GLAST Large Area Telescope

LAT Pre-Shipment Review

Systems Engineering

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Systems Engineering

Stanford Linear Accelerator Center
LAT System Engineering Overview

• Requirements Baseline Maintenance
  – Specifications Updated
  – Interface Control Documentation
  – Waiver Requests (See Section 7)

• Design Baseline Maintenance
  – Design Documentation Configuration Management
  – Design Changes Since CDR

• Requirements Verification Plan (See Section 4)
  – Traceability to tests, analysis, inspection
  – Running Sell Process with GSFC Project Office

• LAT System Test Plan (See Section 4)
  – Defines Required Tests to Support Verification

• LAT Environmental Test Plan (See Section 4)
  – Defines Environmental Test Flow & Requirements
  – Based on GLAST MAR
Documentation Status

- The SE related documentation: see next chart(s)
  - No Liens on requirements and flowdown
  - LAT Specification Current
  - Traceability to verification complete
  - Verification Cross Reference Matrix Released
  - LAT Test Plan Released
  - Three pending changes to LAT-S/C ICD: See later chart
  - Several Waivers in Process: See Later Talk

- I&T documentation status: See I&T presentation
- QA documentation status: See QA presentation

No significant documentation liens
Key Documentation

**Mission Level Documents**
- 433-SRD-0001: GLAST Science Requirements Document
- 433-SPEC-0001: GLAST Mission System Specification
- 433-OPS-0001: GLAST Operations Concept
- 433-MAR-0001: Mission Assurance Requirements (MAR) for GLAST LAT
- 433-RQMT-0005: GLAST EMI Requirements
- 433-ICD-0001: GLAST LAT-GBM Burst Interface Control Document
- 1196 EI-Y46311: SC-LAT Interface Control Document
- 1196 EI-S46310: 1553 Interface Control Document

**LAT Level Documents**
- **LAT-SS-00010**: LAT Performance Specification
- **LAT-SS-00778**: LAT Environmental Specification
- **LAT-SS-00115**: MechanicalSubsystem Specification (in final release cycle)
- **LAT-SS-00715**: TCS Performance Specification
- **LAT-SS-00019**: Trigger & Dataflow Subsystem Specification
- **LAT-TD-00399**: Software Requirements Specification
- **LAT-SS-00016**: ACD Subsystem Specification
- **LAT-SS-00017**: Tracker Subsystem Specification
- **LAT-SS-00136**: Power Subsystem Specification
- **LAT-SS-00018**: CAL Subsystem Specification
- **LAT-MD-00446**: LAT SVAC Plan
- **LAT-MD-00408**: LAT Performance Verification Plan
- **LAT-MD-02730**: LAT Performance and Operations Test Plan
- **LAT-MD-07658**: LAT Verification Cross Reference Matrix
SC-LAT ICD Pending Changes

SC-LAT ICD EIY46311-000C is released

- The following table lists pending changes

<table>
<thead>
<tr>
<th>ICN #</th>
<th>Title</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>-096</td>
<td>Unregulated Power Voltage</td>
<td>For shorts periods of time, the SC will be unable to provide the minimum 25V for the unregulated feeds. The voltage may get as low as 23V.</td>
<td>SASS voltage drop analysis in process</td>
</tr>
<tr>
<td>-099</td>
<td>LAT Integration</td>
<td>This is an appendix to the ICD that is meant to capture agreements for Observatory I&amp;T activities.</td>
<td>Final logistical details in work</td>
</tr>
<tr>
<td>-100</td>
<td>LAT Impedance</td>
<td>Incorporate into ICD the as-measured LAT differential impedance.</td>
<td>To be measured</td>
</tr>
</tbody>
</table>

Issues Well In Hand – No Risks Anticipated
Overview of Subsystem Changes Since CDR

- Design Changes Flowed From LAT MRB Process & CDR Liens
  - Changes incorporated in final design documentation
  - Validated through subsystem test programs
- LAT baseline design now implemented
  - Resulting changes to integrated LAT design have been implemented
  - All changes consistent with LAT-SC ICD
- Residual Design Liens Against Flight Software
  - FSW Qualification Test Baselined at 0-6-6 (149/183 rqmts)
  - Delta FQT Planned Pre-TVAC
    - Added Science related filters/diagnostics
    - GRB Detection
    - Final data compression
    - FSW Standards
Calorimeter Changes Since CDR

- FM CAL: GRID interface modified to incorporate shear pins
  - 4 shear pins added, mounting tabs adjusted
- EMI/EMC improvements
  - Exterior metal surface treatment changed to electroless nickel plating
  - EMI gaskets and O-rings seal cracks
  - Extra power filtering added to AFEE cards
- PIN photodiodes: slightly smaller, different optical window material
  - Flight design has been fully qualified
- ASICs: GCFE and GCRC have additional revision for flight from that used on EM CAL
  - Flight screening complete; qualification program completes on 10/15
- AFEE board
  - Improved PIN diode connections; additional filtering
  - Removed Novacap; new QML cap replacement
  - Voltage ref diode current limiting resistor modified
- FM composite structures use an improved (autoclaved) curing process
  - Each structure verified for strength in vibration test program
ACD Design Changes Since CDR

• Mechanical
  – The side layers of Kevlar in the Micrometeoroid Shield were increased from 6 layers to 8 layers due to an update to NASA’s orbital debris model.
  – Modified the mechanical mounting of the Photomultiplier Tubes (PMTs). Changed from a Silicone potted mounting method to thermal compensated mechanical mounted. This design change required a change to the magnetic shielding of the PMTs as well. Design change required to prevent cracking of the PMT glass tubes.
  – Minor design changes on the PMT Housings and fiber bushing caps were made to improve the light-tightness
  – Composite panel aluminum honeycomb grounded
  – The entire Tile Shell Assembly (with Tile Detector Assemblies) was raised 1mm with respect to the Base Electronics Assembly and the Large Area Telescope interface.

• Tile Detector Assemblies and Clear Fiber Cables
  – Redesigned the wave shifting and clear fiber connectors to optimize assembly and light tightening the detectors and fiber cables.
ACD Design Changes Since CDR (II)

- **Electrical**
  - Changed from a 3 independent Printed Circuit Board (PCB) stack for the resistor network to a flex board design. Change made to reduce assembly time and improve reliability.
  - GARC Parity Bit. The way the GARC implements the GAFE command parity calculation was not consistently reliable so a work around in software was required (e.g., we calculate the command parity in software and bypass the hardware calculation) to resolve the issue.
  - GARC Look-at-Me circuitry. There are two Look-at-Me circuits, a primary and a secondary, and each needs a clock during power-on reset to initialize properly. On the FREE board it was necessary to cross-strap the incoming differential clock to provide these initial pulses to both sides of the circuitry.
  - HVBS grounding change. During interface testing between the HVBS and FREE boards a common mode noise issue was found. A capacitor was added to the HVBS and the issue was resolved.
  - An aluminized Kapton shield was placed between the two FREE boards on the four double row Electronic Chassis. This was done to prevent self induced interference between the two FREE Boards, specifically the GAFE’s (analog ASIC).
Tracker Changes Since CDR

- **Front-End Electronics:**
  - Added a resistor to the tri-state bus for the GTFE control register readback, to prevent it from floating when in the high impedance state.
  - Changed the MCM clock bus termination from 100 ohms to 75 ohms.
  - Changed the flex-circuit cable termination resistors from 100 ohms to 75 ohms.
  - Increased VDD from 2.5V to 2.65V to improve communication margins.
  - Added a Kapton layer to the back of the MCM to improve electrical isolation and also improved the MCM layout to reduce the risk of a bias-voltage short.
  - Fixed a logic bug in the GTRC TOT algorithm and in the GTRC-to-GTRC communication timing.
  - Reduced internal delays and increased drive power to improve GTFE-to-GTFE and GTFE-to-GTRC communication margins.
  - Eliminated the cover layer from the MCM pitch adapter, in order to accommodate assembly tolerances.
  - Changed from Nanonics connectors to Omnetics connectors.
  - Changed the ground-shield plane of the bias circuit from hatched ½-oz copper to solid ¼-oz copper.
  - The entire detailed geometric layout of the flex-circuit cables was redone post-CDR. The biggest change was to bring 4 of the cables up over the edge of the top tray, with 180-degree bends.
  - Added tape and foam to the flex-circuit cables, to ensure that they cannot move and won’t be damaged once the sidewalls are put on.
Tracker Changes Since CDR (II)

• Interface of the MCMs to the Trays
  – Eliminated the mounting screws and transfer adhesive and developed a completely new procedure to bond the MCM to the tray with epoxy, including small aluminum alignment pins that included washers for setting the bondline thickness.
  – Eliminated the encapsulation of wire bonds from the MCMs to the SSDs and bias circuits (with the exception of two mid trays, which were encapsulated before this change was made).

• Ladders:
  – Eliminated encapsulation of wire bonds between SSDs in ladders for heavy trays and bottom trays (except in Towers A and B).

• Trays and Converter Foils
  – Added a slot to (almost) cut the heavy foils in half.
  – Added an etching and priming step for all foils.
  – Implemented a scheme to electrically connect the aluminum core and carbon structure to the MCM ground.
Tracker Changes Since CDR (III)

• **Sidewalls:**
  – Put aluminum foils on both sides, not just on the outside.
  – Changed fasteners from 100 countersink to 120 countersink to distribute the load better and prevent crazing of the carbon-fiber material.
  – Added a locking mechanism for the fasteners (Solithane on the threads).
  – Eliminated holes for inspection and made detailed changes to layout of alignment holes.

• **Tower-Grid Interface:**
  – Complete fastener redesign, based on the nested eccentric cones and studs.
  – Adding locking mechanisms to the fasteners.
  – Flexures modified to have conical holes.
  – New design of the fastener on the Grid side of the interface.
  – Completely new CMM and alignment procedure, based on the new interface.

• **Top Tray:**
  – Added machined corner brackets to support alignment nests and the flex-circuit cable terminations.
  – Added aluminum shielding over the entire top of the tray, plus black paint on the top.
TEM and TEM Power-Supply Changes Since CDR

- TEM
  - FPGA code finalized
    - Flow-control changed slightly to optimize dataflow throughout system
  - Some resistor/capacitor values have changed to optimize monitoring ranges
  - Details of monitoring circuit have changed and a sub-set of current monitoring functions were eliminated

- TPS
  - Resistor/capacitor changes to optimize circuit performance over temperature
  - Changes in poly-switch values to protect better over temperature (instead of RXE185, split the load into two paths with a RXE110 each), increased the current sensing resistor from a 1W to a 3W resistor.
  - Changed resistor values to
    - Modify TKR 2.5V to 2.65V
    - Decrease maximum CAL Bias from 120V to 90V
  - Changed Zener diodes at Bias output voltage for new max values
  - Changed resistor values to optimize in-rush current level
GASU Changes since LAT CDR

- Code in FPGA’s finalized
- ACD power-on low-frequency system clock selection added
- ACD power circuits replaced with circuit to protect for over-current and updated ICD interface voltage/current requirements
- Some resistor/capacitor values have changed to optimize monitoring ranges
PDU Changes since LAT CDR

- FPGA code finalized
- Some resistor/capacitor values have changed to optimize monitoring ranges
- Details of monitoring circuit have changed
- Redesigned load-switch circuit
  - To incorporate under-voltage protection
    - Added in case space-craft converters enters current-limiting mode with subsequent drop in output voltage
  - To incorporate over-current protection
    - Avoids damage to MOSFET switches
  - Changed resistor values to optimize in-rush current level
EPU/SIU Changes since CDR

• SIB/LCB
  – Code in FPGA finalized
  – Some resistor values were changed to optimize performance

• CPS
  – Some resistor/capacitor values were changed to optimize performance

• Backplane
  – Some interconnections were added between modules and connector IO
### Mechanical Subsystem Changes Since CDR

- CAL-Grid interface design was not finalized at CDR, Calorimeter shear plate design finalized after CDR
- Tracker Grid interface modified for new attach method (flexures) (2/04)
- Tracker cable chaseways in Grid walls modified as well as Grid top flange
- Wiring grooves cut into +Z surface of Grid
- -Z surface (CAL & Spacecraft interface) of Grid Nickel plated
- **Spacecraft Interface**
  - WAS: 3/8-24 inserts in grid, IS: 7/16-20 insert in grid
  - WAS: 9/16” Dia reamed hole in grid, IS: .964” ID Steel bushing in grid
- +Y Grid wings were notched & close out bars added for Radiator integration
- Radiator Mount Brackets were made compliant in X direction to allow for thermal contraction of Radiator in Survival mode
- Added fiberglass isolator between Radiator mount bracket and GRID
- EMI skirt pieces Nickel plated and EMI gaskets added
- Deferred Protoflight Thermal Cycle test of Grid Box Assy until the LAT level
- MLI design (material selection, number of layers) finalized
Mechanical Subsystem Changes Since CDR (II)

- X-LAT plate was 3 individual plates, is a single plate
- X-LAT – E-box thermal joint was proposed as Vel-therm (flexible conductive spacer material)– is dry bolted joint
- Added liquid ground cooling tubes to X-LAT Plate
- Revised XLAT test program
  - Deleted Low Level Sine Survey and Static Load testing (not meaningful tests in the final design configuration)
  - WAS: Thermal vacuum cycling while mated to Radiators, IS: Thermal cycling in air as a stand alone test
- Revised Radiator test program
  - Low level Sine Sweep replaced with Tap testing during Acoustic test set up
  - Sine Vibration testing requirements satisfied with a Static Load test
  - Radiator to LAT interface strength test deferred to LAT integration flow
Thermal Subsystem Design Changes Since CDR

- The Tracker qualification cold limit was changed from -30°C to -15°C; This resulted in the following LAT design changes:
  - Change to new primary grid thermostats with -1.7°C set points
  - Change to new secondary grid thermostats with -5.0°C set points
  - Addition of 4 new 50 W grid heaters
  - Removal of 12 antifreeze heaters and adjustment of locations of remaining heaters
Final FQT Closure Plan - Overview

• Baselined 0-6-6: 149 of 183 requirements completed FQT 4/17/06
• Release 1-0-0 target for delta-FQT - 183 of 183 requirements
  
  ECD: POST NRL Ship, Need science closure
  – Added function: GRB detection, data compression
  – New scripts: GRB detection, FSWSTD → 57/57 total scripts
  – Additional requirements verified
    • 5.3.10.2 LAT GRB Detection
    • 5.3.10.2.1 GRB Location Accuracy
    • 5.3.10.2.2 Modification of GRB Criteria
    • 5.3.11.3.3 Process Attitude Data
    • 5.3.11.5 LAT Closeout to GBM
    • 5.4.1 System of Units
    • 5.4.2.1 LAT Coordinate System
    • 5.4.2.2 Observatory Coordinates
    • 5.4.2.3 Celestial Coordinate System
    • 5.4.3 Resource Margin
## Summary of FSW Current Status

<table>
<thead>
<tr>
<th>Current Status</th>
<th>Liens</th>
<th>Impact/Risk</th>
</tr>
</thead>
</table>
| - Core Software Complete, B0-6-6 | - Minor Bugs/Fixes via Commissioning Effort  
  - Current Build 0-6-7  
  - Planned upgrade B 0-6-8 prior to Pre-ship CPT | - None identified |
| - CNO/Alignment Filters | - Complete Unit Testing  
  - Test-bed Environment For Filter Tests | - Commissioning effort given higher priority  
  - No risk to defer to ∆-FQT |
| - GRB Detection Algorithm  
  - Software Standards | - GRB Detection Algorithm Requirements ECD 1 May 06  
  - Verification of Software standards awaiting final code base | - No risk to LAT functionality or schedule  
  - Current code base meets software standards  
  - Target ∆-FQT complete prior to TVAC (June 06) |
Subsystem Change Summary

- All changes incorporated during the design implementation and qualification process
- Design documentation is up to date
- Subsystem to Subsystem interfaces complete
- Integrated LAT system has accommodated changes
- SC-LAT Interface has accommodated changes as required

No open subsystem hardware design liens
Closure plan for FSW in place, no impact on environmental test
### LAT Mass Properties

**LAT Mass Properties Summary**

<table>
<thead>
<tr>
<th>Mass Properties</th>
<th>LAT Mass Properties Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Martin Nordby</td>
<td>LAT-TD-00564-12</td>
</tr>
<tr>
<td>Effective Date</td>
<td>24-Apr-06</td>
</tr>
<tr>
<td>Print Date</td>
<td>24-Apr-06</td>
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</table>

**May-06**

<table>
<thead>
<tr>
<th>Mass (kg)</th>
<th>Estimate</th>
<th>Alloc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TKR</td>
<td>524.5</td>
<td>530.0</td>
</tr>
<tr>
<td>CAL</td>
<td>1381.7</td>
<td>1440.0</td>
</tr>
<tr>
<td>ACD</td>
<td>281.6</td>
<td>295.0</td>
</tr>
<tr>
<td>Mech</td>
<td>351.5</td>
<td>386.6</td>
</tr>
<tr>
<td>Elec</td>
<td>242.5</td>
<td>240.0</td>
</tr>
<tr>
<td>Systems</td>
<td>7.1</td>
<td>8.0</td>
</tr>
<tr>
<td><strong>LAT Total</strong></td>
<td><strong>2789.0</strong></td>
<td><strong>2899.6</strong></td>
</tr>
<tr>
<td>Rsrv/Margin</td>
<td>211.0</td>
<td></td>
</tr>
<tr>
<td>Rsrv/Margin*</td>
<td>7.6%</td>
<td></td>
</tr>
<tr>
<td><strong>Allocation</strong></td>
<td><strong>3000.0</strong></td>
<td></td>
</tr>
</tbody>
</table>

* AIAA G-020 recommended min reserve = 3.8%

*Allocations per latest mass CCB on 3 Nov 2004*

**Center of Mass (mm)**

- CMx: -1.57 \(-20 < CMx < 20\)
- CMy: -1.20 \(-20 < CMy < 20\)
- CMz: -65.99 \(CMz < -51.2\)
- Ht off LIP: 170.21 \(Ht < 185\)

**Second Moment of Inertia (kg-m\(^2\))**

- Ixx: 1039.4 \(1400.0\)
- Iyy: 996.8 \(1350.0\)
- Izz: 1385.1 \(1580.0\)

Mass properties evaluated in LAT Coordinate System

---

**Mass Estimate Breakdown**

<table>
<thead>
<tr>
<th></th>
<th>(kg)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parametric</td>
<td>21.4</td>
<td>0.8%</td>
</tr>
<tr>
<td>Calculated</td>
<td>40.4</td>
<td>1.4%</td>
</tr>
<tr>
<td>Measured</td>
<td>2727.2</td>
<td>97.8%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2789.0</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

---

**Mass Budget**

- Review Threshold
- Total Allocated to S.S.
- LAT Mass Estimate
- CoM Ht off LIP

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**Mass Estimate**

- Mass (kg)
  - Oct-99: 2400
  - Jan-00: 2500
  - Apr-00: 2600
  - Jul-00: 2700
  - Oct-00: 2800
  - Jan-01: 2900
  - Apr-01: 3000
  - Jul-01: 3100
  - Oct-01: 3200
  - Jan-02: 3300
  - Apr-02: 3400
  - Jul-02: 3500
  - Oct-02: 3600
  - Jan-03: 3700
  - Apr-03: 3800
  - Jul-03: 3900
  - Oct-03: 4000
  - Jan-04: 4100
  - Apr-04: 4200
  - Jul-04: 4300
  - Oct-04: 4400
  - Jan-05: 4500
  - Apr-05: 4600
  - Jul-05: 4700
  - Oct-05: 4800
  - Jan-06: 4900
  - Apr-06: 5000
  - Jul-06: 5100
  - Oct-06: 5200

---

**Subsystem Allocation**

- LAT Margin
- LAT Reserve
- LAT Est Mass
- Subsystem Allocation

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**Center of Mass Height Above L.I.P. (mm)**

- Oct-00: 153.7
- Apr-00: 155.2
- Jul-00: 156.7
- Oct-00: 158.2
- Jan-01: 159.7
- Apr-01: 161.2
- Jul-01: 162.7
- Oct-01: 164.2
- Jan-02: 165.7
- Apr-02: 167.2
- Jul-02: 168.7
- Oct-02: 170.2
- Jan-03: 171.7
- Apr-03: 173.2
- Jul-03: 174.7
- Oct-03: 176.2
- Jan-04: 177.7
- Apr-04: 179.2
- Jul-04: 180.7
- Oct-04: 182.2
- Jan-05: 183.7
- Apr-05: 185.2
- Jul-05: 186.7
- Oct-05: 188.2
- Jan-06: 189.7
- Apr-06: 191.2
- Jul-06: 192.7
- Oct-06: 194.2

**Date**

- Oct-00: 125
- Jun-00: 150
- Apr-00: 175
- Jul-00: 200
- Oct-00: 225
- Jan-01: 250
- Apr-01: 275
- Jul-01: 300
- Oct-01: 325
- Jan-02: 350
- Apr-02: 375
- Jul-02: 400
- Oct-02: 425
- Jan-03: 450
- Apr-03: 475
- Jul-03: 500
- Oct-03: 525
- Jan-04: 550
- Apr-04: 575
- Jul-04: 600
- Oct-04: 625
- Jan-05: 650
- Apr-05: 675
- Jul-05: 700
- Oct-05: 725
- Jan-06: 750
- Apr-06: 775
- Jul-06: 800
- Oct-06: 825

**Date**

- Oct-00: 125
- Jun-00: 150
- Apr-00: 175
- Jul-00: 200
- Oct-00: 225
- Jan-01: 250
- Apr-01: 275
- Jul-01: 300
- Oct-01: 325
- Jan-02: 350
- Apr-02: 375
- Jul-02: 400
- Oct-02: 425
- Jan-03: 450
- Apr-03: 475
- Jul-03: 500
- Oct-03: 525
- Jan-04: 550
- Apr-04: 575
- Jul-04: 600
- Oct-04: 625
- Jan-05: 650
- Apr-05: 675
- Jul-05: 700
- Oct-05: 725
- Jan-06: 750
- Apr-06: 775
- Jul-06: 800
- Oct-06: 825

---

**Mass properties evaluated in LAT Coordinate System**
## LAT Power Status

### LAT Power Status

<table>
<thead>
<tr>
<th>Item</th>
<th>30-Mar-06 Estimate (Watts)</th>
<th>PARA CALC MEAS SPEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACD</td>
<td>11.3</td>
<td>0.0 0.0 11.3 11.5</td>
</tr>
<tr>
<td>Tracker</td>
<td>159.2</td>
<td>0.0 0.0 159.2 160.0</td>
</tr>
<tr>
<td>Calorimeter</td>
<td>67.8</td>
<td>0.0 0.0 67.8 71.0</td>
</tr>
<tr>
<td>Trigger &amp; Data Flow</td>
<td>297.3</td>
<td>0.0 0.0 297.3 327.5</td>
</tr>
<tr>
<td>Grid/thermal</td>
<td>20.4</td>
<td>20.4 0.0 0.0 35.0</td>
</tr>
<tr>
<td>Instrument Total</td>
<td>556.1</td>
<td>20.4 0.0 535.7 605.0</td>
</tr>
<tr>
<td>Instrument Allocation</td>
<td>650.0</td>
<td></td>
</tr>
<tr>
<td>% Reserve</td>
<td>16.9%</td>
<td></td>
</tr>
</tbody>
</table>

**PDR Reserve Was 15.2%**

**CDR Reserve Was 13.4%**

**Goal for PSRR Reserve > 5%**


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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**

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**LAT Power**

- **PDR:** 7/30/02
- **CDR:** 5/1/03
- **PSRR:** 05/06

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*Page Number 3 of 12*
• **Survival Power**

<table>
<thead>
<tr>
<th>Component</th>
<th>Current Alloc.</th>
<th>Subsystem Power Estimates (W)</th>
<th>Total</th>
<th>Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Orbit Average Power Total(^1)</td>
<td>278.00</td>
<td>PARA 0.00 CALC 203.00 MEAS 0.00</td>
<td>203.00</td>
<td>36.90%</td>
</tr>
<tr>
<td>Regulated VCHP Power Total</td>
<td>58.00</td>
<td>PARA 0.00 CALC 43.00 MEAS 0.00</td>
<td>43.00</td>
<td>34.90%</td>
</tr>
<tr>
<td>Unregulated Passive Survival Power</td>
<td>220.00</td>
<td>PARA 0.00 CALC 160.00 MEAS 0.00</td>
<td>160.00</td>
<td>37.50%</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.
## Residual 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>Reduced On Orbit temperature excursions</td>
<td>Trending tracker efficiency throughout integration testing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Optimized placement of towers A/B based on individual tower performance</td>
<td>No current concern for mission performance over life identified</td>
</tr>
<tr>
<td>SE-013</td>
<td>Moderate</td>
<td>If Observatory I&amp;T requirements and procedures are not finalized then there will be schedule delays</td>
<td>LAT proposed integration plan appendix to ICD</td>
<td>LAT prepared mechanical integration issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Optimize use of existing test info for observatory</td>
<td>Reviewing options for transitioning LAT tests to Observatory</td>
</tr>
<tr>
<td>Proj Mgt - 008</td>
<td>Low</td>
<td>If there are availability conflicts with the environmental facilities at NRL then there will be schedule delays</td>
<td>•LAT Deputy PI part of NRL facility planning and is a LAT advocate</td>
<td>•No conflicts with current LAT schedule</td>
</tr>
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<td>•No project that requires the TV chamber is currently scheduled at NRL</td>
</tr>
</tbody>
</table>
LAT System Engineering Summary

- Design Baseline and Documentation Complete
- Requirements Verification Planning is Complete
- Test Plan has Been Established That Meets Verification Plan
  - Flowed to I&T Procedures
  - Results Feedback Process to VCRM in place
- Process for Verification Closure With GSFC in Place
- Environmental Test Plan In Place
  - Flowed to I&T Plans & Procedures
- SE Review of LAT Baseline Performance Tests Indicate Ready To Ship
- SE Review of LAT Environmental Test Planning Indicate Ready For Environmental Test