Mechanical Systems

GLAST LAT Acoustic Vibration Test Readiness Review

John Ku kuj@slac.stanford.edu

June 28, 2006 @ 1pm-4pm EDT
NRL, HESE Conference Room - Bldg 209, Rm 323A
510-665-5437, Meeting ID: 7756

Contents

Mechanical Systems

GLAST LAT Acoustic Vibration TRR: Test Plan Review

John Ku kuj@slac.stanford.edu

Acoustic Vibration Test – Document List and Status

All Drawings and specifications are released and ready for use

Number	Title
Government Specifications	
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components
433-IRD-0001	GLAST SC-LAT Interface Requirements Document
433-SPEC-0001	GLAST Mission System Spec
433-MAR-0001	GLAST Mission Assurance Requirements Spec

Number	Title
Non-Government Specifications	
LAT-SS-00788-04	LAT ENVIRONMENTAL SPECIFICATION
LAT-MD-00404-03	LAT CONTAMINATION CONTROL PLAN
LAT-MD-00471-02	CONTROL OF NONCONFORMING PRODUCT
LAT-MD-01196-03	LAT DYNAMICS TEST PLAN
LAT-PS-07728-01	LAT ENVIRONMENTAL TEST HANDLING PROCEDURE
LAT-TD-00035-06	LAT COORDINATE AND NUMBERING SYSTEMS
LAT-TD-00890-03	LAT INSTRUMENTATION PLAN
LAT-TD-08116-01	LAT ACOUSTIC VIBRATION PRE-TEST ANALYSIS
LAT-PS-08113-01	LAT ACOUSTIC VIBRATION TEST PROCEDURE
N/A	INSTRUMENTATION MANUALS

Number	Title
Drawings	
LAT-DS-02561	LAT Tower and Electronics Assembly
LAT-DS-02563	LAT Instrument Assembly
LAT-DS-06186	LAT Environmental Test Handling Config. Assy
LAT-DS-06188	LAT Environmental Test Acoustic Test Config. Assy

Test Plan – Objectives

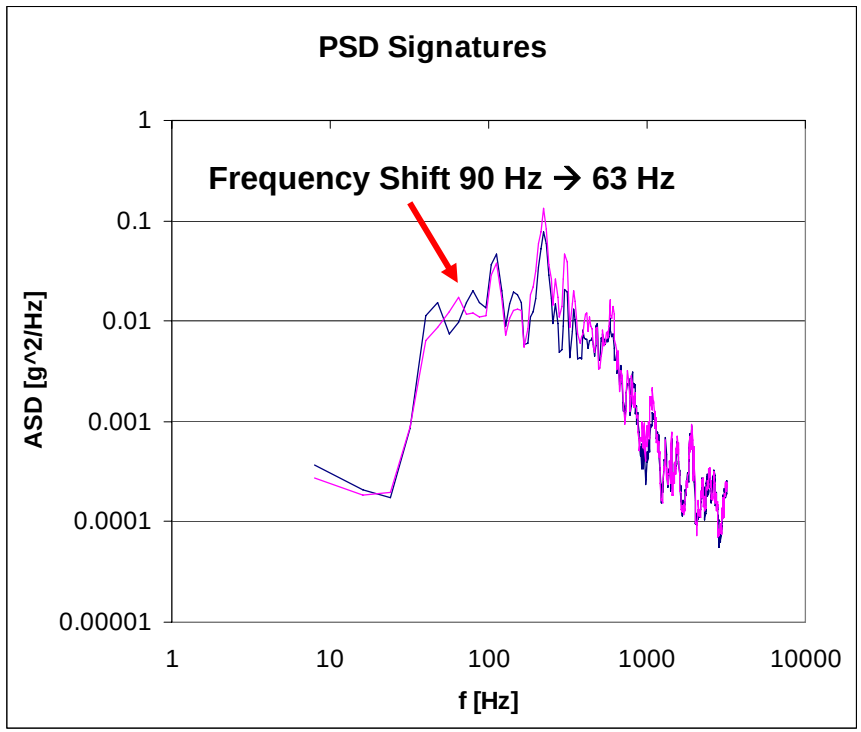
- The LAT will be subjected to acoustic vibration to accomplish two objectives:
  - The primary objective is to demonstrate that the fully integrated LAT is capable of withstanding acoustic noise loads, simulating launch conditions
  - A secondary objective is to verify the acoustic analysis, i.e. that the LAT components were qualified to high enough levels of random vibration

Test Plan – Entrance Criteria

- **Entrance/Exit Criteria are well understood by all; from the test plan:**
  - **The acoustic vibration dynamic test is a harsh environmental test to be performed after successful completion of the EMI test and the subsequent LPT. Criteria which must be met before this test can be executed are:**
    - **LAT integration on the acoustic test stand is complete—visual inspection verifies that all the LAT has been re-configured correctly. All travelers verified to be complete. The LAT is in its flight configuration, except as detailed on page 9.**
    - **All subsystem units/modules function—each subsystem has passed its LPT following EMI/EMC testing. Any performance discrepancies have been clearly documented.**
    - **Ensure all E-GSE needed is installed and functioning. After moving and orienting the LAT in the acoustic test chamber, ensure each subsystem has passed its LPT. All E-GSE cable harnesses have been removed from the LAT prior to test.**
    - **All accelerometers, microphones, and other test instrumentation are in place and functioning—instrumentation has been verified to be securely mounted in the correct locations and oriented in the correct direction, as defined in the test procedure, and electronics are working correctly and reading out signals. Cable harnesses for this instrumentation are connected and properly restrained for the test.**
    - **Pass Acoustic Test TRR**

Test Plan – Exit (Pass / Fail) Criteria

- Following the acoustic test, an LPT will be performed.
- The GLAST LAT will have passed this series of testing if the following criteria are met:
  - Visual inspection of the LAT—indicating that there is no visible damage to the LAT
  - Successful completion of the LPT—verifying that all components and subsystems function properly after testing.
  - Preliminary analysis of test data—verify that all recorded data is useable for analysis purposes
  - No significant mode shifts—pre- and post-test signatures match within 5% showing modal frequencies have not changed as a result of testing.
    - An example from my experience



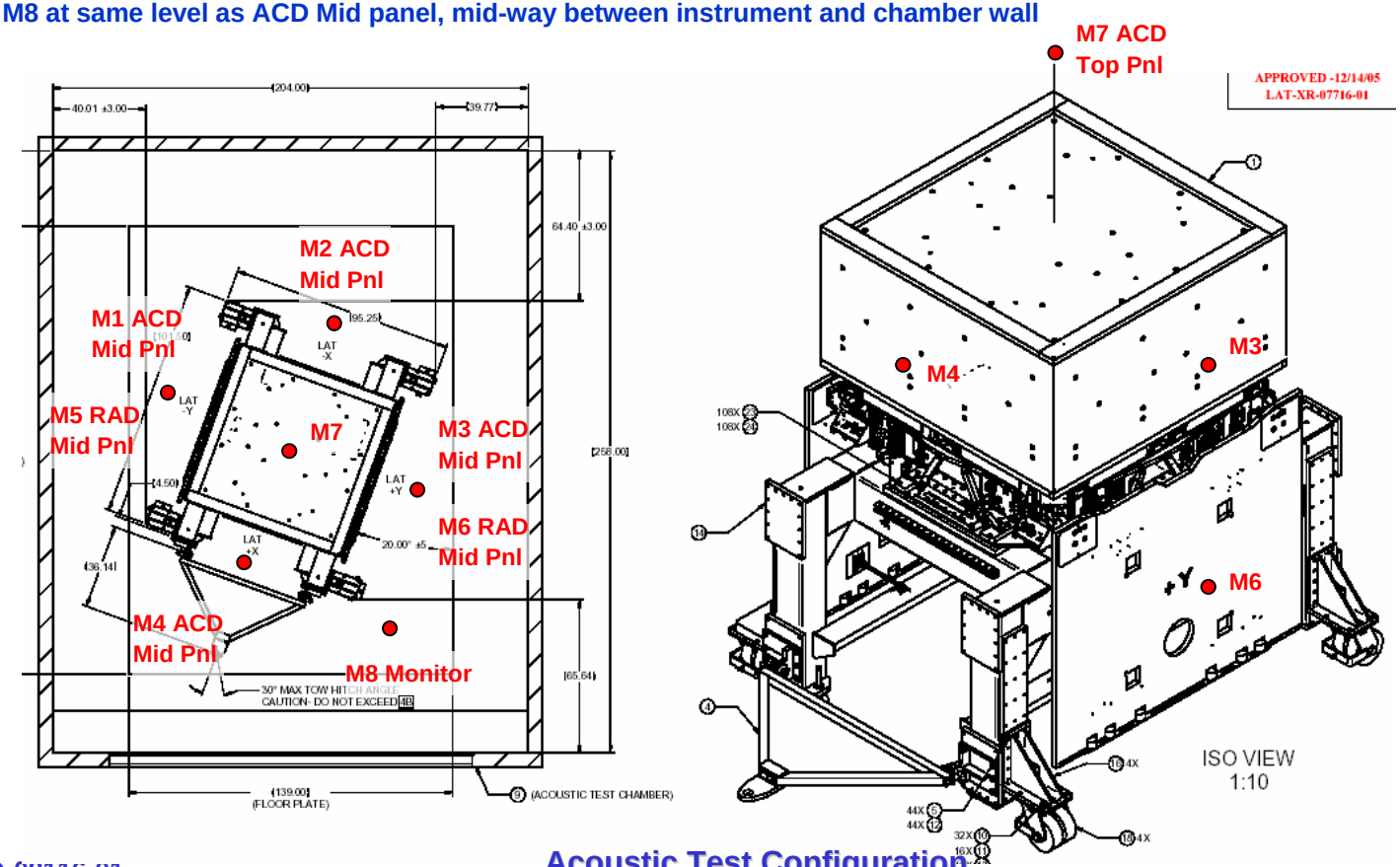
Because of the frequency shift, further inspection was requested in the area of the accelerometer. A fiberglass strut was discovered detached on one side.

Test Plan – Deviations From Flight

- Some MLI Test blankets installed instead of flight blankets
  - No spacecraft during test, so SC to LAT blankets are test blankets supported in as flight-like manner as possible
    - The flight blankets will be verified at the observatory test
- Mounted to GD/Spectrum Astro-provided test flexures and Special Test Equipment (STE)
  - Test flexures have been proof tested at GRID static test
  - TIP used to attach LAT to slip table/expander head, and has been proof tested
  - The STE is intended to simulate the influence of the SC volume and geometric proximity on acoustic pressures immediately adjacent to significant LAT surfaces, such as the XLAT plate
- Electrical Configuration
  - Voltage type accelerometers have BNC connectors
    - No adapters are needed to interface with NRL equipment
  - Strain gauges and thermocouples do not have connectors (open leads)
  - EGSE needed for LPTs but not connected during vibe or present in chamber during test
    - Connector savers are installed and removed before flight
  - No spacecraft during test, so SC to LAT cabling not connected
    - Connections, harnesses, attachment methods are not verified in this test
    - Flight SC to LAT cables verified at the observatory test

Acoustic Vibration Test – Test Configuration

- The LAT is transported and supported on the TIP on the Test Stand
  - TIP is already installed on Test Stand for all handling before and after test
  - TIP is designed to simulate SC top deck interface, so it provides a nearly flight-like interface for the test
  - Z-Axis is always vertical in the test
- The stand is simply rolled into the chamber and angled at approximately 20 degrees, as shown below
- Microphones are located as shown below (M1 - M7 control, M8 Monitor),
  - M1 through M6 approximately 36 inches away from instrument perimeter surface
  - M7 approximately 60 inches directly above ACD center
  - M8 at same level as ACD Mid panel, mid-way between instrument and chamber wall

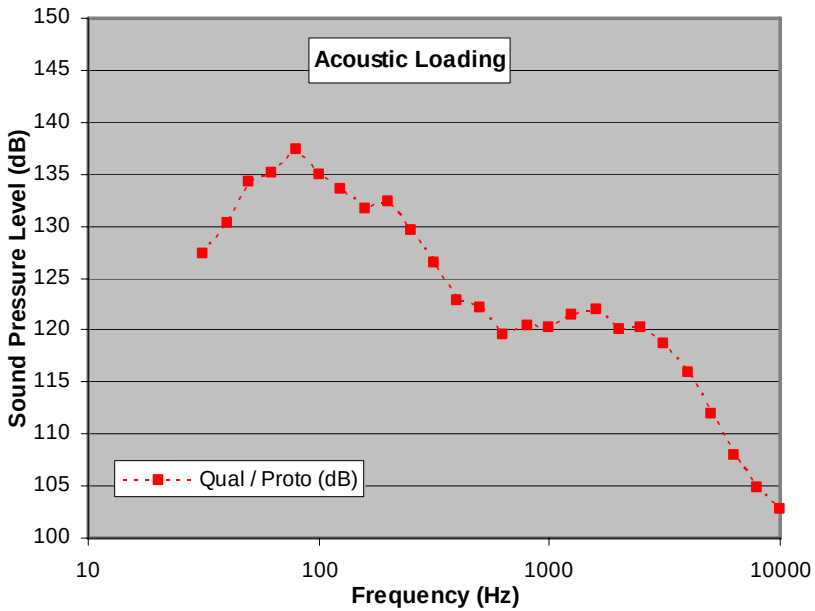


Acoustic Test Configuration

Acoustic Vibration Test – Test Plan – Requirements

- **Protoflight Test Levels**
  - The tests will be performed to the levels published in LAT-SS-00778, shown below
  - The dynamics tests are to be performed in the mode in which the equipment will observe the environment
    - LAT will be launched in a "powered off" mode
    - The acoustic vibration tests will be performed with the article powered off

Freq (Hz)*	Qual / Proto (dB)
31.5	127.4
40	130.3
50	134.2
63	135.1
80	137.4
100	134.9
125	133.6
160	131.6
200	132.4
250	129.6
315	126.4
400	122.9
500	122.1
630	119.6
800	120.5
1000	120.2
1250	121.4
1600	122
2000	120
2500	120.3
3150	118.6
4000	116
5000	111.9
6300	107.9
8000	104.8
10000	102.8
OASPL	143.8



(*) One-third octave center frequency

Protoflight Levels = Qualification Levels

Test Duration = 60 seconds for protoflight tests

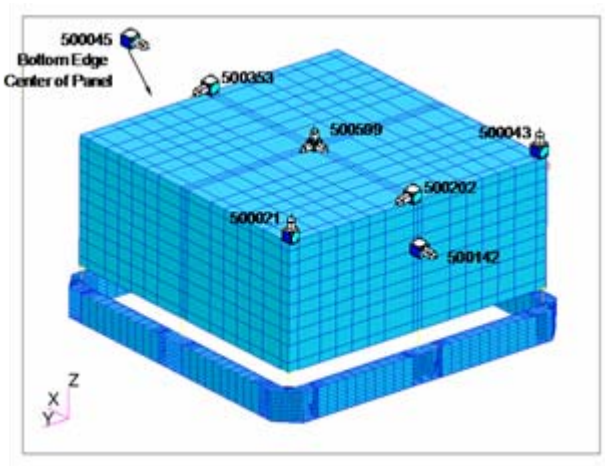
Acoustic Vibration Test Planning: Detailed Sequence

- **Pre-test Activities**
  - Ensure chamber floor is free from all debris (fasteners, tape, fibers, etc)
  - Move LAT and test stand into position in acoustic chamber via tow bar, and orient LAT at 20 degree angle from walls
  - Lock wheels and remove tow bar
  - Cable Hook-ups and system checkouts
    - Electrical connections to control system and accel tap checks (NRL)
- **Acoustic Test**
  - Instrumentation check
    - Low-level acoustic to verify that all instrumentation is operational and taking useful data
  - Pre-test “signature” run at -6dB for 30 seconds
  - Low-level acoustic run at -3dB for 15 seconds, or as-needed
  - Protoflight level acoustic run
    - Ramp up SPL to Protoflight levels and maintain for 60 seconds
  - Post-test “signature” run at -6dB for 30 seconds
    - Compare pre- and post- test overlays to verify any frequency shifts are within +/-5%
- **Post-Test Activities**
  - Limited Performance Test – reconnect EGSE cables and execute LPT while still on acoustic stand
  - Attach tow bar and unlock wheels
  - Move from acoustic chamber to clean tent

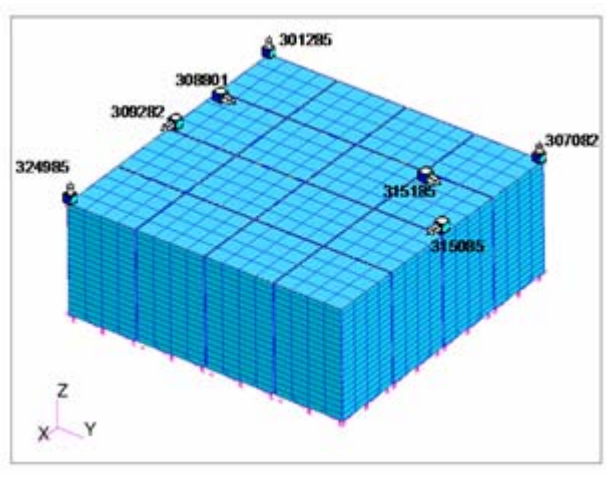
Acoustic Vibration Test – Test Configuration – Instrumentation

- Test instrumentation by subsystem, total of 65 channels, calibrated and installed by SLAC I&T, final checkout by NRL

Anti-Coincidence Detector	9 Accel Channels	9 Uni (9 Fly-away)	0 Tri (0 Fly-away)
Trackers	7 Accel Channels	7 Uni (7 Fly-away)	0 Tri (0 Fly-away)
Calorimeters	6 Accel Channels	0 Uni (0 Fly-away)	2 Tri (2 Fly-away)
Electronic Boxes	18 Accel Channels	9 Uni (3 Fly-away)	3 Tri (2 Fly-away)
Mechanical Systems	25 Accel Channels	1 Uni (1 Fly-away)	8 Tri (0 Fly-away)

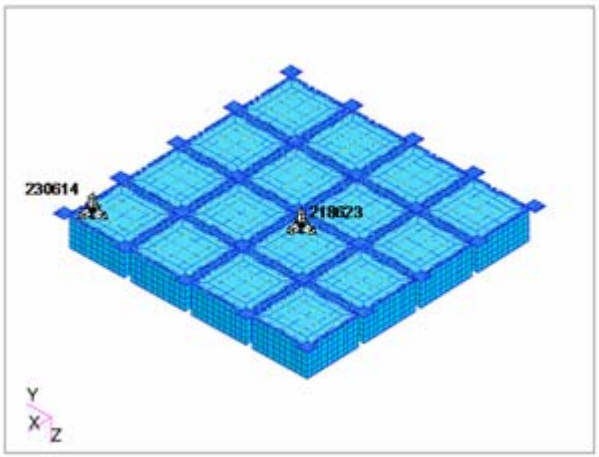


ACD Accelerometers

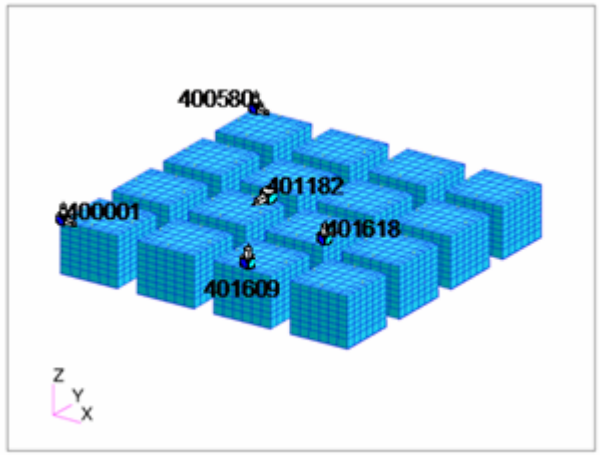


TKR Accelerometers

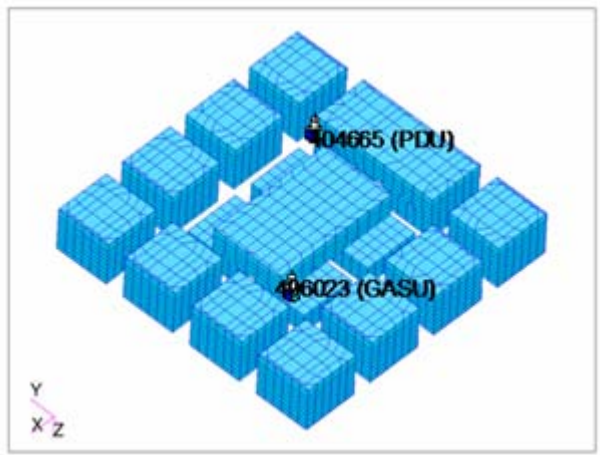
Acoustic Vibration Test – Test Configuration – Instrumentation



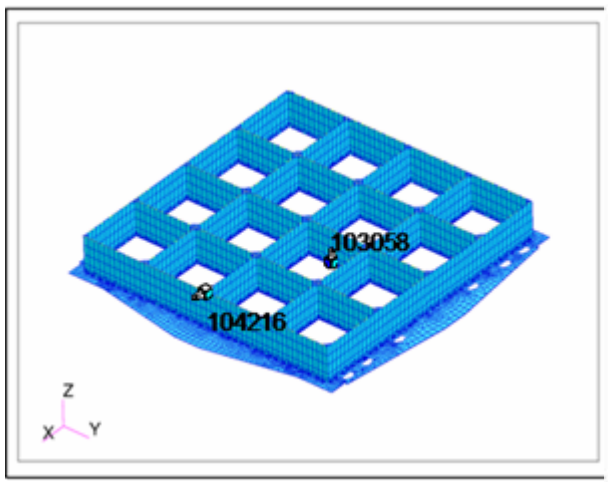
CAL Accelerometers



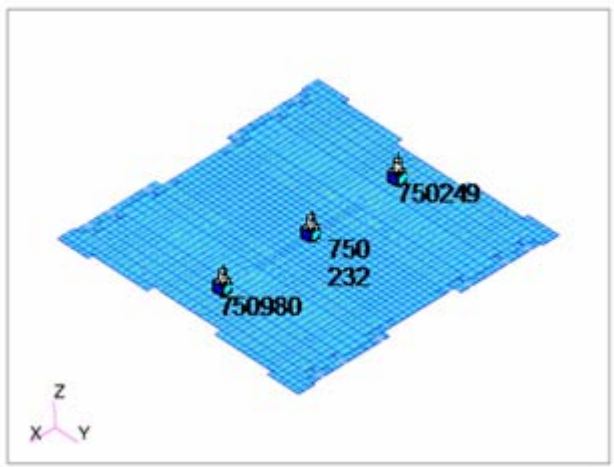
ELX Accelerometers



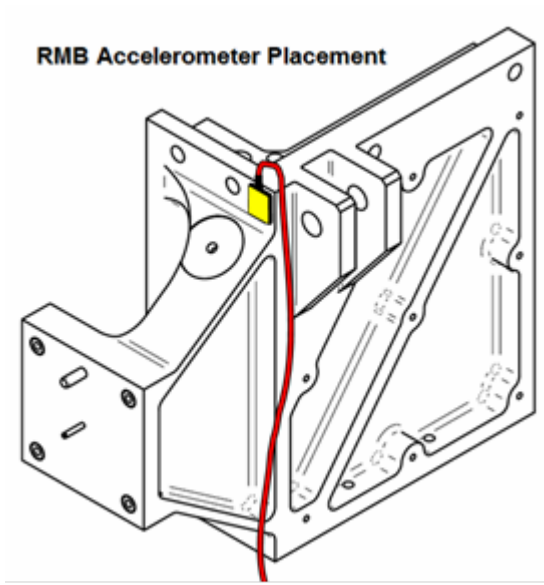
ELX Accelerometers



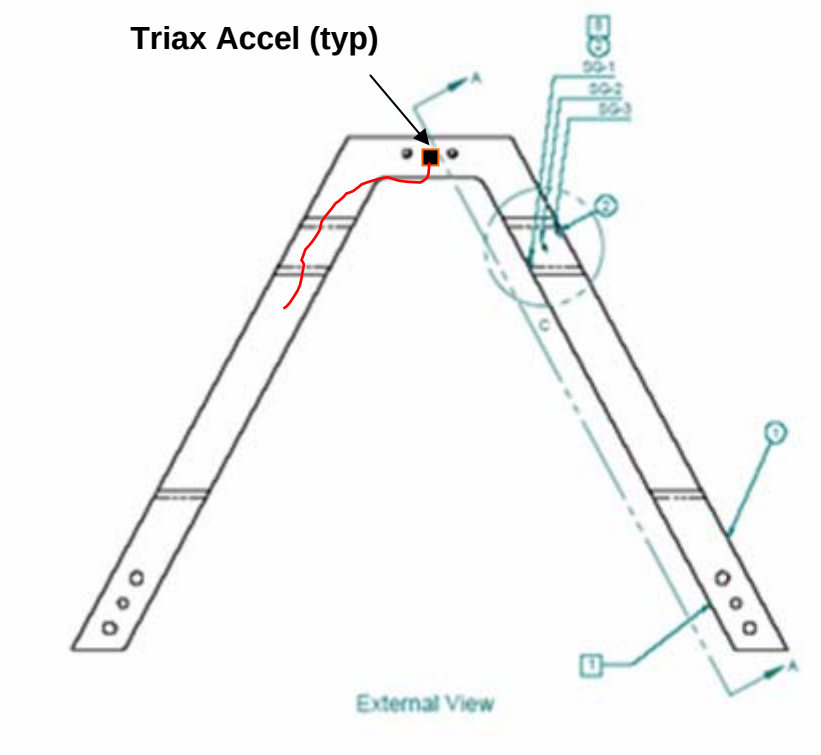
Mech Accelerometers

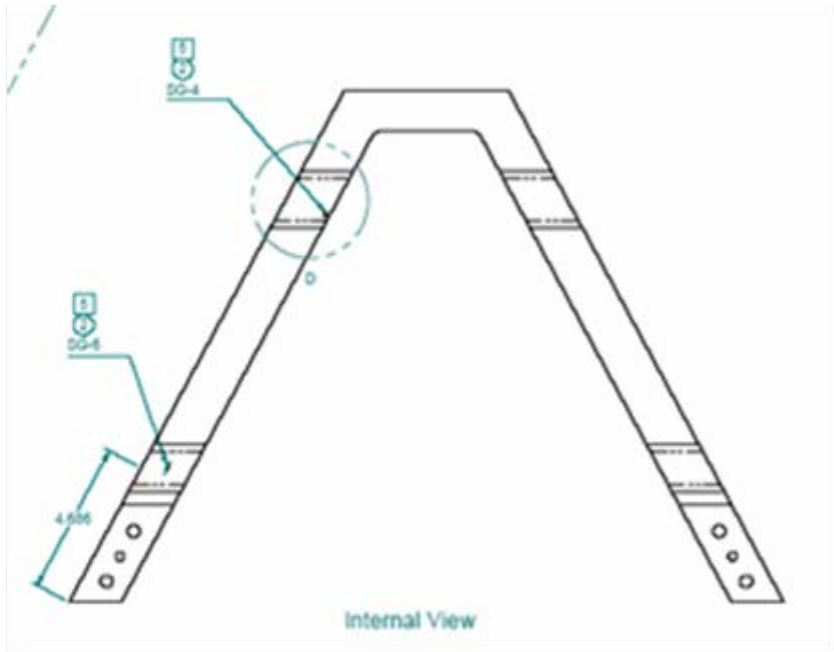


XLAT Accelerometers



Acoustic Vibration Test – Test Configuration – Instrumentation





Test Flexure Accelerometers

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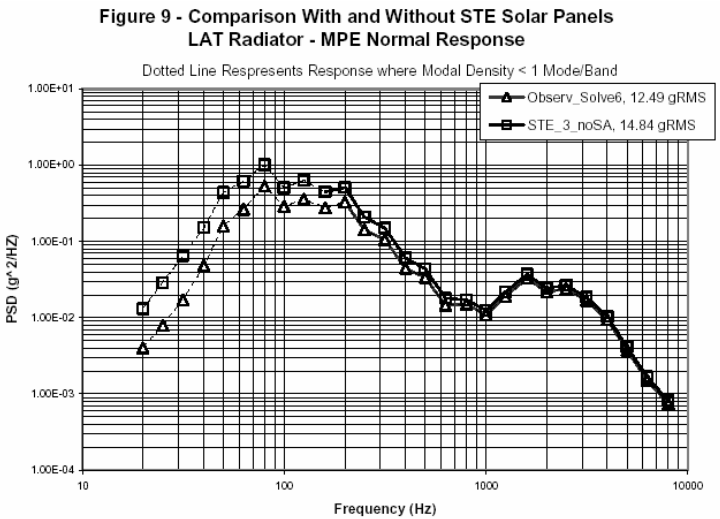
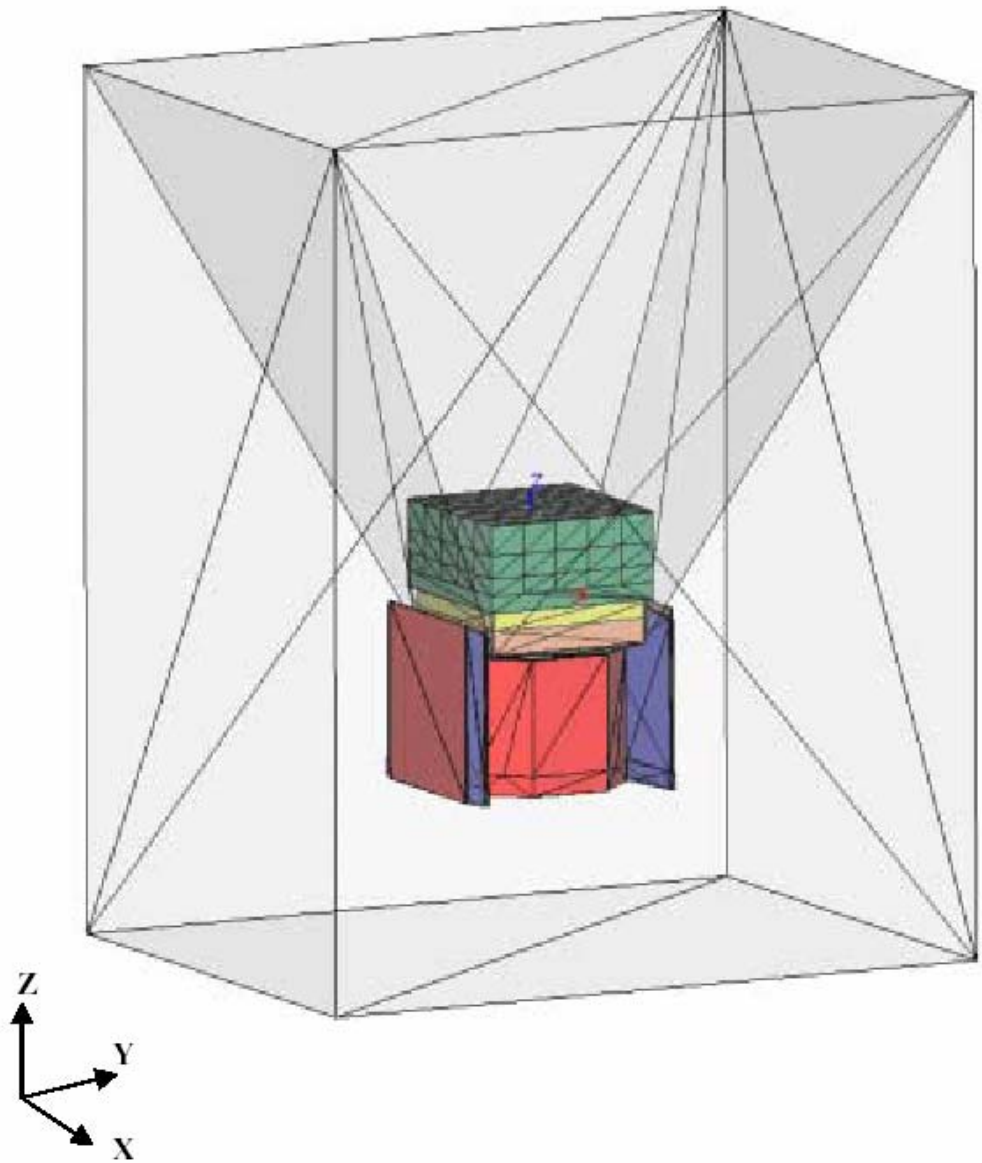
GLAST LAT Acoustic Vibration TRR: Pre-Test Analysis

John Ku kuj@slac.stanford.edu

Pre-Test Analysis: Finite Element Model

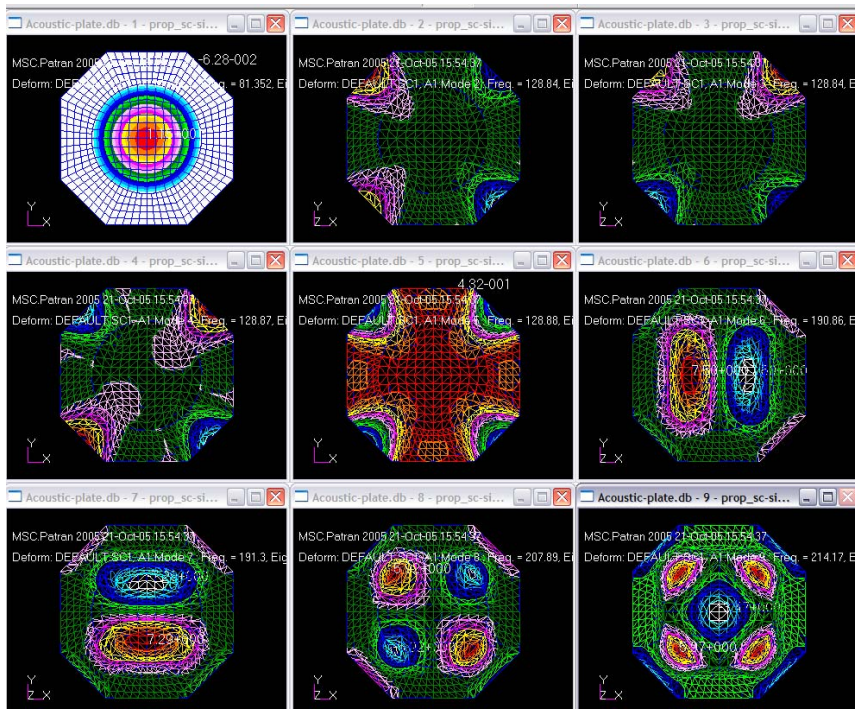




Pre-Test Analysis: Purpose

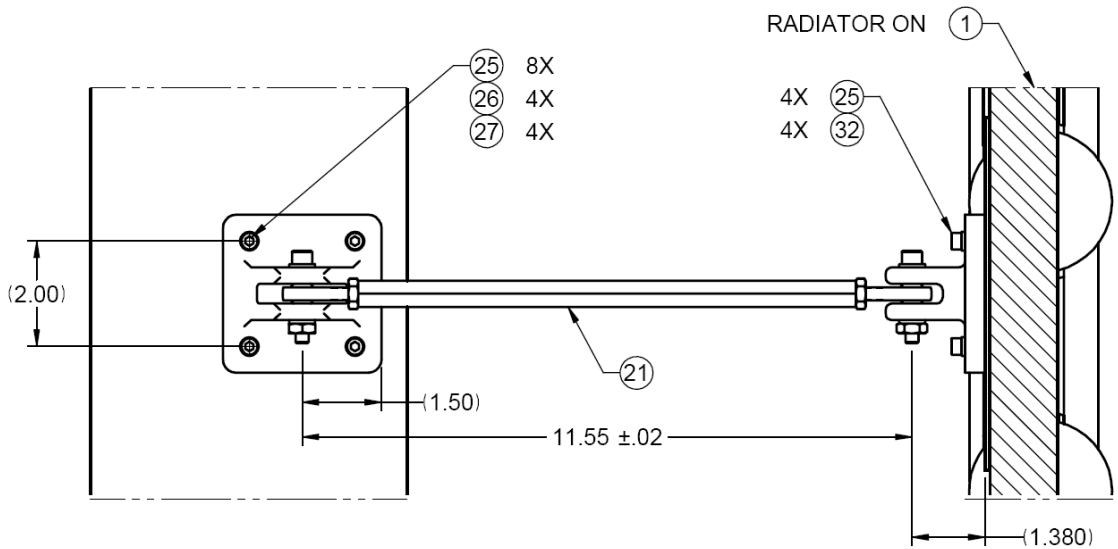
- **The GLAST observatory was analyzed using Statistical Energy Analysis (SEA) to predict vibroacoustic responses for various subsystems (SAI-TM-2467)**
  - **Subsystem test levels were derived from these results**
- **Instrument level SEA was also performed to evaluate vibroacoustic responses in the LAT when the SC is not present (SAI-TM-2621)**
  - **Analysis showed that RAD and XLAT surfaces could be subjected to artificially high acoustic pressures**
    - **RAD subsystem level testing envelopes the "unshielded" condition, so simulating solar arrays at the instrument test was not deemed necessary.**
    - **XLAT acoustic responses were significant enough that a SC Top Deck simulator was warranted. The construction is similar to the SC design, and has been mass loaded to produce a similar dynamic response**

	SC Top Deck	SC Sim w/10#	SC Sim w/19#	SC Simulator
Mass(model) [lb]	33.42	19.85	28.85	9.85
Mass(design) [lb]	29.1	21.95	30.95	11.95
Area [in^2]	1754	1385	1385	1385
f1 [Hz]	43.9	54.7	41.7	115.2
f2 [Hz]	81.1	129.4	129.4	129.4
f3 [Hz]	110.7	129.4	129.4	129.4
f4 [Hz]	170.2	129.4	129.4	129.4
f5 [Hz]	177.4	129.4	129.4	129.8
f6 [Hz]	216.8	164.0	136.7	196.2
f7 [Hz]	216.9	173.6	150.3	196.8
f8 [Hz]	290.1	220.1	215.8	227.0
f9 [Hz]	315.8	225.6	223.2	256.1



Pre-Test Analysis: Purpose

- **A radiator level SEA was also performed to determine optimal lower strut mount aggregate stiffness (SAI-TM-2903)**
  - **Spacecraft strut stiffnesses are calculated to be**
    - **8,061 lb/in & 15,657lb/in for –Y**
    - **~35,500 lb/in for +Y**
  - **Analysis showed that an aggregate strut interface stiffness of between 5,000 and 7,000 lbs/inch would accomplish the detuning necessary to avoid excessive panel response with respect to the Observatory test.**
    - **However, with the LAT test stand affording some shielding, an intermediate number, closer to SC stiffnesses is preferred.**
    - **It was decided that customizing each strut stiffness was not a practical way to go**
  - **As designed RAD lower strut mount interface has an aggregate stiffness of ~18,000 lb/in**



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GLAST LAT Acoustic Vibration TRR: Test Procedure Review

John Ku kuj@slac.stanford.edu

Acoustic Vibe Test Procedure Details

- **See the table, below, for a list of all MGSE/STE that is needed for conducting the Acoustic vibe test**

All MGSE is built, proof-tested and ready for use

MGSE Assembly	Use / Comments
Test Stand	Holds LAT during test
Test Interface Plate Ass'y	Mounts LAT to test stand
Grid Perimeter Ring	Lifting fixture for hoisting LAT into position
4x4 Lift Fixture	Lifting fixture for hoisting LAT into position
MGSE Cart	Parking space for GPR/4x4 Fixture
Chill Bars and Aux. Cooling	Cool LAT for pre-/post-test LPT's

MGSE/STE Needed for Acoustic Vibe Testing

Logistics: Other Considerations

- Thermal Blankets are intalled
- Auxiliary cooling plans
  - LAT needs to be cooled during LPT's between each vibe axis run and before and after
    - Chill Bars: one under each of the wings on the Grid
    - Chill bars remain on the LAT during vibe, but hoses are disconnected using quick-disconnect fittings
  - This is room-temperature cooling to remove LAT process heat
  - To simplify cooling connections, Chill Bars and X-LAT cooling will be designed to handle vibe loads
- Handling and mechanical operating procedures covered in LAT-PS-07728-01
  - LAT lifting procedure
  - TIP mounting procedure
- EGSE Constraints → fully compliant
  - EGSE Cables
    - Disconnected during vibration
    - Must be long enough to reach LAT while mounted to either expander head or slip table
    - Cable trays or protection if laid on floor
  - Cart with EGSE Hardware
    - Portable, can be rolled out of the way during vibration test
    - Power interface to lab established

Logistics: Other Considerations (cont.)

- Non-conformance reporting
  - Handled in LAT-MD-00471
- Expected Test Durations
  - LPT estimated to take 6 – 8 hours
  - Instrumentation check 4-8 hours
  - Pre-test “signature” run at -6dB for 30 seconds → 1 hour
  - Low-level acoustic run at -3dB for 30 seconds → 1 hour
  - Protoflight level acoustic run → 1 hour
  - Post-test “signature” run at -6dB for 30 seconds → 1 hour

Schedule

- **Optimistic but feasible Schedule**
  - **Jun 28 → We → 1) TRR 2) Move LAT to chamber**
  - **Jun 29 → Th → 2) System Checkout**
  - **Jun 30 → Fr → 1) Run test**
  - **Jul 0 1 → Sa → 1) EGSE LPT 2) LAT to clean tent**

Manpower

- **Test Personnel**
  - **Test support personnel have been confirmed**
    - **GPO Representative: Chris Fransen for Paul Baird (NASA)**
    - **Test Director: John Ku (SLAC)**
    - **Test Conductor, Vibration: Bob Haynes (NRL)**
    - **Test Conductor, Science Subsystem: Eric Grove (NRL)**
    - **Test Conductor, Electrical Subsystem: Brian Grist (SLAC)**
    - **Discipline Lead: Jim Haughton (NRL)**
    - **Facility Manager:Bill Raynor (NRL)**
    - **Mechanical Lead: Marc Campell (SLAC)**
    - **High-bay operations: Paul Dizon (NRL)**
    - **Quality Assurance: Joe Cullinan (SLAC)**
    - **I&T Manager: Ken Fouts (SLAC)**
  - **Subcommittees will be assembled from the appropriate personnel above, with expert consultation brought in if needed**
    - **Potential Vibration Experts: Paul Baird; Chris Fransen; Bill Haile**

Acoustic Vibration Facility Readiness

- Bare Chamber run to protoflight levels is complete and verified
- Handling Pathfinder has been verified
- Accelerometers – calibration is current
- Amplifiers – calibration is current
- Facility is ready to support LAT Vibration Test Activities
- All essential test personnel available for scheduled test

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GLAST LAT Acoustic Vibration TRR: Wrap-up and Conclusions

Neil Johnson neil.johnson@nrl.navy.mil

Acoustic Vibration TRR Action Item Form

- **Topic / presentation slide number:** _____
- **Submitted by:** _____
- **Actionee:** _____
- **Request:** _____

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- **Reason / Comment:** _____

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