GLAST-LAT MEMORANDUM

20 January 03

TO:	**William Althouse**	**LAT No.:**	**LAT-LR-00870-01**
FROM:	Dick Horn	**Ref. No.:**	LAT-TD-00793 LAT-LR-01120-01

SUBJECT: Tracker Vibration Test Anomaly Review Committee Report

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1.0 Summary

This memorandum summarizes the findings and recommendations of the Tracker Vibration Test Anomaly Review Committee chartered by the LAT IPO to investigate the tracker prototype vibration test failures documented in LAT-TD-00793 and associated corrective actions. The review committee consisted of the following individuals:

Dick Horn--Chairman
Tim Thurston (LAT Sys. Engr., Mech Engr)
Tune Kamae (LAT Scientist)
Minh Phan (GSFC Mech. Engr.)
Ben Rodini (Swales carbon fiber structure mech engineer)

Six review meetings with the tracker team were completed. These meetings were structured as follows:

Meeting 1 - 2 July, Understand failure, data available, analysis results, and probable cause(s)
Meeting 2 - 8 July, Review & concur on likely cause
Meeting 3 - 9 July, Review candidate corrective actions
Meeting 4 - 11 July, Review selected corrective action plan
Meeting 5 – 6 August, Review FEM failure analysis plan
Meeting 6 – 14 August, Review closure plan

A splinter meeting was conducted with the Hytec analysis group by Tim Thurston to audit the

Tracker FEM. The summary of this evaluation and FEM recommendations is provided in LAT-LR-01120-01.

All materials and meeting minutes are available on the LAT Tracker Website:

http://www-glast.slac.stanford.edu/Tracker-Hardware/ART/art1.html

During the 14 August meeting it became apparent that the original design had insufficient design margin and there was irresolvable uncertainty in the interdependency of the two test failures. This led to a recommendation that a modified design approach be pursued that could demonstrate excessive design margin. In addition the new design approach needed to be supported by an improved knowledge of material allowables, FEM analysis, design and EM test readiness review.

Given the findings of the ARC, the LAT IPO charged the Tracker Subsystem to evaluate alternatives that would ensure excessive design margin and address the ARC findings to the extent possible. Further, the ARC was released pending completion of an implementation plan.

2.0 Findings

In summary, the Review Committee concurs with the Tracker Team assessment that the bottom tracker tray was likely under designed and that the corner mount failure was aggravated by the over stress condition which occurred during the first test. Specific findings are outlined below as requested by the LAT IPO.

2.1 Tracker Design, Analytical Models and Margins

Several areas of concern were identified with respect to the proto type design:

- Polymeric thermal gasket failure led to instability in the dynamic response that corrupts our ability to correlate the failure to the analytical model. In addition, the design approach has a low probability of success, therefore the Review Committee concurs that the design change to a metallic thermal interface should be an improvement over the current thermal design.
- The planned sidewall screw-locking feature should be implemented before the next test. Although considered to be a secondary locking feature by the Tracker Team, the Review Committee believes failure of this interface during future tests would have too high a consequence to warrant delaying implementation.
- Consider a single-piece flexure design to possibly improve strength and response. It is noted that the flexure/grid interface design is being simplified due to the deletion of the polymeric gasket.
- Consider titanium inserts instead of aluminum ones in the bottom tray sidewalls for better CTE compatibility within the Carbon-Carbon
- Consider increasing the head diameter of the bottom tray sidewall inserts to spread out the fastener loads in the Carbon-Carbon.
- If possible, maintain a minimum of three insert diameters edge-distance and side-distance for inserts in the sidewalls.

- The processes used for machining parts and insert installation need to be clearly specified and validated. The Review Committee did not receive sufficient detail in these areas and it is understood that the Italian partners will be responsible for this effort with the Engineering Model versus the U.S. vendor used for the Proto type.
- Allowables for Carbon-Carbon should utilize a B-Basis for margin of safety calculations
- In addition to the Launch Vehicle Quasi Static Loads, The Margin Safety of the stress analysis should include the dynamic loading conditions such as random vibration, and the Thermal Induced Stress (such as temperature gradient, bulk temperature change between the ambient condition and the predicted max temperature range)
- For random vibration, the stress analysis of fasteners to the lower tray should assume a load factor in shear of 1.25(TBR) to account for uneven load distribution amongst fasteners due to tolerance build-up. This assumes that tolerances are controlled to less than 3 mils.
- A fitting load factor of 1.15(TBR) should be applied to the corner flexures.
- A stress concentration factor should be estimated for this specific application and material, 2.1was assumed in the initial analysis.

2.2 Anomaly Correlation To Analytical Model

A plan has been submitted by the Tracker Team to correlate the FEM to the failure scenario to the extent possible. This plan includes assessment of assembly pre-stress and will consider the loss of fasteners to assess increased corner loads. The detailed model updates and analysis cases were reviewed by Tim Thurston and documented in LAT-LR-01120-01.

The review committee also recommends that an evaluation of the failed part be conducted to ensure that it met strength expectations and no process steps introduced defects.

2.3 Proposed Corrective Actions

The Tracker Team has submitted a corrective action plan that includes:

- Removing light-weighting pockets from the bottom tray closeouts
- Adding 5 mm of material between inserts and bottom-tray edge
- Larger head on flexure mount inserts
- Change to titanium or steel inserts
- Add metallic bracket reinforcement to bottom tray corners
- Metallic thermal interface versus polymeric material

The review Committee concurs with the supporting analysis verification plans and that these actions strengthen the design, however detailed analysis, planning, and designs need to be reviewed before a final recommendation can be made.

The primary concern at this point is the process control for machining, insert installation and inspection of all elements related to the critical interfaces. It is not currently clear how these parameters are being developed and specified to the Italian partners. The corrective action plan should incorporate the development of the process control requirements so that they are established in time for the engineering model development.

2.4 Retest Recommendations

The Tracker Team corrective action plan includes a proof load test of the Engineering Model Bottom Tray prior to integration with the tracker assembly. Details of this test plan are not yet available, but should be reviewed by the LAT System Engineering group well in advance to insure adequate and not over test of the tray. This test and supporting dynamic analysis prior to the EM vibration test should provide sufficient insight to the design capability.

A series of thermal tests are also planned for the Beryllium-Copper thermal interface to characterize the heat conduction capability of the system. These tests should be completed as soon as possible to ensure design feasibility.

2.5 Schedule & Cost Assessment

The corrective action schedule is success orientated in order to protect the ~30 day Engineering Model float prior to Tracker CDR. It is likely that some schedule erosion will occur. In particular, closure of the FEM failure and redesign analysis appears to be dependent on a single HYTEC analyst.

No current data is available with respect to over all cost impact.

2.6 Technical Risks

The Tracker Team approach is to over design the bottom tray to the extent practicable. The level of over design achieved with the design recommendations to date is unknown without completion of the supporting analysis. In addition, until an integrated tower dynamic analysis is complete with the new design, the over-all design capability has uncertainty. Completion of the HYTEC failure analysis is required to understand the prototype design shortfalls and gain confidence in the proposed design solutions.

Insufficient process control of carbon-carbon machining, tolerances and insert installation could lead to lower than expected capability and repeatability.

3.0 Recommendations

- Implement the corrective action plan proposed by the Tracker Team
- Conduct evaluation of failed parts to ensure expected material strength was achieved
- Strengthen the development of process controls during this phase of development
- Tracker Team should develop and maintain a list of uncertainties and mitigation strategies (ex. Fitting, tolerance, stress concentration factors, material property variability, load uncertainty)
- The LAT IPO should conduct an EM Production Readiness Review prior to Engineering Model fabrication.
- The formal Anomaly Review Committee should be released pending closure of open action items.