GLAST Large Area Telescope: SIU TRR

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LAT Electronics

16 Tower Electronics Modules & Tower Power Supplies

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

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

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

Primary & Secondary Units shown in one chassis
SIU/EPU Mounted on LAT
SIU/EPU Crate Electronics

- **Storage Interface Board (SIB)**
  - EEPROM
  - MIL1553 Communication with spacecraft*
  - Power Control of PDU/GASU power switches in PDU*
  - Power Control of VCHP switches in heater box*
- **LAT Communication Board (LCB)**
  - Communication with GASU
    - Commanding
    - Read-back Data
    - Housekeeping Data
    - Event Data
- **Crate Power Supply Board (CPS)**
  - 28V to 3.3V/5V conversion
  - Power-On Reset
  - LVDS-CMOS conversion of spacecraft discretes*
  - System clock to GASU
- **CPU Board (RAD750)**
  - Processor**
  - IO of level-converted SC discretes
- **Crate Backplane (CBP)**
  - passive

*Only used in SIU crate
**Start-up ROM code different from EPU and SIU
SIU/EPU Crate

- Partially loaded crate on left (without LCB and SIB)
- Fully loaded crate on right
- Shown are also serial card and ethernet cards, not part of flight assembly (cards with front-panel connections)
CBP & CPS & CPU

CBP (Crate Backplane) →

CPS (Crate Power Supply Board) →

CPU (RAD750 from BAE) →
SIB & LCB

SIB (Storage Interface Board) →

LCB (LAT Communication Board) →
Changes since LAT CDR

- Code in LCB and SIB FPGA’s were modified/finalized and bugs fixed
- Some resistor/capacitor values have changed to optimize performance
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 SIU 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 SIU functional successfully passed
• Exit
  – As-run procedures completed
  – Correct and accurate application of test environment
  – Test data acquired and archived
  – No damage to SIU
  – SIU performance within specification limits
  – Post-test SIU functional successful
Status

• First SIU (to be proto-flight tested)
  – Assembled
  – Pre-conformal coat SIB, LCB, CBP, CPS in crate tested, tests to verify that boards perform over temperature (was prerequisite to programming FPGA’s for additional SIB & LCB’s)
  – Conformal coated modules are being integrated in enclosure
• Additional SIU/EPU’s (to be flight acceptance tested)
  – LCB/SIB/CPS/CBP at various assembly stages
Tests To-Date

- SIU/EPU engineering modules were extensively tested
  - As EGSE in DAQ/I&T
    - Testbed includes SIU & EPU for > 1 year
    - Main difference to flight SIU/EPU: Commercial ACTEL FPGA’s versus flight ACTEL’s.
  - One SIB was assembled with mostly flight parts including flight ACTEL and tested in one enclosure
  - Additional SIU 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-07433 Specifications, Level 5 SIU Specification
- LAT-TD-00606 LAT Inter-Module Communications
- LAT-TD-01685 SIU ICD Specification & Conceptual Design
- LAT-TD-01682 LCB Specification & ICD
- LAT-TD-00860 LCB, Programming ICD
- LAT-TD-01539 SIB Specification and ICD
- LAT-SS-01538 CPS Specification
- LAT-SS-01540 CBP (Backplane) Specification

- LAT-SS-00778 LAT Environmental Specification

- LAT-SS-07433 SIU lists requirements
  - LAT-TD-07434 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 SIU 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 SIU
  - EM completed full functional test program with exception of thermal-vacuum, EMI/EMC, mass, and C.G.
  - Demonstrated compliance with specifications
Test-Procedures

• SIU/EPU Crate
  – LAT-TD-07194 SIU Electrical Interface Continuity and Isolation Test procedure
    • Power-off impedance tests of I/O
  – LAT-TD-07195 SIU Stray-Voltage-Test Procedure
    • Power-on voltage test of I/O
  – LAT-TD-01686 SIU Comprehensive Test Procedure
    • Functionality and Performance test

• LCB
  – LAT-TD-01683 LCB Test Procedure
  – LCB-TD-06939 LCB Qualification Test Procedure

• SIB
  – LAT-TD-07382 Procedures for Uploading Files to SIB EEPROMs in a cCPI crate
  – LAT-TD-01678 SIB Test Procedure
  – LAT-TD-06978 SIB Qualification Test Procedure

• CPS
  – LAT-TD-04811 CPS Electrical Interface Continuity and Isolation Test procedure
    • Power-off impedance tests of I/O
  – LAT-TD-04812 CPS Stray-Voltage-Test Procedure
    • Power-on voltage test of I/O
  – LAT-TD-01673 CPS Test Procedure (Electrical)

• CBP
  – LAT-TD-07012 Backplane Assembly Continuity Test Procedure
Test Configurations

• Test-Procedures/Configurations
  – LAT-TD-01686
  – Examples (SIB and LCB) test configurations shown in following slides
• Upload SIB EEPROM Configuration (LAT-TD-07382)
SIB Test Configuration

- SIB Test Configuration (LAT-TD-01686)
LCB Test Configuration (LAT-TD-01686)
Verification Level – Module Detail

• Breakout of verification at SIU-EPU 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-03648 Vibration test-procedure (not signed off as of Oct 3)
  - 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>
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<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>

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

- Mass properties checked at SLAC
  - Procedure LAT-PS-07372 (performed at SLAC Metrology)
  - Expected: (ref LAT-TD-00564)
    - Total 6.2 kg
    - Allocation 12% above = 7.5 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
  - SIU Thermal Vacuum Test-Procedure LAT-TD-03649
  - First SIU 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 SIU Thermal Vacuum Test Procedure LAT-TD-03638

At < 10^-5 Torr

**PROTO-FLIGHT THERMAL VACUUM CYCLE TIMELINE**

- 4 Cycles Total

**ACCEPTANCE THERMAL VACUUM CYCLE TIMELINE**

- 4 Cycles Total

4.1.7 DAQ & FSW V1
EMI/EMC Test

- **Proto-Flight = Qualification Test (Conductive & Radiative)**
  - Sub-contracted to CK Labs
  - Statement of Work: LAT-PS- 04568
    - CE102, CECN, CS102, CSCM, 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-07107
    - Only CE102, CS102
    - SLAC supplies test-report
    - LAT QA at SLAC present for tests
Manpower & Quality Assurance

- **Test man-power**
  - SIU: 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 SIU assembly

- Configuration Management
  - Via standard LATDOC system
Planned Tests

- Function/Performance Tests (LAT-TD-01686)
  - Verifies all requirements in SIU Specification Document 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 the CPS and Full-crate level only (28V +/-1V)
  - Internal Voltage margin testing (3.3V/2.5V) is not performed
  - Frequency margin testing only performed on LCB LAT-side interface, no clock frequency margin is tested on cCPI bus
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 every 2 years
Sub-System Safety

• **EGSE**
  – Safe-to-mate
  – Configuration control
  – Calibration verification
  – Functionality verification with “golden” EGSE SIU 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 following modules

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

- Estimated as follows, order subject to EMI/TV availability
- First SIU (proto-flight)
  - 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
- Following SIU’s
  - Lag first SIU by about 4 days each
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)