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>
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</table>
Technical Baseline: Flight Drawing Release

- Status details (DAQ reported separately)
  - Tracker
    - 141 of 141 completed (total is 15 over original plan)
  - ACD
    - Completed
  - Calorimeter
    - Completed
  - Mech
    - Completed 66 of 73 (total is 20 over original plan)
      - 12 MLI drawings reduced to 6, 3 of which are signed off
      - Remaining 4 drawings (shims and spacers) are needed in July
  - Design Integration
    - Major drawings: 2 of 6 signed off, 1 in signoff
  - DAQ
    - 2 drawings remaining, coupled to MLI resolution, need date is post tower integration
## Technical Baseline: DAQ Flight Drawing Release

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<th>Group</th>
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<th>In Sign off</th>
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<td>PDU</td>
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<td>GASU</td>
<td>69</td>
<td>69</td>
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<td>EPU/SIU</td>
<td>59</td>
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<td>Harness</td>
<td>35</td>
<td>35</td>
<td>0</td>
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<tr>
<td>Brackets/hardware</td>
<td>35</td>
<td>33</td>
<td>2</td>
<td></td>
<td>2 brackets coupled to MLI resolution, need date is post tower integration</td>
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<tr>
<td>Heater Control Box</td>
<td>20</td>
<td>20</td>
<td>0</td>
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<td>One drawing deleted, was 21</td>
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## Issues

<table>
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<th>Actionee</th>
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</table>
| 3   | Technical baseline: Flight Drawing release | - All drawings to be under CM prior to flight build  
- Flight drawing release plan generated and statused weekly | Weekly Review | P. Hascall |
| 22  | ASIC radiation testing status | Radiation testing scheduled for completion. GLTC tests successfully completed, documentation in work | 30 April > June > Jan 05 > March 05 | Sadrozinski |
| 24  | No plans to conduct Tracker Subsystem EMI/EMC | Looking at an EMI/EMC test to be performed after Tracker delivery but before integration. Tracker B AT complete, Tracker 2 qual test complete, one waiver in work | 30 Sept > March | Himel |
### Issues (continued)

<table>
<thead>
<tr>
<th>No.</th>
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<tr>
<td>31</td>
<td>Tracker flex cable coupon failures</td>
<td>Process change implemented. Coupons from flight panels failed. Steve Kahn assigned to work with Parlex on quality and schedule. MRR held at Pioneer on 12 May. Delivery of flight articles in July.</td>
<td>10/15/04-11/5&gt;1/31</td>
<td>Rich</td>
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<tr>
<td>35</td>
<td>Reliability assessments not completed</td>
<td>FMEAs done, reviews with Subsystems started. Held TKR and Mech reviews with SLAC, TPS, GASU and PDU held on 5/13. Updates to FMEA provided on 5/21.</td>
<td>12/31/04</td>
<td>DiVenti</td>
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<tr>
<td>37</td>
<td>SIB EEPROM DPA Failure</td>
<td>PCB approved enough parts for flight build, still working parts for spares and qual</td>
<td></td>
<td>Haller</td>
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### Issues (continued)

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<thead>
<tr>
<th>No.</th>
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<th>Actionee</th>
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</thead>
<tbody>
<tr>
<td>38</td>
<td>RAD750 heat sink and Omnirel alert</td>
<td>Heat sinks reworked and Omnirel regulators to be replaced.</td>
<td></td>
<td>Haller</td>
</tr>
<tr>
<td>39</td>
<td>LAT Stay-Clear Violations</td>
<td>Successful series of meetings, <strong>change paper underway.</strong></td>
<td>31 Jan</td>
<td>Bielawski</td>
</tr>
<tr>
<td>40</td>
<td>LAT-DAQ FPGA development and qualification</td>
<td>SLAC to respond to AIs’ from FPGA reviews – AI’s in review</td>
<td></td>
<td>Haller</td>
</tr>
<tr>
<td>41</td>
<td>Qualification of ERNI connectors</td>
<td>BAE to respond to GSFC solder joint analysis Trial runs for LAT ERNI connectors at Aeroflex had issues, process in work</td>
<td></td>
<td>Haller</td>
</tr>
<tr>
<td>43</td>
<td>TEM/TPS voltage ripple</td>
<td>Combination of hardware test and modeling in process to determine cause and potential fixes. <strong>Cause and corrective action determined, retrofit in process</strong></td>
<td></td>
<td>Haller</td>
</tr>
<tr>
<td>45</td>
<td>ACD PMT Noise</td>
<td>Several ACD channels showed noise during high bias voltage tests. <strong>Noisy PMTs replaced, action closed</strong></td>
<td></td>
<td>D. Thompson</td>
</tr>
</tbody>
</table>
Interface Management
Interface Document Status

- Successful F2F TIM @ Spectrum was held on May 17 and 18 to close remaining ICD issues and to discuss Observatory I&T activities.

- SC-LAT ICD ICN Status
  - LAT signed this month
    - None
  - Currently under signature review
    - None
  - Currently in draft or revision
    - ICN-087 LAT Deliveries Table
    - ICN-090 LAT Current Transients
    - ICN-0XX LAT Survey Feature Locations and Access Requirements
    - ICN-0XX Location and Access Requirements for LAT test connectors, auxiliary cooling inlet/outlet and purge ports.
    - ICN-0XX MLI Interface

- Internal LAT ICD’s
  - Signed off this month
    - CAL-LAT ICD
  - Currently in signature review
    - ACD-LAT ICD
  - Currently in update
    - Electronics-LAT ICD (Comments being incorporated as they are received)
Deliverables/Receivables

• LAT Deliverables
  – May: None Scheduled
  – June: None Scheduled
  – July: None Scheduled
  – Aug: None Scheduled

• LAT Receivables
  – May: SIIS and SIIS harness
  – June: None Scheduled
  – July: SC Interface Tool
  – Aug: None Scheduled
Key Design Metrics
Mass and Power Status Summary

- **Mass**
  - Formal update in process
  - No significant issues on measured data (within a few percent of predicts)

- **Power**
  - No change to budget
  - Potential increase based on Tower A and Tower B measurement was estimated to be 13.8 W for the complete 16 towers, but want to see a few more towers before the LAT budget is updated. Will have 2 more towers within a week

- **FSW estimates updated**
  - Boot PROM replaced by EEPROM, single copy is less than 25% of capacity with multiple copies to fill memory used as risk mitigation
  - EPU CPU cycle loading estimates went from 30% to 40%
LAT Mass Status

Sep-04

<table>
<thead>
<tr>
<th>Mass (kg)</th>
<th>Estimate</th>
<th>Alloc.</th>
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<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>
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<tr>
<td>ACD</td>
<td>286.2</td>
<td>295.0</td>
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<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>
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<tr>
<td>Systems</td>
<td>7.0</td>
<td>8.0</td>
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<tr>
<td>LAT Total</td>
<td>2778.5</td>
<td>2879.6</td>
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<tr>
<td>Rsv/Margin</td>
<td>221.5</td>
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<tr>
<td>Rsv/Margin*</td>
<td>8.0%</td>
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</table>

Allocation: 3000.0

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

Center of Mass (mm)

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<tr>
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<th>CMx</th>
<th>-20 &lt; CMx &lt; 20</th>
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<tr>
<td>CMy</td>
<td>-0.89</td>
<td>-20 &lt; CMy &lt; 20</td>
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<tr>
<td>CMz</td>
<td>-72.55</td>
<td>CMz &lt; -51.2</td>
</tr>
<tr>
<td>Ht off LIP</td>
<td>163.65</td>
<td>Ht &lt; 185</td>
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Second Moment of Inertia (kg-m²)

<table>
<thead>
<tr>
<th></th>
<th>Ixx</th>
<th>1500.0</th>
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<tbody>
<tr>
<td>lyy</td>
<td>1032.1</td>
<td>1500.0</td>
</tr>
<tr>
<td>lzz</td>
<td>1410.8</td>
<td>2000.0</td>
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## LAT Power Status

### Power Status Table

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<thead>
<tr>
<th>Item</th>
<th>30-Mar-05 Estimate (Watts)</th>
<th>PARA (Watts)</th>
<th>CALC (Watts)</th>
<th>MEAS (Watts)</th>
<th>ALLOC. (Watts)</th>
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</thead>
<tbody>
<tr>
<td>ACD</td>
<td>11.5</td>
<td>2.4</td>
<td>3.9</td>
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<td>Tracker</td>
<td>146.9</td>
<td>1.5</td>
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<td>Calorimeter</td>
<td>67.4</td>
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<td>Trigger &amp; Data Flow</td>
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<td>43.2</td>
<td>87.2</td>
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<tr>
<td>Grid/thermal</td>
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<td>Instrument Total</td>
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<td>67.5</td>
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<td>Instrument Allocation</td>
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<td>% Reserve</td>
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<td></td>
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<td>14.6%</td>
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**Goal for PSRR Reserve > 5%**

**PDR Reserve Was 15.2%**

**CDR Reserve Was 13.4%**

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**PARA** - Best Estimate based on conceptual design parameters  
**CALC** - Estimate based on Calculated power from detailed design documentation  
**MEAS** - Actual power measurements of components

### Measured LAT Power

#### Tower Assembly Power Consumption

<table>
<thead>
<tr>
<th>Tower Bay</th>
<th>Measured Power</th>
<th>Instrument</th>
<th>Tracker</th>
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<tr>
<td>A</td>
<td>26.86</td>
<td>0.956</td>
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<td>B</td>
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#### TEM/TPS Assembly Power Consumption

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<th>Estimate</th>
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<th>Hot</th>
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#### Calorimeter Power Consumption

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#### Tracker Module Power Consumption

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<th>Ambient</th>
<th>Hot</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9.70</td>
<td>9.80</td>
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<td>B</td>
<td>9.70</td>
<td>9.80</td>
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<td>1</td>
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<td>14</td>
<td>9.66</td>
<td>9.80</td>
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</table>

### Notes

1. Tower A and B measurements consistent and above predicts
2. TEM/TPS measured values are based on telemetry and are relatively inaccurate
• Survival Power

<table>
<thead>
<tr>
<th>Component</th>
<th>Current Alloc.</th>
<th>Subsystem Power Estimates (W)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PARA</td>
</tr>
<tr>
<td>On-Orbit Average Power Total(^1)</td>
<td>278.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Regulated VCHP Power Total</td>
<td>58.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Unregulated Passive Survival Power</td>
<td>220.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

\(^1\)Power 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>
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<tbody>
<tr>
<td>EPU Boot EEPROM (SUROM)</td>
<td>256 kB</td>
<td>&lt;64 kB*</td>
<td>4*</td>
</tr>
<tr>
<td>SIU Boot EEPROM (SUROM)</td>
<td>256 kB</td>
<td>&lt;64 kB*</td>
<td>4*</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>40%</td>
<td>&gt; 5</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>

* Storing multiple copies (4 currently to use available memory) for risk mitigation
**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;100 MeV)</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 changes
# 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 - 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 | •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  
•Testing complete, data package in work |
## 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>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>• Updated detailed test plan released</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Include monthly Demos to verify functionality/measure progress</td>
<td>• Demo frequency increased from monthly to approximately weekly</td>
</tr>
</tbody>
</table>
## 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 - 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, |
## 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 - 011</td>
<td>Low</td>
<td>If individual tracker towers do not meet performance requirements due to manufacturing issues (e.g. wire bond breaks) then the LAT may not meet science requirements</td>
<td>Understand stability of performance to determine mitigation strategies</td>
<td>Temperature range reduced at the LAT level to allow a narrower range during Tracker and LAT tests</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Limit LAT temperature excursions to minimize possible propagation of some types of tracker issues</td>
<td>Alternate plan for placement of Tracker A and B being implemented</td>
</tr>
</tbody>
</table>
## Cost Report

### 4.1.2 SYSTEM ENGINEERING

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost Incurred</th>
<th>Estimated Cost</th>
<th>Estimated Final Cost</th>
<th>Unfilled Orders Outstanding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>During Month</td>
<td>Cum. to Date</td>
<td>Detail</td>
<td>Balance of Contract</td>
</tr>
<tr>
<td></td>
<td>Actual</td>
<td>Planned</td>
<td>Actual</td>
<td>Planned</td>
</tr>
<tr>
<td>4.1.2.1 REQ'TS MGMT, DESIGN INTEGRATION &amp; TEST</td>
<td>71</td>
<td>27</td>
<td>3,078</td>
<td>3,114</td>
</tr>
<tr>
<td>4.1.2.3 SYSTEM ANALYSIS</td>
<td>-12</td>
<td>11</td>
<td>1,016</td>
<td>981</td>
</tr>
<tr>
<td>4.1.2.4 QUALIFICATION &amp; TRACKING</td>
<td>59</td>
<td>59</td>
<td>433</td>
<td>389</td>
</tr>
<tr>
<td>4.1.2.5 RISK &amp; RELIABILITY ANALYSIS</td>
<td>99</td>
<td>98</td>
<td>99</td>
<td>98</td>
</tr>
<tr>
<td>4.1.2.6 CONFIGURATION MGMT &amp; DOCUMENT / DATA</td>
<td>5</td>
<td>9</td>
<td>280</td>
<td>276</td>
</tr>
<tr>
<td>4.1.2.7 MANAGEMENT &amp; PLANNING</td>
<td>50</td>
<td>75</td>
<td>1,903</td>
<td>2,027</td>
</tr>
<tr>
<td>CAPW[3]Totals:</td>
<td>174</td>
<td>181</td>
<td>6,808</td>
<td>6,884</td>
</tr>
</tbody>
</table>
Cost Variance Explanation

- Why overrun/underrun?
- What will be done to correct?
FTE Report

4.1.2 Systems Engineering
FTEs

PLANNED
ACTUALS
FTE Variance Explanation

- Why overrun/underrun?
- What is the impact?
- What will be done to correct?