GLAST Large Area Telescope:

Systems Overview
WBS: 4.1.2

Tim Thurston
Stanford Linear Accelerator Center
Systems Engineering Manager

thurston@slac.stanford.edu
Systems Engineering

LAT Systems Engineering
Tim Thurston
(WBS 4.1.2)

Requirement Management 4.1.2.1

System Verification
- System Validation
- IV&V Support
- Verification Plan

DOORs
- Risk/Reliability
- Power Budget
- Mass Budget

LAT System Configuration Management 4.1.2.6

Interface Control
- System Design
- Level III Change Control Board
- Document Management
- CyberDoc
- Database

System Analysis 4.1.2.3

Science Requirements Analysis
- Structural Analysis
- Thermal Analysis
- FMEAs

System Engineering, WBS 4.1.2
System Requirements Flow Down & Tracking

GLAST Mission & LAT Project have selected Telelogic DOORS® requirements management tool

Requirements Management:
- Tracking
- Flowdown
- Verification
## System Requirements Tracking (Example)

### LAT Level IIb Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Constraint</th>
<th>Predicted Performance (PDR)</th>
<th>Requirement</th>
<th>Goal</th>
<th>Verification</th>
<th>Spec Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{\text{eff}}$</td>
<td>20 MeV</td>
<td>630 cm$^2$</td>
<td>&gt; 300 cm$^2$</td>
<td>&gt; 1000 cm$^2$</td>
<td>Sim, BT (&gt;10,000 TPT, 20±5 MeV, NI)</td>
<td>5.2.1</td>
</tr>
<tr>
<td></td>
<td>100 MeV</td>
<td>2000 cm$^2$ (being worked)</td>
<td>&gt; 3000 cm$^2$</td>
<td>&gt; 8000 cm$^2$</td>
<td>Sim, BT (&gt;5000 TPT, 100±10 MeV, NI)</td>
<td>5.2.1</td>
</tr>
<tr>
<td></td>
<td>1, 10 GeV (peak within range)</td>
<td>&gt;10,000 cm$^2$ @10 GeV</td>
<td>&gt; 8000 cm$^2$</td>
<td>&gt; 12,000 cm$^2$</td>
<td>Sim, BT (&gt;1000 TPT, 1±0.1 &amp; 10±1 GeV, NI)</td>
<td>5.2.3</td>
</tr>
<tr>
<td></td>
<td>300 GeV</td>
<td>8000 - 10,000 cm$^2$</td>
<td>&gt; 6400 cm$^2$</td>
<td></td>
<td>Sim, BT (&gt;1000 TPT, 10±1 GeV, extrapolate)</td>
<td>5.2.1</td>
</tr>
<tr>
<td></td>
<td>1 TeV</td>
<td>TBD</td>
<td></td>
<td>&gt; 9500 cm$^2$</td>
<td>Sim</td>
<td>5.2.1</td>
</tr>
<tr>
<td>$A_{\text{eff}}$ knowledge (1σ)</td>
<td>20 – 50 MeV</td>
<td>TBD</td>
<td>&lt; 50 %</td>
<td>&lt; 20 %</td>
<td>Sim (every 10 MeV), BT (see cases above)</td>
<td>5.2.4</td>
</tr>
<tr>
<td></td>
<td>50 – 300 MeV</td>
<td>TBD</td>
<td>&lt; 25 %</td>
<td>&lt; 10 %</td>
<td>Sim (every 10 MeV from 50 to 90 MeV, then see cases above), BT (see cases above)</td>
<td>5.2.4</td>
</tr>
</tbody>
</table>

**Comments:**

- BT – beam test
- TPT – tagged photon trigger
- NI – normal incidence

For 300 GeV data:

- Simulations must match measured backsplash rates to better than 10% – earlier measurements must be reviewed and, if necessary, another set of measurements must be made.

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**Effective Area vs. Energy**

![Effective Area vs. Energy Graph](image)

- Red: Spec
- Green: Goal
- Blue: PDR

Single point from SRD
LAT Technical Trade Studies

- Many Studies Complete prior to Nov '99 proposal
- Studies completed since selection
  - Tracker SSD size, pitch \rightarrow \text{instrument footprint, mass}
    - SSD spec finalized, prototypes made and evaluated
  - Tracker radiator thickness distribution
  - Grid Material: Al vs. CFC
    - Aluminum selected
  - ACD Segmentation
    - 104 segments selected
  - Grid Pitch
    - Pitch increased 1 mm
  - SAA protection scheme
    - PMT current limit in addition to SAA alert protective action
  - Optimized I&T, calibration and verification test plans
- Ongoing Studies
  - Hardware Triggers/Onboard Filter
  - Optimized on-board processors
  - Thermal Control System
  - Star Tracker Mount
# Systems Performance Budget (1)

## LAT Mass Status

<table>
<thead>
<tr>
<th>Item</th>
<th>March 2002</th>
<th>Current Estimate (kg)</th>
<th>AIAA Recm'd Reserve (kg)</th>
<th>%</th>
<th>Reserve + Margin (kg)</th>
<th>Reserve + Margin (%)</th>
<th>Mass Estimate Breakdown (kg)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracker</td>
<td>504.9</td>
<td>10.1</td>
<td>2.0%</td>
<td></td>
<td>286.5</td>
<td>10.6%</td>
<td>Parametric 528.9</td>
<td>19.5%</td>
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<tr>
<td>Calorimeter</td>
<td>1466.3</td>
<td>70.8</td>
<td>4.8%</td>
<td></td>
<td></td>
<td></td>
<td>Calculated 920.0</td>
<td>33.9%</td>
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<tr>
<td>ACD</td>
<td>228.1</td>
<td>25.3</td>
<td>11.1%</td>
<td></td>
<td></td>
<td></td>
<td>Measured 1264.6</td>
<td>46.6%</td>
</tr>
<tr>
<td>Mech Systems</td>
<td>309.7</td>
<td>66.1</td>
<td>21.3%</td>
<td></td>
<td></td>
<td></td>
<td>Total 2713.5</td>
<td>100.0%</td>
</tr>
<tr>
<td>Trigger &amp; Data Flow</td>
<td>204.4</td>
<td>40.9</td>
<td>20.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LAT Total</strong></td>
<td><strong>2713.5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reserve + Margin</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Center of Mass (mm)

- X-coordinate: -0.83
- Y-coordinate: -1.33
- Z-coordinate: -87.21
- HITL off interface: 148.99

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LAT Configuration Management

Configuration Identification

Online Access to LAT Team

Baseline Documents

CI Selection

CIDL

Configuration Status Accounting

Online Access for Status Reporting and Real-Time Inquiries

Configuration Audits

Change Verification

Configuration Change Control

Proposed Change

Change Approval (Manager or CCB)
Risk & Reliability

- Risk Plan and Reliability Requirements
  - Assessment
    - Reliability
    - Failure Mode & Effects Analyses
    - Critical Items Identification
    - Parts Stress Analysis
    - Worst Case Analysis
  - Allocations
    - Reliability & Operability Requirements
  - Mitigation
    - Design Evaluation
    - Probabilistic Risk Assessment
    - Top Risk List and Actions
  - Tracking
    - Critical Item List.
    - Trend Analyses
Risk & Risk Mitigations

- **Power & Mass**
  - Established Power & Mass Review Board to control the power growth

- **Trigger/Background Filtering**
  - Flexible compute/software architecture
  - Trigger/Filtering studies underway

- **Thermal Control System Ground Testing**
  - Enhanced validation program
  - Additional concepts being studied

- **Calorimeter: Diode/Crystal optical bonding**
  - Pre-production testing program
  - Optional non-bonded pin diode configuration
  - A parallel effort has begun to mitigate risk
Highlights: January PDR Recommendations

- Provide requirements verification traceability matrix
  - Done: Program Instrument Verification Plan, LAT-MD-408
- Provide current Risk List and the plan for updating it
  - The Risk Management Plan is underdevelopment. It will be released before the Delta Review
- Provide list of open trade studies; provide status of drawings, tracking plan; provide list of RFAs from Subsystem Peer Reviews
  - Done: See LAT-LR-559
- Describe expected transition of LAT CM and PFR processes to observatory integration
  - This will be added to the SEMP and CMP
- Provide descriptions of the performance and acceptance of LAT
  - The test parameters are under development and will be included in the Performance Verification Plan (LAT PVP)
- Describe validation of EGSE
  - Will be included in the LAT test plan
- Include EMI/EMC acceptance testing on all flight boxes
  - LAT PVP will be updated to include verification and acceptance testing
Issues and Concerns

• Test and Calibration Planning is incomplete

• Test and verification parameters require clarification

• Spacecraft/Instrument ICD’s are not linked with the LAT CDR

• LAT system FEMA’s and Risk analyses are incomplete - Risk reducing mitigations should be implemented to CDR
System Engineering Cost
System Engineering Cost & Commitments

$M, Then Year Dollars

FY00 FY01 FY02 FY03 FY04 FY05 FY06

0 1 2 3 4 5

ACWP
BCWS
Actual Commit
BCWS + Planned Commit