GLAST Large Area Telescope:  
I & T Peer Review

Mechanical Ground Support Equipment

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Outline

• MGSE Development Plan
  – Hardware Development List / Rationale
  – Design Factors
  – Proof Testing

• LAT MGSE List
  – EM-Single Bay Hardware
  – CU and Flight
  – Shipping Container Status
LAT MGSE Development Plan

- LAT-MD-01462, LAT MGSE Development Plan
  - Summarizes Assembly Sequence, Precedence document is LAT-PS-00676
  - Defines MGSE Hardware and Tooling Elements
  - Defines provision responsibility
  - All MGSE Designs to Meet EWR 127.1, as Tailored by SLAC
    - Material Yield not more than 85% of Ultimate
    - Design Factor of Safety (No Earth Quake) > 3
    - Proof Test about 2 times maximum expected load
    - Earth Quake per SLAC-I-720-0A24E-001, Specification for Seismic Design at SLAC.
      - Design for 5% Damping to reduce G loading to 1.5 G at 45°
      - Does not apply to temporary (crane) operations
LAT MGSE List

1. EM-Cal Rotation / Support Stand (in house)
   • Also Used to Rotate EM Single Bay, CU 1 x 4 and then Calorimeter
2. EM Lifting Fixture*1
3. EM ACD Scintillator Support Fixture
4. Calorimeter Lift Fixture *2 (in house)
5. Calorimeter Alignment Tool*2 (in house)
   • Includes 0.45 m long Alignment Rods (in house)
6. Calibration Unit (1 x 4) to Rotation Stand interface plates (Design Complete)
7. CU Integration Stand Proof Test Article (Design Complete)
8. Calibration Unit Lift Fixture (in work)
9. Calibration Unit ACD Support Fixture
10. Calibration Unit X, Y, θ Movement System (for Beam Test)
    • 42” Troyke Rotating Table in house (major find!)
11. Thermal – Dew Point Control Tent (Double Walled) for Beam Test
12. CU & LAT Thermal Control Cart Ducting, Hoses, Cold plates
13. Grid Perimeter Ring (GPR)
   • Supports Grid Through Entire Integration & Test at SLAC
   • Supports LAT in Shipping Container (To Protect SC Bus Interfaces)

Note: *1 - Tracker Tower Lift Fixture Supplied by Tracker Sub-System
*2 – Successful Installation Demonstration completed Nov. 02
14. Tilt Over Stand
   • Two LAT-GPR Support Box Frames tied together by pivot bearing brackets
   • TBD counterweights to adjust Cg along Z axis during sequential build up
   • Practice will be required to obtain Tilt Over Certification
15. Special Crane Attachment to GPR (for Tilt Over Operations)
   • Includes addition of load cell to crane’s lift cable for feedback to operator
during tilt over
16. Tilt Over Stand Proof and Protocol Test Article
17. ACD Integration Frame
18. ACD Lift Fixture
19. ACD Lift Fixture Proof Test Article
20. LAT Shipping Container
   • Insulated for Thermal Cycling Tests
   • Includes Electrical Feed Throughs to Power up & Receive Data from LAT
   • Includes Ducting for Thermally Controlled Air Circulation
   • May Include transits for use of cold plate on X-LAT Heat Plate
   • Container Cover Lift Fixture (Same as LAT Lift Fixture (TBR))
21. Staging Table (in house)
   • Preparation / Sub-System Functional Tests
22. Vibration Test Fixture
   • Provides Interface Between NRL Vibration Table and LAT to SC Bus Attach Points
   • Single Stand Will Support All Three Axes
23. Thermal Vacuum Support Kit
   • Vibe Test Fixture (VTF) with side support arms for Z axis horizontal
   • Radiator Support Frame attaches to bottom of VTF and provides lower attach strut interface
   • LAT Perimeter Heat Exchanger (to help drive to next temp)
24. Acoustic Test SC Simulator, Very Low Fidelity (TBR)
   • Open Frame with attach points at – Z end of Radiators
25. Van de Graaff Support Stand (in house)
26. Calibration Unit Transport Box
   • Includes Dry Air Purge for Humidity Control
27. EM Single Bay Transport Box
   • For EM transport to Germany (GSI)
Critical LAT MGSE Integration Steps / Req’ts

• Grid handling
  – Grid Perimeter Ring provides attachment points at each of 4 corners; Consistent with current Radiator Support Structure design
  – Grid Perimeter Ring includes SC Bus attach bracket interfaces (i.e., all eight attach points used during shipment; FEA required to validate approach)

• Calorimeter-to-Grid mating
  – Chosen concept uses alignment tool that interfaces with Calorimeter’s GSE Support Posts and is lowered into position using Precision Crane

• Tracker-to-Grid mating
  – 4 attachment points at corners of TKR top plate
  – Plan to mate Tracker to Grid with alignment tooling (provided by Tracker) and precision crane operation

• ACD-to-Grid mating
  – 4 Three Bolt attachment points at corners of BEA, 4 two bolt attachment points mid span on BEA sides
  – Plan to mate ACD to Grid using alignment tooling and precision crane operation
  – Low Profile Lift Fixture Has Been Added to Hardware List (including needed funding)
• **SLAC Beam Test**
  – De-humidification/cooling system for SLAC Beam Test
  – Calibration Unit Grid (1 X 4), Remote X, Y, Θ Movement System
    • True Position Tolerance with respect to Beam is ± 1 mm [0.040”] in X and Y and ± 0.5° in Theta
• **SLAC Reference Comprehensive Test / Airborne Cosmic Test (TBR)**
  – De-humidification/cooling/heating system for shipping container
  – Ship w/o radiators (to fit in aircraft with LAT +Z up)
• **NRL Environmental Tests**
  – EMC/EMI – LAT in GPR on Box Stand or LAT on Vibe Test Fixture on TBD
  – Random Vibe / Sine Sweep* – Vibe Test Fixture
  – Acoustic Test – Vibe Test Fixture with Radiator Attach SC Interface Simulator
  – Thermal Balance & Cycling in Vacuum – Vibe Test Fixture with SC Attach Interface Simulator and Side Support Braces
LAT Transport Container

- LAT Transport Container
  - Requires Vibration / Shock Isolation System
    - Initial Concept allows 154.2 mm (6”) travel in X, Y and Z for Isolation
    - Theoretical Isolation Assessment indicates good loads filtering above 3 Hz
  - Baseline Review (July 02) Concept
    - 2159 mm (85”) Tall by 2921 mm (115”) Wide by 2667 mm (105”) Deep
    - Sized with LAT on GPR that attaches to Isolation Frame
    - Footprint can be reduced if LAT is on VTF, but at the expense of increased height; Under Evaluation
  - Fits in the following Aircraft, Upper Cargo Deck Only:
    - Boeing 747-100F, 747-200C, Commercial
    - McDonnel Douglas MD-11, DC-10, Commercial
    - C130, C141 and C5A, Military Transport
- Will Require a Dedicated (Full Charter) Flight
LAT Transport Container, Initial Concept

152.4 mm (6”) Clearance between GPR and inside surface perimeter
152.4 mm (6”) Clearance between ACD and Top Side Stiffeners in work

Fits through aircraft doors

Weight Estimate
Container ~ 635 kg (1,400 lbs)
GPR ~ 408 kg (900 lbs)
LAT ~ 2903 kg (6,400 lbs)
Total ~ 3946 kg (8,700 lbs)
~ 513 kg/m² (105 lbs / ft²)
Van de Graaff is Ready to Use

Out Riggers for Earthquake Stability

Adjustable Feet to Allow Beam Pipe Height Adjustment
• Alignment Tool and Alignment Rods available and ready to use
- Available, Proof Tested and Ready to Use

Lift Fixture Turnbuckles Allow Leveling Adjustment with 10 kg (22 lb) Alignment Tool Attached

Alignment Tool Weight Reduced to about 4 kg (9.0 lbs)

Calorimeter Mass / Outermost Features Mock Up ~ 93 kg (205 lbs)

EM-Single Grid Bay In Modification to Support EM Integration and Test
LAT MGSE

- EM-Cal Rotation / Support Stand
  - Multi-Function, Support EM and CU Integration, Then Acts as Calorimeter Rotation Stand

Level Fine Tune Adjust Tool,
Removed Before Powering Up Drive Motor
(Designed to Fall Away When Person Lets Go of it)
Proof Test Stand with 1360.8 kg (3,000 lbs)

Rotate 1x 4 with Tracker and Calorimeter, Then Attach SLAC Lift Fix

Use SLAC Lift Fix and Alignment System to Install Calorimeter

Install 1st Tracker, Attach Calorimeter to Rotation Interface with + Z Up

Proof Test Cal Rotation Interface to 204.1 kg (450 lbs)

Calorimeter Alignment System Not Shown for Clarity
LAT MGSE CU Integration Stand

EM-Cal Rotation / Support Stand Weldment – In House & Under Assembly
Level Fine Tune Adjust Tool, Removed Before Powering Up Drive Motor (Designed to Fall Away When Person Lets Go of it)

Motor Rotation About 40 Seconds for 180°

Double Worm Gear Reduction Prevents Rotation When Motor Not Powered

After CU Processing is Complete, 1 x 4 Extension Frame and Driven Side Removed; Calorimeter Rotation Interface Assembly Re-Attached to Become the Calorimeter Rotation Stand
LAT MGSE, Rotation Concepts / Status

- Three concepts under evaluation
- Universal Support Stand
  - Operationally nice; Provides Up, Down and Rotation
  - Analytically expensive to manage Seismic Loads
- Tilt Over Stand
  - See next slide for discussion
  - Must manage changing Cg along Z during build sequence
  - Requires personnel access platforms
- Scaled up version of EM-Cal Rotation / Support Stand
  - Operationally nice, but anticipated to be fairly high off the ground
  - Several personnel access platforms would be required
• Concerns and Mitigations
  – Tilt Over Shock as LAT passes 90°
    • Position GPR along average Cg Z (Study In Work)
    • Guide Ropes, Counter Balance Weights, Stop Brackets
  – Over Lift of LAT + Stands at High Point
    • Add load cell to Crane’s Lift Cable to provide feedback to operator
  – Available hook height can not support ACD Installation without special ACD Integration Stand
• Safety Aspects
  – All Crane Operations are classified as Hazardous Operations
    • Due to suspended loads
  – Tilt Over Crane Operations are considered Critical Crane Operations
    • Critical Crane Operations require more Safety Review Oversight
      – Special operator training
      – Demonstration of correct protocol performance
      – SLAC Site Certification for the specific tilt over operations with the specific required equipment
        » Coordination with SLAC Riggers TBW
Supplemental Slides
LAT MGSE Grid Perimeter Ring

- Depiction of LAT Center of Gravity as a Function of Build Sequence
  - From CDR Mass Properties