GLAST Large Area Telescope:
LAT System Engineering

Pat Hascall
SLAC
System Engineering
Topics

• Action Item Status
• Technical Baseline Management
• Issues
• Interface Control Documentation
• RFA Closure
• Key Metrics
• Risk Management
## Monthly Action Item Status

<table>
<thead>
<tr>
<th>Action Item ID</th>
<th>Actionee</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-30-03-008</td>
<td>B. Estey</td>
<td>Define and maintain the production readiness/execution plan to include vendor selection and associated schedule to ensure unit availability dates are met</td>
<td>OPEN: Draft production plan completed &amp; provided to GSFC. Refinement required as vendors are selected. Update provided early December, 2003. Next update and process for update: TBD. Schedules for TEM/TPS provided to B.Graf, action to be closed when similar schedules are provided for the rest of the boxes. <strong>GASU schedule provided, Harness schedule to be provided within a week, followed by the Heater Control Box schedule.</strong></td>
</tr>
</tbody>
</table>
Technical Baseline: Flight Drawing Release

- Status details (DAQ reported separately)
  - Tracker
    - 141 of 141 completed (total is 15 over original plan)
  - ACD
    - One assembly drawing remains, no impact to delivery
  - Mech
    - Completed 57 of 81 (total is 22 part over original plan)
  - Design Integration
    - Major drawings: 1 of 5 signed off
## Technical Baseline: DAQ Flight Drawing Release

<table>
<thead>
<tr>
<th>Group</th>
<th>Total</th>
<th>In Config Control</th>
<th>To Go</th>
<th>In Signoff</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEM/TPS</td>
<td>48</td>
<td>48</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDU</td>
<td>34</td>
<td>34</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GASU</td>
<td>72</td>
<td>41</td>
<td>31</td>
<td>12</td>
<td>28 to close with FPGA docs, 3 do not affect production</td>
</tr>
<tr>
<td>EPU/SIU</td>
<td>61</td>
<td>49</td>
<td>12</td>
<td>6</td>
<td>9 to close with FPGA docs, 3 do not affect production</td>
</tr>
<tr>
<td>Harness</td>
<td>40</td>
<td>23</td>
<td>17</td>
<td>4</td>
<td>Near term needs in signoff</td>
</tr>
<tr>
<td>Brackets/hardware</td>
<td>39</td>
<td>28</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heater Control Box</td>
<td>20</td>
<td>1</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>314</strong></td>
<td><strong>224</strong></td>
<td><strong>90</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Issues

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Status</th>
<th>Due Date</th>
<th>Actionee</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Technical baseline: Flight Drawing release</td>
<td>- All drawings to be under CM prior to flight build</td>
<td>Weekly Review</td>
<td>P. Hascall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Flight drawing release plan generated and statused weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>ASIC radiation sensitivity testing completion</td>
<td>Radiation testing scheduled for completion. 2 ASICS remain. GTFE testing started, GLTC in house</td>
<td>30 April -&gt; June&gt; Jan 05</td>
<td>Sadrozinski</td>
</tr>
<tr>
<td>24</td>
<td>No plans to conduct Tracker Subsystem EMI/EMC</td>
<td>Looking at an EMI/EMC test to be performed after Tracker delivery but before integration. Test approaches outlined, in review by Tom Himel. Meeting on 12/8</td>
<td>30 Sept&gt;</td>
<td>Blanchette</td>
</tr>
</tbody>
</table>
## Issues (continued)

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Status</th>
<th>Due Date</th>
<th>Actionee</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Tracker flex cable coupon failures</td>
<td>Process change implemented. <strong>Coupons from flight panels failed. Working with Parlex and investigating second source.</strong></td>
<td>10/15/04-11/5</td>
<td>Rich</td>
</tr>
<tr>
<td>32</td>
<td>Tracker wire bond breaks (heavy trays)</td>
<td>Evaluating root cause. Potentially delete encapsulation. Tower A and B to proceed w/o encapsulation. <strong>Reviewing alternate coatings</strong></td>
<td></td>
<td>R. Johnson</td>
</tr>
<tr>
<td>35</td>
<td>Reliability assessments not completed</td>
<td>FMEAs done, reviews with Subsystems started</td>
<td>12/31/04</td>
<td>DiVenti</td>
</tr>
<tr>
<td>36</td>
<td>SIIS capability to support I&amp;T</td>
<td><strong>Identified first cut at needed extensions to SIIS capability. Coordinated I&amp;T, FSW and Test Bed plan in development</strong></td>
<td>12/15/04</td>
<td>Haller/Bloom</td>
</tr>
</tbody>
</table>
Interface Management
Interface Document Status

• SC-LAT ICD ICN Status
  – LAT signed this month
    • ICN-76 Spare Discrete Mon for SIU Boot Status
  – Currently under signature review
    • None
  – Currently in draft or revision
    • None

• Internal LAT ICD’s and IDD’s
  – Currently in signature review
    • TKR-LAT Electrical ICD
  – Currently in update
    • Electronics-LAT ICD (Comments being incorporated as they are received)
    • TKR-LAT Mech/Therm ICD
    • CAL-LAT ICD
GFE Deliverables/Receivables

- LAT GFE Deliverables
  - Nov: None
  - Dec: ISIS
  - Jan: None Scheduled
  - Feb: None Scheduled

- LAT GFE Receivables
  - Nov: None
  - Dec: SIIS, SC-LAT Test Flexures
  - Jan: None Scheduled
  - Feb: None Scheduled
RFA Closure

- 37 CDR RFAs total, submitted 36 answers
  - Still working Radiator MGSE response

- Peer review RFAs
  - 177 pre CDR RFAs, one outstanding
    - ACD handling plan for blankets
  - 21 post CDR RFAs, 1 outstanding
    - X-LAT thermal test approach – answer drafted and passed by NASA. One additional analysis required to close.
Key Design Metrics
LAT Mass Status

<table>
<thead>
<tr>
<th>Mass (kg)</th>
<th>Estimate</th>
<th>Alloc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TKR</td>
<td>514.0</td>
<td>510.0</td>
</tr>
<tr>
<td>CAL</td>
<td>1374.3</td>
<td>1440.0</td>
</tr>
<tr>
<td>ACD</td>
<td>286.2</td>
<td>295.0</td>
</tr>
<tr>
<td>Mech</td>
<td>366.6</td>
<td>386.6</td>
</tr>
<tr>
<td>Elec</td>
<td>230.4</td>
<td>240.0</td>
</tr>
<tr>
<td>Systems</td>
<td>7.0</td>
<td>8.0</td>
</tr>
<tr>
<td>LAT Total</td>
<td>2778.5</td>
<td>2879.6</td>
</tr>
</tbody>
</table>

Rsrv/Margin: 221.5
Rsrv/Margin*: 8.0%
Allocation: 3000.0

* AIAA G-020 recommended min reserve = 5.2%
Allocations per latest mass CCB on 18 June 2004

<table>
<thead>
<tr>
<th>Mass Estimate Breakdown</th>
<th>(kg)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parametric</td>
<td>139.9</td>
<td>5.0%</td>
</tr>
<tr>
<td>Calculated</td>
<td>1062.6</td>
<td>38.2%</td>
</tr>
<tr>
<td>Measured</td>
<td>1575.9</td>
<td>56.7%</td>
</tr>
<tr>
<td>Total</td>
<td>2778.5</td>
<td>100%</td>
</tr>
</tbody>
</table>

Center of Mass (mm):
- CMx: -1.22, -20 < CMx < 20
- CMy: -0.89, -20 < CMy < 20
- CMz: -72.55, CMz < -51.2
- Ht off LIP: 163.65, Ht < 185

Second Moment of Inertia (kg-m^2):
- Ixx: 1084.5, 1500.0
- Iyy: 1032.1, 1500.0
- Izz: 1410.8, 2000.0
### LAT Power Status

Calorimeter CR approved to change allocation to 67W

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimate (Watts)</th>
<th>PARA (Watts)</th>
<th>CALC (Watts)</th>
<th>MEAS (Watts)</th>
<th>ALLOC. (Watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACD</td>
<td>11.5</td>
<td>2.4</td>
<td>3.9</td>
<td>5.2</td>
<td>10.5</td>
</tr>
<tr>
<td>Tracker</td>
<td>146.9</td>
<td>1.5</td>
<td>0.0</td>
<td>145.4</td>
<td>153.0</td>
</tr>
<tr>
<td>Calorimeter</td>
<td>66.8</td>
<td>0.0</td>
<td>0.0</td>
<td>66.8</td>
<td>66.0</td>
</tr>
<tr>
<td>Trigger &amp; Data Flow</td>
<td>320.1</td>
<td>43.2</td>
<td>86.1</td>
<td>190.8</td>
<td>327.5</td>
</tr>
<tr>
<td>Grid/thermal</td>
<td>20.4</td>
<td>20.4</td>
<td>0.0</td>
<td>0.0</td>
<td>36.0</td>
</tr>
<tr>
<td>Instrument Total</td>
<td>565.6</td>
<td>67.5</td>
<td>90.0</td>
<td>408.2</td>
<td>591.0</td>
</tr>
<tr>
<td>Instrument Allocation</td>
<td>650.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Reserve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14.9%</td>
</tr>
</tbody>
</table>

**PDR** Reserve Was 15.2%

**CDR** Reserve Was 13.4%

Goal for PSRR Reserve > 5%

**PARA** - Best Estimate based on conceptual design parameters

**CALC** - Estimate based on Calculated power from detailed design documentation

**MEAS** - Actual power measurements of components

Lat Power Status (Continued)

- Survival Power

<table>
<thead>
<tr>
<th>Component</th>
<th>Current Alloc.</th>
<th>Subsystem Power Estimates (W)</th>
<th>PARA</th>
<th>CALC</th>
<th>MEAS</th>
<th>Total</th>
<th>Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Orbit Average Power Total1</td>
<td>278.00</td>
<td></td>
<td>0.00</td>
<td>230.40</td>
<td>0.00</td>
<td>230.40</td>
<td>20.7%</td>
</tr>
<tr>
<td>Regulated VCHP Power Total</td>
<td>58.00</td>
<td></td>
<td>0.00</td>
<td>48.40</td>
<td>0.00</td>
<td>48.40</td>
<td>19.8%</td>
</tr>
<tr>
<td>Unregulated Passive Survival</td>
<td>220.00</td>
<td></td>
<td>0.00</td>
<td>182.00</td>
<td>0.00</td>
<td>182.00</td>
<td>20.9%</td>
</tr>
</tbody>
</table>

1Power estimates reflect the LAT steady state orbit average. Numbers do not reflect transition into or out of survival mode, i.e. early orbit operations.
## FSW Resource Usage Current Estimates

<table>
<thead>
<tr>
<th>Resource</th>
<th>Total Available</th>
<th>Current Usage</th>
<th>Margin Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPU Boot PROM</td>
<td>256 kB</td>
<td>128 kB</td>
<td>2</td>
</tr>
<tr>
<td>SIU Boot PROM</td>
<td>256 kB</td>
<td>128 kB</td>
<td>2</td>
</tr>
<tr>
<td>EPU EEPROM</td>
<td>6 MB</td>
<td>1.5 MB</td>
<td>4</td>
</tr>
<tr>
<td>SIU EEPROM</td>
<td>6 MB</td>
<td>1.5-2.5 MB</td>
<td>3</td>
</tr>
<tr>
<td>EPU CPU cycles</td>
<td>200% in 2 EPUs</td>
<td>30%</td>
<td>&gt; 6</td>
</tr>
<tr>
<td>SIU CPU cycles</td>
<td>100% in 1 SIU</td>
<td>25%</td>
<td>4</td>
</tr>
<tr>
<td>EPU memory</td>
<td>128 MB</td>
<td>16-32 MB</td>
<td>4-8</td>
</tr>
<tr>
<td>SIU memory</td>
<td>128 MB</td>
<td>&lt; 16 MB</td>
<td>8</td>
</tr>
</tbody>
</table>
# Instrument Bandwidth Resources

- LAT communication, bandwidth (BW) in Mbyte/sec

<table>
<thead>
<tr>
<th>Resource</th>
<th>Max Total BW limited by Hardware</th>
<th>Max limited by SC-ground transmission</th>
<th>Ave current BW at 10 KHz max trigger rate*</th>
<th>Ave current BW at 2 KHz nominal trigger rate*</th>
<th>Margin Factor (for 10 KHz rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detector to GASU-EBM</td>
<td>45</td>
<td>N/A</td>
<td>10</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>GASU-EBM to EPU-CPU</td>
<td>20</td>
<td>N/A</td>
<td>5</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>EPU-CPU to GASU-EBM</td>
<td>2.5</td>
<td>0.075</td>
<td>0.04*</td>
<td>0.02*</td>
<td>2</td>
</tr>
<tr>
<td>GASU-EBM to SIU-CPU</td>
<td>5</td>
<td>0.15</td>
<td>0.08*</td>
<td>0.015*</td>
<td>2</td>
</tr>
<tr>
<td>SIU-CPU to Spacecraft</td>
<td>5</td>
<td>0.15</td>
<td>0.08*</td>
<td>0.015*</td>
<td>2</td>
</tr>
</tbody>
</table>

* Present performance of event filter for EPU-CPU, still being optimized. Eventually the physics filter will be adjusted/loosened to take advantage of the max average bandwidth.

**EBM:** Event-Builder Module  
**EPU:** Event-Processing Unit  
**SIU:** Spacecraft Interface Unit
### Key Science Performance Metrics

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

• No new risks identified this month
## Top risks

<table>
<thead>
<tr>
<th>ID #</th>
<th>Risk Rank</th>
<th>Risk Description</th>
<th>Risk Mitigation</th>
<th>Status</th>
</tr>
</thead>
</table>
| Proj Mgt - 003 | Moderate  | If completion of Tracker subsystem qualification is delayed due to EM or MCM electronics closure; then start of LAT I & T and schedule will be impacted | • Manufacturing Eng assigned to close MCM issues  
• Increased team integration with Italian partners  
• GSFC audit/support to Tracker EM closure  
• Consider second source for tray and flex cable production | • Restructured SLAC engineering support  
• Additional INFN support in place  
• Have 3 proposals for trays, downselect shelved.  
• Identified second source (Titan), development cables in work. Evaluating design mod to simplify production |
| Proj Mgt - 002 | Moderate  | If ASICs fail to meet qualification requirements; then schedule impact will occur | • Focused review & test. Margin for re-runs protected where possible  
• Individual risks Identified by subsystem  
• Extensive use of DAQ test bed to drive out system issues | • Cal/ACD ASIC’s continued testing  
• Test Bed operating  
• No new issues |
| Proj Mgt - 004 | Moderate  | If TEM Power supply fails qualification; then final implementation may exceed schedule impacting delivery to I&T | • Key focus item identified for DAQ  
• TEM/PS extensive EM use as EGSE | • Implementation plan in place and proceeding  
• Fuse audit completed  
• First article flight boards December |
## Top risks

<table>
<thead>
<tr>
<th>ID #</th>
<th>Risk Rank</th>
<th>Risk Description</th>
<th>Risk Mitigation</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE-007</td>
<td>Moderate</td>
<td>If a critical component fails post LAT integration; then de-integration will result in cost &amp; schedule impact</td>
<td>• Extensive use of EM test bed to support flight H/W &amp; S/W development</td>
<td>• Qual &amp; acceptance planning in-place</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Thorough qualification and acceptance tests</td>
<td>• I&amp;T developing re-work contingency plans.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Pre planned I&amp;T actions for de-integration</td>
<td>• Integration plan baselined</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elec-004</td>
<td>Moderate</td>
<td>If target hardware, requirement development or manpower is delayed; Then Flight-Software development schedule will be impacted</td>
<td>• Detailed incremental development program</td>
<td>• Adapting monthly demos</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Ensure sufficient software test on target hardware during development to drive out any requirement disconnects.</td>
<td>• Tracking EGSE resource utilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Include adequate peer reviews before each spiral cycle prior to release</td>
<td>• Hired FSW manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Include monthly Demos to verify functionality/measure progress</td>
<td>• Successful FSW review on 16 September</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Continuing monthly demos</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Updated detailed test plan released</td>
</tr>
</tbody>
</table>
## Top risks

<table>
<thead>
<tr>
<th>ID #</th>
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<th>Status</th>
</tr>
</thead>
</table>
| Proj Mgt - 005 | Moderate | If parts and vendor orders are delayed or bids exceed expectations; then flight production costs & delivery schedule will be impacted | • Manufacturing engineer added to expedite minimum cost closure  
• Clarification and purchase package review to ensure accurate bids  
• Increase production management staff                                                                 | • Purchase order tracking/monitoring system in place to highlight roadblocks  
• Design documentation release plan prioritized by vendor selection and component fabrication need dates  
• Workarounds implemented for late parts  
• Hired additional head to manage production                                                                 |
| IT - 006 | Moderate | If logistic or facility integration issues are found during LAT environmental test program; then re-work will delay schedule | • LAT I&T to plan a roadmap of activities from LAT building 33 to completion of environmental testing  
• LAT I&T to consider and develop opportunities to path find key activities required prior to LAT shipment to NRL | • Follow up Environmental Planning TIM held on 1 October at SLAC, I&T driving AIs to conclusion  
• Continuing periodic TIMS                                                                                                                                     |