Mechanical Systems

GLAST LAT Mass Properties Test Readiness Review

Contents

Mechanical Systems

GLAST LAT Mass Properties TRR: Test Plan Review

Mass Properties Test – Document List

GOVERNMENT SPECIFICATIONS

Number	Title
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

NON-GOVERNMENT SPECIFICATIONS

Number	Title
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
N/A	INSTRUMENTATION MANUALS
LAT-TD-08247	GLAST LAT MASS PROPERTIES TEST REPORT
LAT-TD-08117	TRR SLIDE PACKAGE

DRAWINGS

Number	Title
LAT-DS-08371	LOAD CELL BASES
LAT-DS-08303	OCTAGONAL TEST PLATE
LAT-DS-06170	TEST INTERFACE PLATE
LAT-DS-06191	LAT CONFIGURATION

Mass Properties Test Plan – Objectives

- **The LAT will be set atop of a test platform where mass properties testing will be performed to accomplish the following objectives:**
  - **Measure the overall mass and CG of the fully integrated LAT**
  - **Verify the following three IRD requirements:**
    - **LAT mass does not exceed 3000kg**
    - **By Analysis, show Z_{cg} is a maximum of 185mm above the LAT Interface Plane (LIP)**
    - **By Test, show X-cg and Y-cg are within 20mm of the LAT Coordinate System (LCS) Z-axis**
- **A secondary goal is to verify that the measured mass properties coordinate with the math model mass matrix**

Mass Properties Test Plan – Entrance/Exit Criteria

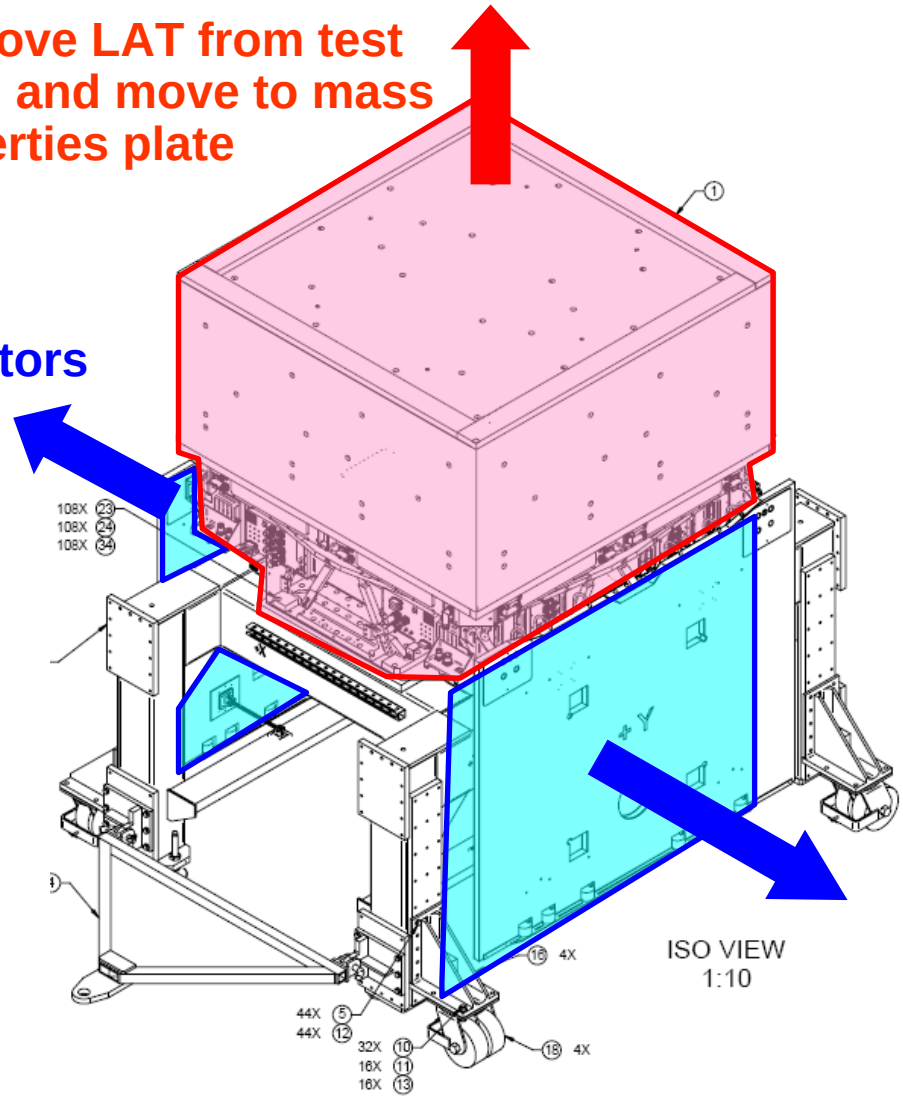
- **The Mass Properties Testing is performed following the LAT thermal vacuum test. The following criteria is to be met before the mass properties testing can begin:**
  - **LAT radiators have been removed and the LAT, flexures, and TIP have been moved into the mass properties test area- visual inspection 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 in the test procedure and Slide 7.**
  - **Remove triple joint cover plate (non-flight)**
  - **Remove chiller bars**
  - **All subsystem units/modules function—each subsystem has passed its CPT following TVAC. Any performance discrepancies have been clearly documented.**
  - **Ensure all E-GSE cable harnesses have been removed from the LAT prior to test.**
  - **All load cells, support equipment, and electronics are in place and functioning properly. Instrumentation has been mounted in correct locations and orientations following the protocol in the test procedure. All non-fly-away accelerometers and other test instrumentation, cables and harnesses are removed or offloaded**
  - **Pass this Mass Properties Test TRR**

- **Whether or not the mass properties testing is successful will be determined by the following exit criteria:**
  - **Visual inspection of the LAT verifying that there is no visual damage**
  - **Preliminary examination of the recorded data; all data is usable for analysis**

Mass Properties Test Plan – Deviations From Flight

•Remove LAT from test stand and move to mass properties plate

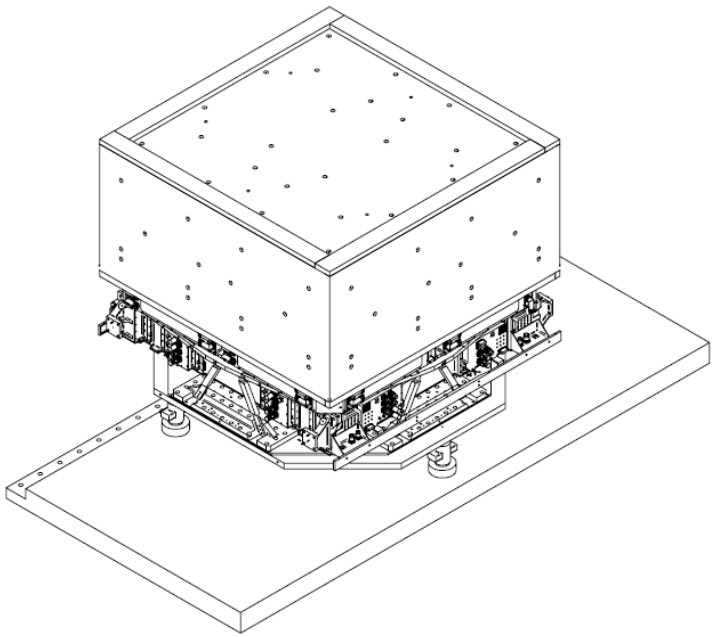
•Remove Radiators



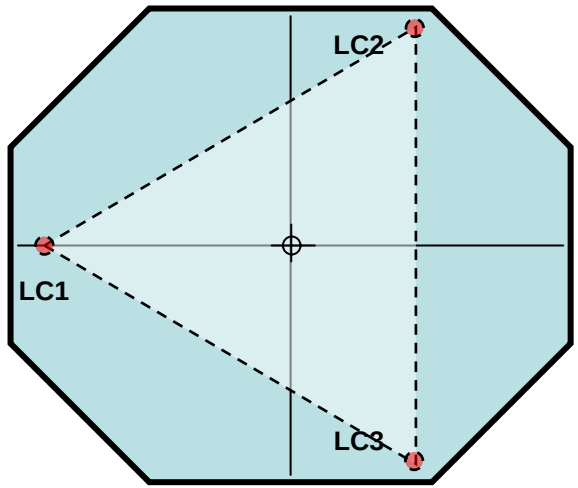
- The following flight hardware is not installed for the mass properties test
  - Radiators not installed
  - Radiator Blankets
  - Fly away instrumentation shorting plugs
  - Miscellaneous tape and sealants
- Additionally, the following non-flight items are installed
  - Connector savers
  - ESD/Contamination control Bag

Mass Properties Test – Test Configuration

- The LAT is mounted to the test interface plate
- The test interface plate is then lowered onto the test platform which will take the mass and cg measurements
- The test platform comprises
  - An octagonal plate (LAT DS-08303) to transfer the weight of the LAT to the three load cells without inducing detrimental distortion to the TIP
  - Three load cells (5K Beowulf model 200-S P/N: LC2030) arranged in an equilateral triangle whose centroid is aligned with the LCS
  - NRL Modal survey plate which provides a stable platform for the test



Test Configuration



Test Platform Top View:

Octagonal test plate and locations of the three load cells

Test Spreadsheet

LAT Mass Properties Testing

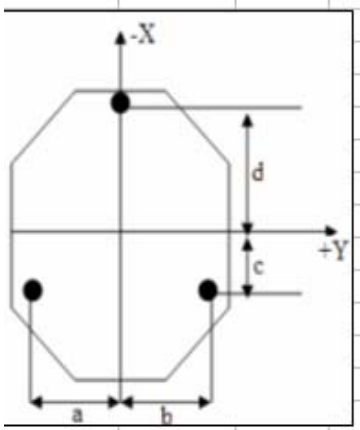
Load Cell	Trial 1
1 [lb] =	1953.3
2 [lb] =	1953.6
3 [lb] =	1953.8
Total [lb] =	5860.7
Xcg [in] =	-0.00373
Ycg [lb] =	0.001536
Time of Trial:	

Load Cell	Trial 2
1 [lb] =	1954
2 [lb] =	1953.9
3 [lb] =	1953.7
Total [lb] =	5861.6
Xcg [in] =	0.000512
Ycg [lb] =	-0.00019
Time of Trial:	

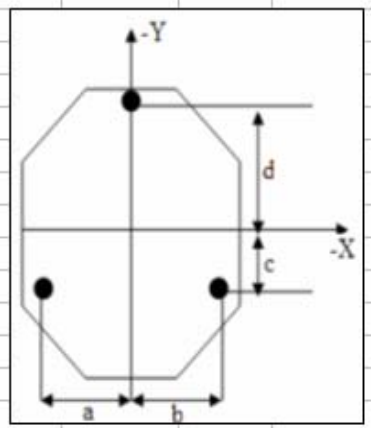
Load Cell	Trial 3
1 [lb] =	1953
2 [lb] =	1953.3
3 [lb] =	1953.1
Total [lb] =	5859.4
Xcg [in] =	0.001371
Ycg [lb] =	0.001536
Time of Trial:	

Load Cell	Trial 4
1 [lb] =	1953.2
2 [lb] =	1953.4
3 [lb] =	1953.3
Total [lb] =	5859.9
Xcg [in] =	0.001024
Ycg [lb] =	0.001667
Time of Trial:	

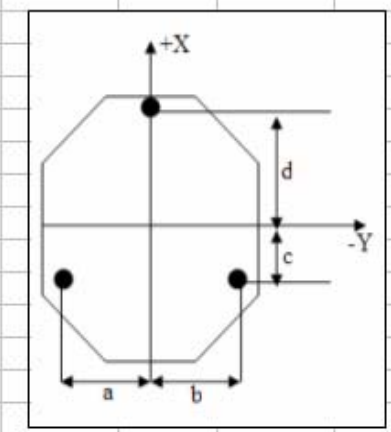
Load Cell	Trial 5
1 [lb] =	1953.6
2 [lb] =	1953.5
3 [lb] =	1953.4
Total [lb] =	5860.5
Xcg [in] =	-0.00078
Ycg [lb] =	-0.00051
Time of Trial:	



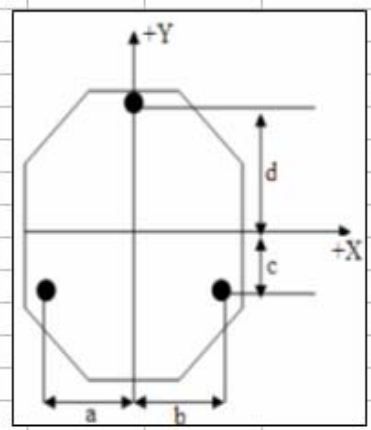
Orientation for Trials 1 & 5



Orientation for Trial 2



Orientation for Trial 3



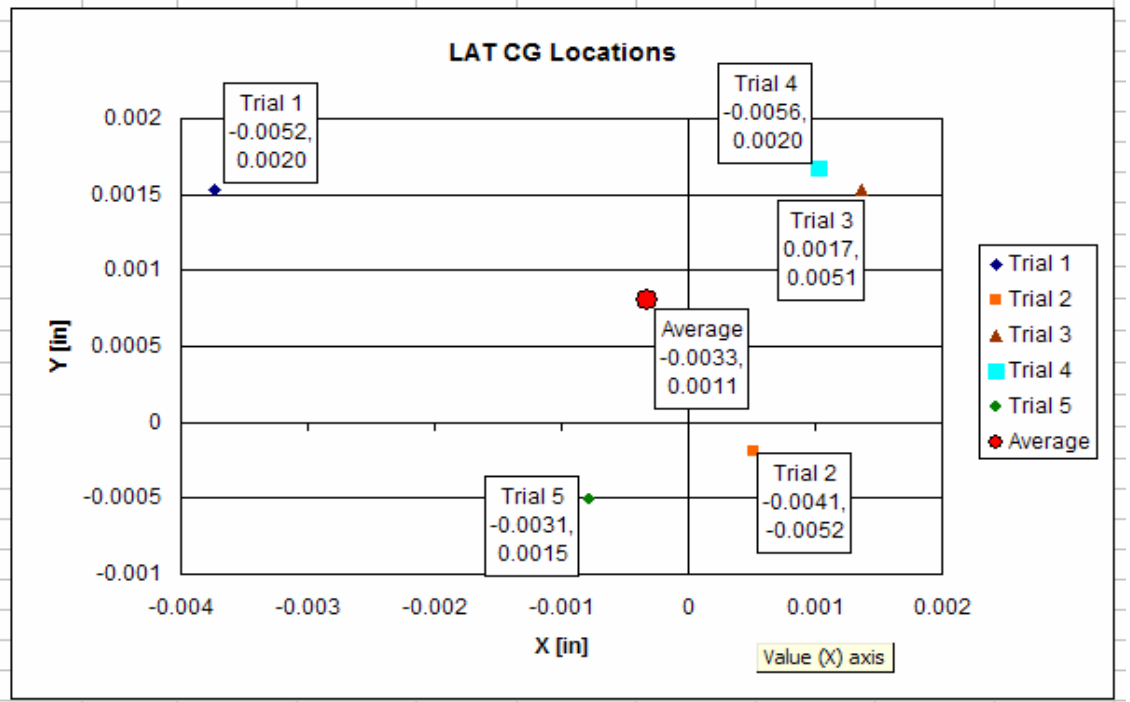
Orientation for Trial 4

Test Spreadsheet, page 2

LAT Mass Properties Testing

Load Cell Locations w.r.t. Geometric Center	
a [in] =	30
b [in] =	30
c [in] =	17.31
d [in] =	34.625

	Xcg [in]	Ycg [in]	Weight [lb]
Trial 1	-0.00373	0.0015	5860.7
Trial 2	0.000512	-0.0002	5861.6
Trial 3	0.001371	0.0015	5859.4
Trial 4	0.001024	0.0017	5859.9
Trial 5	-0.00078	-0.0005	5860.5
Average	-0.00032	0.0008	5860.42



Test Conductor: _____

Quality Assurance: _____

Test Director: _____

Alignment and Accuracy

- **Alignment**
  - To calculate mass and CG of the LAT, the load cell positions must be known w.r.t. the LAT coordinate system. To accomplish this, the following true positions are known:
    - Load cell positions w.r.t. indexing pin locations
    - Indexing hole and slot positions w.r.t. LAT coordinate system
  - From these positions, the load cell positions in LAT coordinate system is known.
  - From the Load cell positions, a sum of moments about the LCS is performed to calculate X_{cg} and Y_{cg}

- **Accuracy**
  - The 5 KIP load cells have been calibrated to be accurate within 0.5%, or ±25 lb_f
  - A dry run was performed on 9/10/06
    - 3000 lb_f reference mass weighed in at 3007, 3012, 3011, and 3010 in four readings
    - Additional reference mass was added, which showed accuracy to 2.5 ± 0.5 lb_f
  - Worst case aggregate error on mass is believed to be on the order of 10 lbf, or less than 0.5%
  - CG calculations will be taken in four orientations (0°, 90°, 180°, 270°) and then averaged in order to cancel round-off errors

Mass Properties Test analysis - Summary

- Mass properties platform has been analyzed to evaluate the following structural elements:
  - Distortion under load – peak distortion is 0.012 inches (minimal rotation) out of plane, which is on the same order of magnitude as plate flatness – under 1g load, this is insignifcant
  - Stresses in the plate – maximum stress under load is 2.54 ksi → margins high
  - Tip-over loads – minimum lateral load for tip-over is over 1000 lb_f, which is not credible
  - Handling loads – 2-point lift margins are high

- Mass properties spreadsheet has been updated to include
  - 97.8% measured mass (2727.2 kg)
  - 2.2% calculated mass (61.8 kg)
  - Total mass = 2789.0 kg
  - Current Predictions (including radiators)
    - Xcg = -1.57 mm
    - Ycg = -1.2 mm
    - Zcg = -65.99 mm

- Analysis is provided in the Back-up slides

Expected Test Schedule and Durations

Date of Test:
9/12/06 – 9/13/06

Time	Duration	Task
	1 hour	Position LAT on the platform, get load cell reading
	1 hour	Lift LAT off platform, rotate 90 degrees, remount to plate, get load cell reading
	1 hour	Lift LAT off platform, rotate 90 degrees, remount to plate, get load cell reading
	1 hour	Lift LAT off platform, rotate 90 degrees, remount to plate, get load cell reading
	1 hour	Lift LAT off platform, rotate 90 degrees, remount to plate, get load cell reading

Personnel

The following personnel are responsible for the procedures of the test:

Role	Name	Telephone Number
Project Representative	Scott Clough Paul Baird	(301) 286-7007 (301) 471-4822
Test Director	John Ku	(408) 910-4139
Test Conductor, Primary Instrumentation/Data Support	Bob Haynes	(202) 404-7139
I&T Support	Bill Olson Eliazar Ortiz Leo Manger Tom Nieland Dave Kheil	
Quality Assurance Support	Joe Cullinan Doug Bartholemew	(650) 926-5034
Facilities Logistical Support	Bill Rayner	(202) 767-0704
High Bay Logistical Support	Paul Dizon	(202) 404-7139

Mass Properties Facilities Readiness and Schedule

- Facilities ready to go
  - Mass properties test dry-run complete on 9/10/06 → all systems go
- LAT ready to go
  - LAT extracted from TV chamber 9/10/06
  - LAT rotation complete 9/10/06
  - Radiator removal estimated completion 9/11/06
- LAT ready to test 9/12/06 – 9/13/06
- Preliminary report complete 9/14/06

Mass Properties TRR Action Item Form

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

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- **Reason / Comment:** _____

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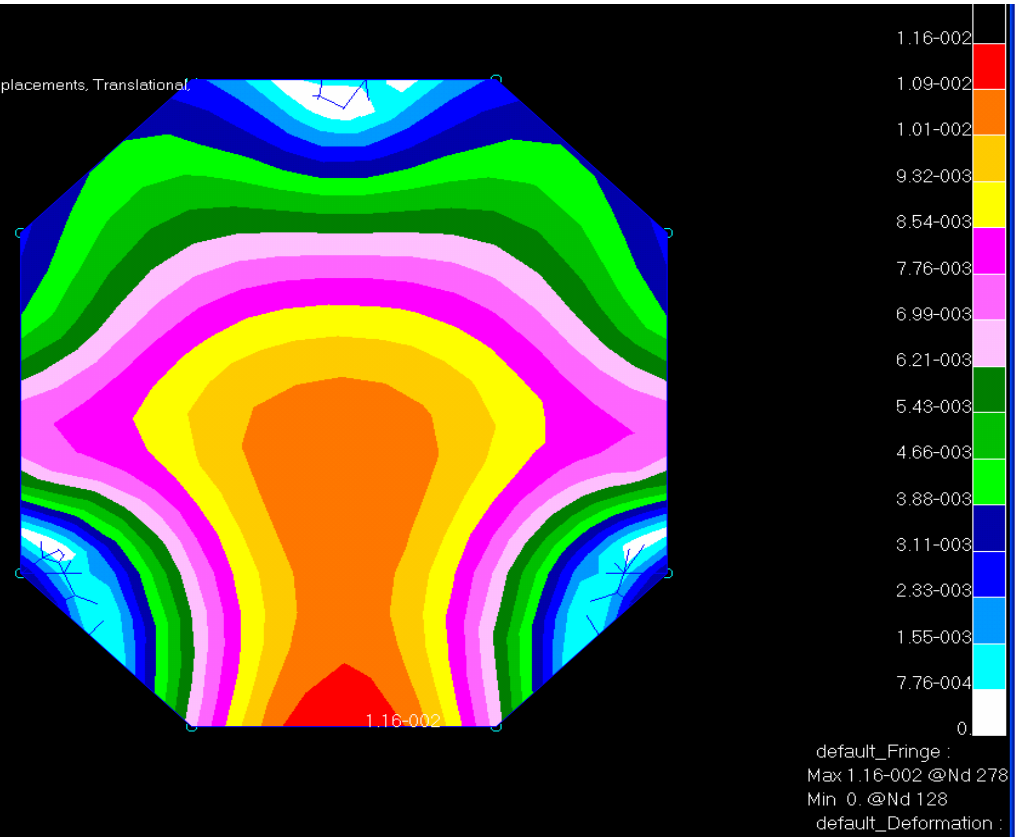
Mechanical Systems

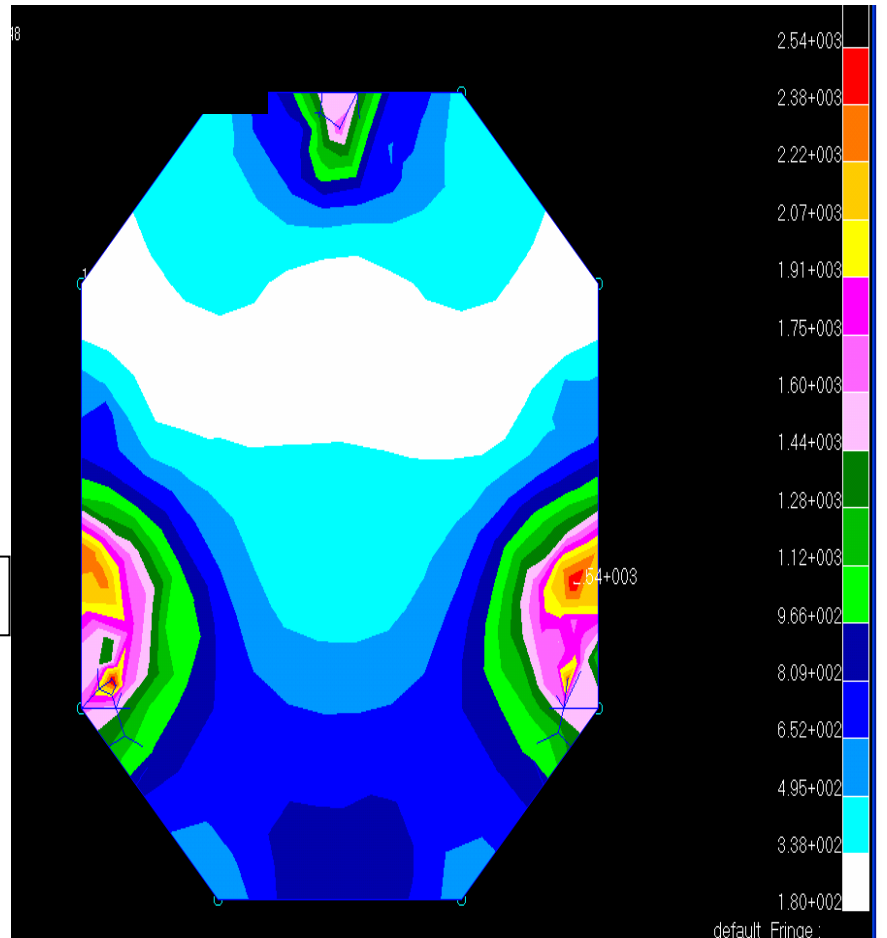
GLAST LAT Mass Properties TRR: Back-up Slides

Finite Element Models

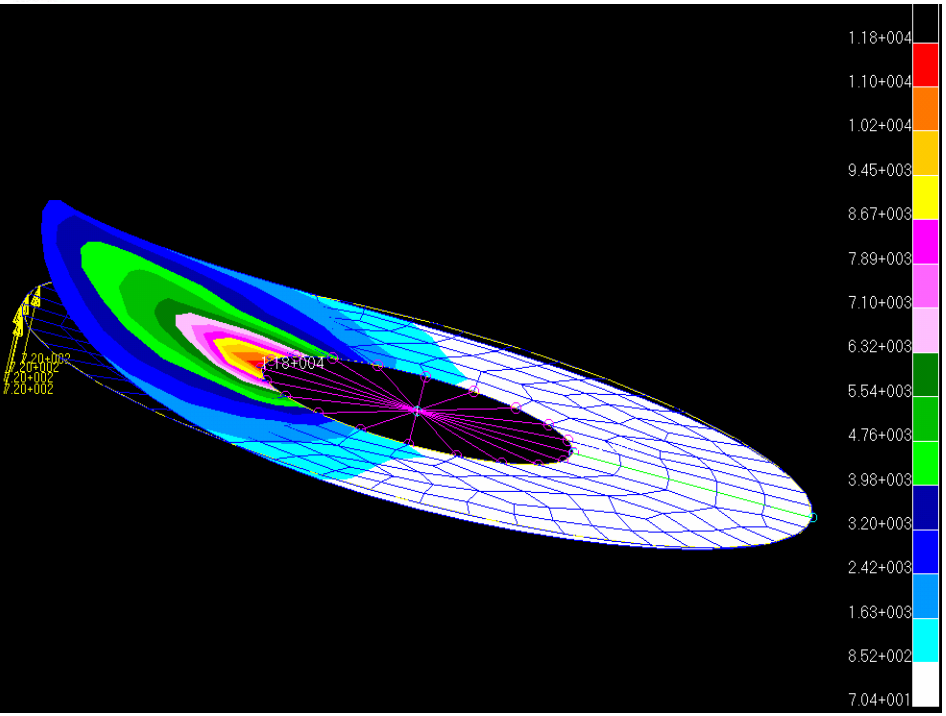


Shown above are the displacements (inches) of the octagonal plate when the LAT and test interface plate are mounted on top and secured

Shown below are the stress reactions (lbs/in^2) of the octagonal plate when the LAT and test interface plate are mounted on top and secured

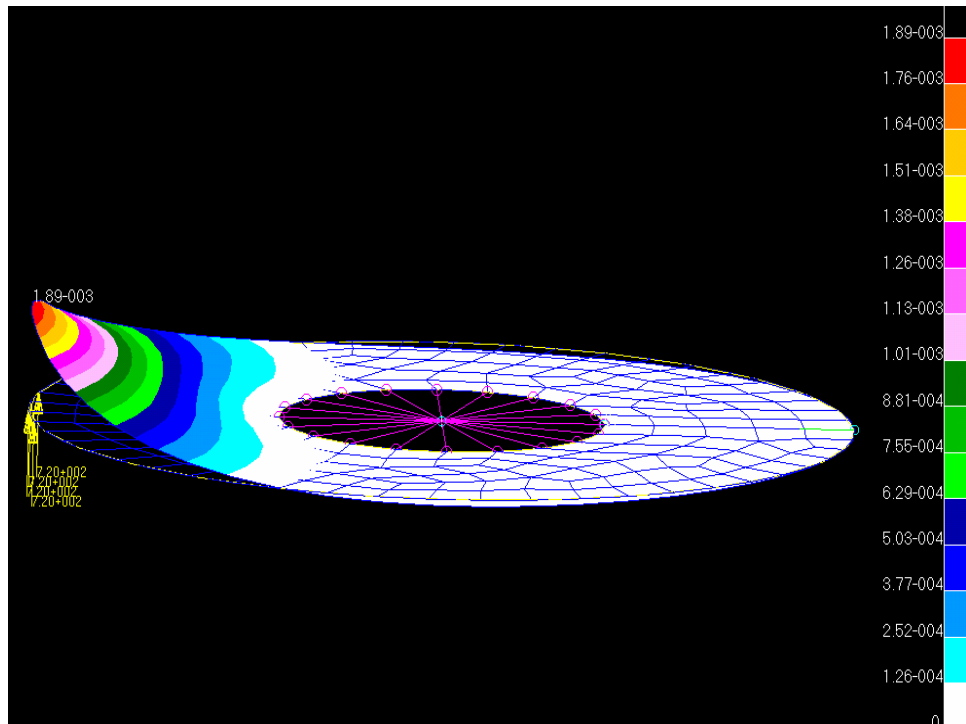


Finite Element Models



Shown above are the stress concentrations (lb/in^2) of the load cell base plate when a force strong enough to tip the load cell occurs

Shown below are the displacements (inches) of the load cell base plate when a force strong enough to tip the load cell occurs



Calculations

Final Results of the Hand Calculations and Finite Element Modeling

	Max Stress	Max Displacement
Load Cell Base	< 11,800 lb/in^2	< .00189 in
Test Plate	2540 lb/in^2	.0116 in

Tip-Over Force for Load Cell → **1118 lbs**

Tip-Over Force for Entire LAT → **5010 lbs**

** The force for the load cell was calculated as if the force were applied at the top edge of the load cell, while the force for the entire LAT were calculated as if it were applied at the CG of the entire system **

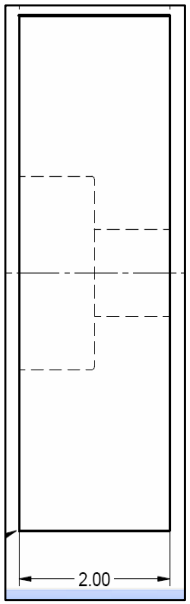
Calculated Torques

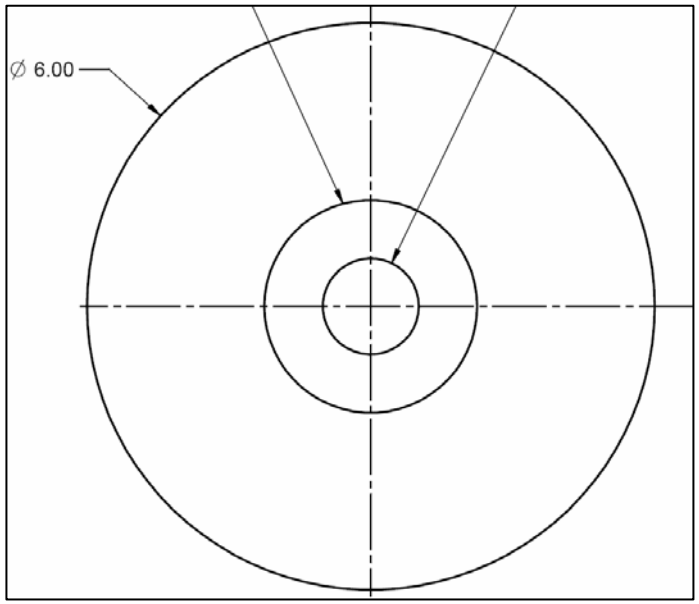
Required torques were calculated for three crucial fasteners in the mass properties testing

Fastener Type	Torque
#10-32 UNF	40 in x lb
½ -13 UNC	100 ft x lbs
1 – 14 UNF	190 in x lbs

- A tear out shear was calculated for the swivel rings
  - Calculated as a two-point lift
  - A36 steel has a yield of 36 ksi (21.6 ksi when the shear to tension yield ratio is considered)
  - The allowable shear would be 21.6 ksi, while the swivel had a tear out shear of only 7.9 ksi
- The threat of a tear out is not realistic with the 1.5” plate

Drawings for the Load Cell Base and Octagonal Plate





Shown above is the drawing for the load cell base plate

Shown below is the drawing for the octagonal plate