GLAST Large Area Telescope:

GASU TRR

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LAT Electronics

- TKR Front-End Electronics (MCM)
- ACD Front-End Electronics (FREE)
- CAL Front-End Electronics (AFEE)

3 Event-Processor Units (EPU) (2 + 1 spare)
- Event processing CPU
- LAT Communication Board
- SIB

Global-Trigger/ACD-EM/Signal-Distribution Unit* (GASU)

Spacecraft Interface Units (SIU)*
- Storage Interface Board (SIB): Spacecraft interface, control & telemetry
- LAT control CPU
- LAT Communication Board (LCB): LAT command and data interface

Power-Distribution Unit (PDU)*
- Spacecraft interface, power
- LAT power distribution
- LAT health monitoring

Primary & Secondary Units shown in one chassis
EGSE GASU Mounted on LAT
Primary and Redundant GASU DAQ Module in same enclosure, separated by metal

To follow
Boards in Flight GASU

- Enclosure contains primary and redundant GASU Power-Supply Boards and DAQ Boards
GASU Module

- One enclosure houses primary and redundant GASU Power-Supply and GASU DAQ Circuit Card Assemblies
  - Separated by aluminum wall
- GASU Power Supply
  - Receives 28-V supply voltages for
    - Primary and redundant DAQ board,
      - Generates 3.3V and 2.5v
    - ACD FREE cards
      - Filtering for 28-V
      - 3.3V regulation
- GASU DAQ Board
  - Contains 9 FPGA’s
  - Includes Command Response Unit, fan-out and fan-in of commanding to 16 TEMs, PDU, EPU’s, ACD
  - Includes Global Trigger Logic
  - Includes LAT Event-Builder Logic
  - Includes command/control/read-back for ACD sub-system
  - Includes power-control for ACD FREE Boards
Changes since LAT CDR

- Code in 9 FPGA’s were modified/finalized and bugs fixed
- 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
Objectives

- Demonstrate that hardware, software, procedures, and support equipment are prepared to support system environmental test
- Demonstrate that planned and completed testing meets performance and interface requirements
- Identify and understand all the risks and limitations
- TRR is not intended to
  - Review GASU design
  - Review flight readiness
  - Buy-off hardware or software
- RFA’s should only be of sufficient concern to stop test
  - Prior to start of an given test, any applicable TRR RFAs must be closed
Test Entrance / Exit Criteria

• Entrance
  – All required paperwork released and in place
    • Procedures, drawings, etc
  – Test configuration verified and approved
  – Essential personnel in place
  – Pre-test GASU functional successfully passed

• Exit
  – As-run procedures completed
  – Correct and accurate application of test environment
  – Test data acquired and archived
  – No damage to GASU
  – GASU performance within specification limits
  – Post-test GASU functional successful
Status

• First GASU (to be proto-flight tested)
  – Assembled
  – Pre-conformal coat GASU with enclosure-internal EGSE harness tested, tests to verify that ACTEL performs over temperature performed (was prerequisite to programming FPGA’s for second GASU box)
  – Conformal coated, integrated in enclosure with flight harness
  – Final GASU to be delivered to SLAC week of Oct 3, 2005

• Second GASU (to be flight acceptance tested)
  – Will be spare or primary flight GASU, depending on schedule
  – Board went thru reflow surface-mount assembly step
  – ACTEL FPGA’s were programmed and are being assembled on boards
  – Remaining are staking, integration of boards into enclosure, integration of EGSE harness, testing at SLAC, conformal coating, integration of flight harness, testing
Tests To-Date

- GASU engineering modules were extensively tested
  - As EGSE in DAQ/I&T
    - Testbed includes GASU for > 1 year
    - I&T uses EGSE GASU during integration of towers in LAT for several months
    - Main difference to flight GASU: ACD power-switch circuit and monitoring was modified
  - Two flight boards of each type were assembled with mostly flight parts and tested in one enclosure
  - Additional GASU tests
    - Informal thermal test -40C to 55C
    - Informal EMI test on EGSE station sent to Lockheed for thermal test
Requirements

- LAT-SS-00285 Specifications, Level 4 LAT Dataflow System
- LAT-SS-00019 Specifications, Level 3 T&DF Subsystem Specification
- LAT-SS-00136 Specifications, Level 3 Power Supply System
- LAT-SS-00183 Specifications, Level 4 Power Supply System
- LAT-SS-07287 Specifications, Level 5 GASU Specification (to be released)

- LAT-TD-00606 LAT Inter-Module Communications
- LAT-TD-0xxxx GASU ICD Specification & Conceptual Design (needs to be updated)
- LAT-TD-00639 AEM, Programming ICD
- LAT-TD-01545 GEM, Programming ICD
- LAT-TD-01546 EBM, Programming ICD
- LAT-TD-01547 CRU, Programming ICD

- LAT-SS-00778 LAT Environmental Specification

- LAT-SS-07287 GASU lists requirements
- LAT-TD-04381 contains Verification Matrix which gives approach to verify each requirement
  - Lists verification method used
System Performance

- Level 3 and level 4 DAQ and TRG and power-system requirements are met with a combination of DAQ modules (TEM/TPS, GASU, SIU, PDU, etc), since the DAQ and trigger and power system is comprised of several sub-system module types
  - Level 5 GASU requirements which are verified are derived from Level 3 and Level 4 DAQ and Trigger and Power system specifications (as noted in the L5 requirements doc)
  - Level 5 requirement doc includes derived requirement addressing
    - Functionality/performance
    - Power
    - Mass/C.G.
    - EMI/EMC
    - Environmental incl temperature and vibration
Verification Status

- Engineering Module GASU
  - EM completed full functional test program with exception of thermal-vacuum, EMI/EMC, mass, and C.G.
  - Demonstrated compliance with specifications
EGSE and Test-Procedures

- **EGSE for Functional/Performance Tests**
  - Test-Stand documented in LAT-DS-01717

- **Test-Procedures**
  - LAT-TD-04260 Electrical Interface Continuity and Isolation Test procedure and LAT-TD-06610 Automated Electrical Interface Continuity and Isolation Test procedure
    - Power-off impedance tests of I/O
  - LAT-TD-04382 Stray-Voltage-Test Procedure
    - Power-on voltage test of I/O
  - LAT-TD-01717 Comprehensive Test Procedure
    - Functionality and Performance test
    - (not signed of as of Sept 30, 05)
LAT-TD-01717 shows several test-configurations, below the AEM functionality test configuration is shown.
Verification Level – Module Detail

- Breakout of verification at GASU Module Level
- Tests to be conducted after successful TRR (order may change depending on availability of resourced (TV/EMI))
  - EICIT & SVT
  - Functional test
  - Vibration (Wyle)
  - Functional test
  - Thermal cycle
  - Functional test
  - Mass properties including CG
  - Thermal vacuum (in-situ testing)
  - EMI/EMC (at CKC-lab for proto-flight, at SLAC for flight acceptance)
  - Functional test
  - Review
  - Deliver to I&T
    - DAQ (out-going) / I&T (incoming) test combined
Verification

- Test-Stand
  - Supplied by SLAC
  - Operated by SLAC engineers
- Vibration facility at Wyle
  - LAT-TD-03634 Vibration test-procedure
  - SLAC engineers present for vibration tests
- Thermal Cycle in thermal chamber in SLAC clean-room
**TC and Vibration Requirements**

<table>
<thead>
<tr>
<th>Parameter Required</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Cycling (4 cycles)</td>
<td>-40 to +55 °C (Qualification and Proto-flight)</td>
</tr>
<tr>
<td>Thermal Cycling (4 cycles)</td>
<td>-35 to +50 °C (Acceptance)</td>
</tr>
<tr>
<td>Random Vibration</td>
<td>See Figure 1.</td>
</tr>
<tr>
<td>Sinusoidal Vibration</td>
<td>0.5g rms, 20 to 2000Hz</td>
</tr>
</tbody>
</table>

### Electronics Module (Special Boxes)

#### Random Vibration Spectra

<table>
<thead>
<tr>
<th>Freq (Hz)</th>
<th>ASD Level (G^2/Hz)</th>
<th>Accept</th>
<th>Qual</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.010</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>0.037</td>
<td>0.038</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>0.040</td>
<td>0.055</td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>0.180</td>
<td>0.360</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>0.180</td>
<td>0.360</td>
<td></td>
</tr>
<tr>
<td>325</td>
<td>0.040</td>
<td>0.060</td>
<td></td>
</tr>
<tr>
<td>350</td>
<td>0.040</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>0.040</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0.025</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>8.91 Grms</td>
<td>11.51 Grms</td>
<td></td>
</tr>
</tbody>
</table>

Duration: 60s/axis AT, PT 120s/axis QT

**Figure 1:** Vibration Levels, Duration, and Spectra
Mass Property

• Mass properties checked at SLAC
  – Procedure LAT-TD-07037-01 (performed at SLAC Metrology)
  – Expected: (ref LAT-TD-00564)
    • Total 13.9 kg
    • Allocation 12% above = 16.7 kg
  – C.G. to be measured for the proto-flight unit only
Thermal Vacuum Test

- Thermal Vacuum facility in Building 33 at SLAC
  - Thermal Vacuum Chamber Operating Procedure LAT-TD-02541
  - GASU Thermal Vacuum Test-Procedure LAT-TD-03635 (not released as of 9-30-05)
  - First GASU tested to proto-flight specifications (same Temperatures as qualification, but 4 TV cycles versus 12 cycles)
Proto-Flight and Flight Acceptance Thermal Vacuum Test

- See GASU Thermal Vacuum Test-Procedure LAT-TD-03635

**PROTO-FLIGHT THERMAL VACUUM CYCLE TIMELINE**

- 4 Cycles Total

**ACCEPTANCE THERMAL VACUUM CYCLE TIMELINE**

- 4 Cycles Total

At < 10-5 Torr

- +60°C +2/-2°C
- +55°C +2/-2°C
- -40°C +2/-2°C

- +60°C +2/-2°C
- +55°C +2/-2°C
- -40°C +2/-2°C
EMI/EMC Test

- Proto-Flight = Qualification Test (Conductive & Radiative)
  - Sub-contracted to CK Labs
  - Statement of Work: LAT-PS-04568
    - CE102, CECN, CS102, CSMC, CS06, RE101, RE102, RS101, RS103
    - Detailed EMI/EMC procedure provided by CKC lab (to be provided)
    - SLAC engineers present at vendor for tests
    - Vendor supplies test-report
    - LAT QA at SLAC present for tests

- Flight Acceptance Test (Conductive)
  - Performed at SLAC
  - LAT-TD-03633
    - Only CE102, CS102
  - SLAC supplies test-report
  - LAT QA at SLAC present for tests
Manpower & Quality Assurance

• Test man-power
  – GASU: L. Sapozhnikov/ J. Thayer
  – Test Support: J. Ludvik
  – Thermal Cycle and TV support: R. Williams, P. Hart
  – TV shift support: 2 contractors
  – EMI support: D. Nelson
  – Vibration support: D. Tarkington

• Quality assurance: Joe Cullinan
  – QA representative (Y.C. Liew) present during tests, review of test-procedure and results
  – Required changes to documentation are red-lined and included in new revisions
  – NCR are created for non-conformance (e.g. exceeding of min/max test limits) and submitted for disposition
Problem Failure Report/ Configuration Management

• Problem Failure Reporting
  – Via standard SLAC LAT Non-Conformance Reporting (NCR) System
    • NCR is entered
    • Reviewed/accepted/resolved
      – LAT engineering
      – LAT QC
    • Already exercised during pre-conformal coat GASU assembly

• Configuration Management
  – Via standard LATDOC system
Planned Tests

- Function/Performance Tests (LAT-TD-01717)
  - Verifies all requirements in LAT-SS-07287 except below
- Thermal Vacuum Tests
  - Verifies performance/function over temperature
- Mass/C.G.
  - Verifies/measures mass and C.G.
- Vibrations test
  - Verifies vibration performance requirements
- EMI/EMC
  - Verifies EMI/EMC performance
- Note to margin testing
  - External Voltage margin testing is performed at all stages (28V +/-1V)
  - Internal Voltage margin testing (3.3V/2.5V) is only performed at pre-conformal coat stage while using internal EGSE harness
  - No internal voltage margin testing once flight harness is used. Respective tests in TD-01717 are omitted at that stage as will be documented in work-order
  - Frequency margin tested pre-conformal coat as well as on final GASU
  - Temperature testing performed during TV testing
Equipment Calibration

- EMI/EMC Test Equipment
  - Quantitative measurement equipment (sensors, antennas, etc) calibrated to NIST standards
  - Calibration performed annually
    - All items are (will be) within calibration at time of testing

- Vibration Test Equipment
  - Accelerometers calibrated against a standard accelerometer traceable to NIST
  - Signal conditioners calibrated annually

- TVAC Equipment
  - Thermocouples calibrated against standard temperature; calibrated prior to test
  - Thermocouple reader calibrated very 2 years
Sub-System Safety

- **EGSE**
  - Safe-to-mate
  - Configuration control
  - Calibration verification
  - Functionality verification with “golden” EGSE GASU prior to test with flight hardware

- **MGSE**
  - No custom MGSE

- **Environment**
  - Temperature controlled in all test-facilities
  - Cleanliness actively controlled in clean-room; hardware bagged and purged when required

- **Training**
  - ESD training completed
  - Clean room training completed
Risk Assessment

- **Schedule**
  - Pressure to deliver flight hardware could force less than complete characterization and analysis of modules, could result in replicating a problem in the second module

- **Performance**
  - None known
Test-Schedule

- Estimated as follows, order subject to EMI/TV availability
- First GASU
  - 10/5: functional test
  - 10/13: TC
  - 10/14: functional test
  - 10/17: vibration test
  - 10/18: functional test
  - 10/24: TV start
  - 10/31: TV end
  - 11/1: mass, c.g. property
  - 11/2: EMI start
  - 11/16: EMI end
- 2nd GASU
  - Lags first GASU by about 8 weeks
Status of Main Test Procedures

- All procedures must be released before respective test
- Procedures to be released
  - EMI vendor procedure to be released
  - CPT and TV modified, revisions are in review
Issue & Concerns

- Schedule
  - Tight
- Vibration test
  - Concern that harness/connectors pass vibration tests
    - (should be ok, but is concern)