SEM investigating)
- Network Firewall - ECD 3/31
- Nitrogen purge line certification - ECD 3/31
- Cleanroom Monitoring Automated Data Archival System (SCS) - ECD 4/30
- Cleanroom air conditioning air intake duct stack - ECD 4/30
- ACD Test Area - ECD 5/31
- ELX Thermal Chamber Installation - ECD 5/31
- ELX T-Vac Installation - ECD 5/31
- Building 33 Back-Up Power Generators - ECD 5/31 (Proposed - awaiting quote/Project approval)
Description of parts:
- Rotation stand supporting plate spanning full-width of LAT
- EM single bay can fasten to central bay
- CAL baseplate external features
- Shear plates
- Cable trays
- Population of cables, electronics boxes for bays 8-15 (50% of LAT)

Status
- All major parts in hand or in manufacturing
- Ready for training 31-Mar-04
Planned Operations Meetings

• Ongoing weekly I&T meeting, Thursdays 1:30 PM – 3 PM (telecon).
• During integration
  – Daily 8 AM meeting in Bldg 33 to define work for the day.
    • Attended by all technicians on day shift that day.
    • Led by electrical and mechanical floor engineers.
  – Daily 4 PM meeting in Bldg 33 to review progress of the day shift and define work for the swing shift.
    • Attended by all technicians on day and swing shift that day.
    • Led and organized by IFCT department manager.
    • Electrical and Mechanical floor engineers define work for the swing shift.
    • Short technical presentation relevant to the days work will be made.
Mechanical Ground Support Equipment (MGSE) - Flow

- **Formal Stress Analysis**
  - 2/6/04 – 4/9/04

- **Grid Perimeter Ring Support Shaft**
  - 3/29/04 – 5/14/04

- **Drive Gear and Bearings**
  - 3/15/04 – 5/7/04

- **Rotation Stand Weldment**
  - 3/29/04 – 6/15/04

- **Z-Axis Horizontal Lift Spreader**
  - 3/29/04 – 6/11/04

- **Grid Perimeter Ring and brackets**
  - 3/29/04 – 5/14/04

- **4x4 Lift Fixture and Proof**
  - 4/12/04 – 5/27/04

- **1x4 Lift Fixture and proof**
  - 4/12/04 – 6/10/04

- **Proof Test Assemblies**
  - 4/5/04 – 6/14/04

- **4x4 Lift Fixture and Proof**
  - 4/12/04 – 5/27/04

- **Rotation Stand Assembly & Proof Test**
  - 6/16/04 – 7/21/04

- **Personnel Access Platforms and proof**
  - 4/19/04 – 6/14/04

- **Metrology Bay**
  - 3/8/04 – 4/19/04

- **Integration Readiness Review**
  - 7/8/04
## Mechanical Ground Support Equipment (MGSE) – Status (All items complete by IRR)

<table>
<thead>
<tr>
<th>LAT I&amp;T MGSE Item</th>
<th>Stress Analysis</th>
<th>Design - Drafting</th>
<th>Procurement</th>
<th>Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Status</td>
<td>Report</td>
<td>Modeled</td>
<td>Detailed</td>
</tr>
<tr>
<td>4x4 Integration Stand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4x4 Rotation / Support Stand</td>
<td>√</td>
<td>75%</td>
<td>√</td>
<td>90%</td>
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<tr>
<td>Grid Perimeter Ring - Brackets</td>
<td>√</td>
<td>95%</td>
<td>√</td>
<td>99%</td>
</tr>
<tr>
<td>Support Shaft - Flange Assemblies</td>
<td>√</td>
<td>95%</td>
<td>√</td>
<td>99%</td>
</tr>
<tr>
<td>Personnel Access Platforms</td>
<td>40%</td>
<td>65%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Z Axis Up Lift Fixture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z Axis Up Lift Spreader</td>
<td>√</td>
<td>95%</td>
<td>√</td>
<td>90%</td>
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<tr>
<td>Z Axis Up Tension Rod Assemblies</td>
<td>√</td>
<td>95%</td>
<td>30%</td>
<td>45%</td>
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<tr>
<td>Z Axis Horizontal Lift Fixture</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z Axis Horizontal Lift Spreader</td>
<td>√</td>
<td>95%</td>
<td>√</td>
<td>95%</td>
</tr>
<tr>
<td>Z Axis Horizontal Shackles</td>
<td>√</td>
<td>95%</td>
<td>√</td>
<td>95%</td>
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<tr>
<td>Z Axis Horizontal, Crane Scale Mod</td>
<td>√</td>
<td>95%</td>
<td>√</td>
<td>95%</td>
</tr>
<tr>
<td>Crane Scale Height Modification</td>
<td>√</td>
<td>95%</td>
<td>√</td>
<td>95%</td>
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<tr>
<td>4x4 MGSE Proof Test Assemblies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAL - Z Up Lift Fixture</td>
<td>√</td>
<td>*</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>CAL Alignment Tool</td>
<td>√</td>
<td>*</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>CAL Alignment Rods</td>
<td>√</td>
<td>*</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>CAL Inversion Stand / Interface</td>
<td>√</td>
<td></td>
<td>√</td>
<td>√</td>
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<tr>
<td>E-Box Shimming</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Metrology Bay with Stand</td>
<td>n/a</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Clamps, Align Rods, Lift Eyes, etc</td>
<td>n/a</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>TWR Mass Simulators</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EM-2 Single Bay (TKR Interface Plate)</td>
<td>√</td>
<td>n/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x4 Lift Fixture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x4 Lift Spreader</td>
<td>√</td>
<td>90%</td>
<td>√</td>
<td>80%</td>
</tr>
<tr>
<td>1x4 Tension Rod Assemblies</td>
<td>√</td>
<td>90%</td>
<td>√</td>
<td>60%</td>
</tr>
<tr>
<td>TKR - TKR No Touch at Ascent Tool</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* Hardware in hand and proof test complete
Personnel Access Platform TKR

- PAP provides ready access to allow crew to Attach or Remove TKR Lift Fixture from any bay position

- TKR cables will need to be dressed to their –Z end to allow TKR motion up and over other installed TKRs
## Electrical Ground Support Equipment (EGSE) / Online - Test Stand Definitions through two tower

### Status:

<table>
<thead>
<tr>
<th>Stand No.</th>
<th>Complete</th>
<th>Complete</th>
<th>1st Release</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS-1</td>
<td>TS-2a</td>
<td>TS-2b</td>
<td></td>
</tr>
<tr>
<td>EGSE Software</td>
<td>=&gt;LATTE 2</td>
<td>LATTE 2+</td>
<td>LATTE 3</td>
</tr>
<tr>
<td>Flight Software</td>
<td>EM1</td>
<td>EM1</td>
<td>EM2</td>
</tr>
<tr>
<td>PC with VME crate, LCB and SBC</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>X board</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>Bench and EGSE TEMPS</td>
<td>Bench</td>
<td>EM or flight PDU</td>
</tr>
<tr>
<td>Spacecraft Interface Simulator (SIS)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Test phase description

| Tracker or Cal receiving test | X |
| TKR installation in EM single bay | X |
| ACD receiving test | |
| Cal/TEM/TEMPS integration | X |
| Tower integration in EM Single Bay and in grid | X |
| 2+ towers in grid through GASU and PDU installation, can be used up to launch for low level tests including ACD | |
| Tests EPU and SIU after installation, including before all 16 towers are integrated | |
| Full up LAT testing | | |
Single Tower EGSE Configuration (TS-1 / 2a)
Particle Test

Van de Graaff

Status:
- 1 kHz g into 4p sr during EM test
- > 100 kHz g into 4p sr with upgraded VdG in work
- Electron veto upgrade in work
- Complete by 6/18/04

Cosmic Ray Scintillator

Status: Needs upgraded support 6/18/04

BGO Monitor

Status: Needs data acquisition system upgrade 6/18/04

Integration and Test

Procedures for equipment setup complete by 6/18/04

Spare Parts for 22 components (8 already have, 14 ordered by 4/15/04)

Integration Readiness Review 7/8/04
Science Verification, Analysis, and Calibration (SVAC)

- Calibrations
  - To verify that offline/online calibrations agree
  - To improve calibrations by using additional LAT information not available to subsystems
  - To develop trend analyses to provide history of calibrations

- Data analyses
  - To apply SAS reconstruction algorithms on real data
  - To uncover and quantify any instrumental effects that could have an impact on science data analysis

- SVAC depends strongly on work outside SVAC
  - Subsystem inputs
  - SAS Calibration infrastructure
  - SAS Pipeline Infrastructure
  - SAS/Online Event Format definitions
Science Verification, Analysis, and Calibration (SVAC) - Roadmap

- SAS Calibration Algorithms (May)
- SAS Database (May)
- SAS Pipeline Infrastructure (March - April)
- SAS Geometry Review (April)
- SVAC Acceptance and Test of SAS Algorithms (May - July)
- SVAC Database and Calibration trending (March - July)
- SVAC Data Pipeline (May-June)
- 1 & 2 Tower Geometry (April - May)
- MC Datasets 1 & 2 tower (May)
- Integration Readiness Review 7/8/04
- Instrument Test Analysis (March – July)
- EM 1 data analysis (March - May)
- SVAC Workshop (May)
- EM 2 data analysis (April - June)
Variances Schedule and Cost

- **Schedule**
  - **Budgeted Cost of Work Scheduled (BCWS):** 3125 k$
  - **Budgeted Cost of Work Performed (BCWP):** 3111 k$
  - **Schedule Variance:** -14 k$ or 0.5%

- **Cost**
  - **Budgeted Cost of Work Performed (BCWP):** 3111 k$
  - **Actual Cost of Work Performed (ACWP):** 3037 k$
  - **Cost Variance:** +74 k$ or 2.4%

- The Integration and Test Subsystem schedule and costs are under control.
Critical Path to Integration of First Flight Module

Tower Integration EGSE Dev & Support 5/18/04 (0) → EGSE Validation for Tower Integration 5/19/04 (0) → EGSE Ready for Integration 5/20/04 (0) → Receive / Inspect Cal Module A 8/13/04 (-24) → Integrate Flight TKR/Cal Towers A 8/27/04 (-11) → Functional Tower Test - A 9/13/04 (-11)

Completion Date (Baseline Variance)

Issues driving critical path
• Test requirements
  – Working closely with Systems in weekly meetings to drive to closure
    • LAT Performance and Operations Test Plan LAT-MD-02730 6/10/04
  – Rapid progress possible on I&T Test plan
    • Integration and Test Plan LAT-MD-01376 5/1/04
  – Working with Design Integration and Tracker in weekly meeting to drive to closure
    • Survey Plan, 5/1/04 draft, 5/31/04 final
• Subsystem scripts
  – I&T EGSE/Online working closely with subsystems to enable delivery by 5/1/04
• Time on Electronics Test-Bed for EGSE V&V and technician training
  – Electronics will give I&T required access to needed equipment starting on 5/1/04
Approved Cost Changes Since Rebaseline

(k$)

4.1.9 Baseline, November 03 $6,384

Changes:
- Additional I&T Manpower $523*
- IFCT Engineering/Design $284
- Tracker/Grid Interface Redesign $35
- Stanford Benefits Rate Increase $147

Total Change $989

4.1.9 Baseline, February 04 $7,373

*Corresponding NASA funding increase, change was pending during rebaseline effort.
Where will I&T be in 6 months?

• The Integration Readiness Review (IRR) will have been completed.
  – The procedures for integration have will been completed.
  – The MGSE for LAT integration will have been built and tested.
  – The EGSE/Online for integration will have been completed and tested in place.
  – Configuration control in place.
  – Technicians will have been trained.
  – Facility will be certified.
  – Van de Graaff will be ready.
• The Grid will have been received and installed on the rotation stand.
• The first tower will have been received, installed and tested.
• The second tower will have been received and work will have begun on installation and testing.
Summary

• I&T is on track to begin integration as currently scheduled.