**Mechanical Subsystem Peer Review Report**

The Peer Review for the Mechanical Subsystem was carried out on March 26 and 27, 2003 as planned; see the LAT Peer Review Web Site for the agenda and presentations. The meeting was attended by Review Committee members, key experts, GLAST support staff from GSFC, and representatives of the GLAST Project Office and the LAT IPO.

The Review Committee consisted of:
Dick Horn (Chair) LAT System Engineering Manager
John Deily (Co-Chair) GSFC Systems Manager
Jim Ryan GSFC, Structures CDR Review Team Lead
Tom McCarthy, GSFC, Thermal CDR Review Team Lead
Ben Rodini, GSFC/Swales Mechanical Design
Mike Menning, Stellar Solutions, Mechanical Design
Harlan Knudson, Stellar Solutions, Thermal Design
Jim Schirle, Lockheed Martin, Thermal Design

Overall the committee was impressed with the progress on the design of the Mechanical/Thermal Subsystem. The current design appears feasible. Nonetheless, all Engineering Model tests have not been completed and the dynamics analysis results and design margins were not yet available. Details of the concerns are captured in the RFAs.

Five primary areas of concern were identified that represent a significant risk to the continued development toward CDR maturity:

1) The Spacecraft to LAT mechanical interface finalization
2) Structural analysis and design margins must be established
3) The X-LAT to electronic box mechanical & thermal design must be finalized. The design approach is unconventional and is dependent upon results of analysis and engineering model development. The current approach appears dependent upon a unique thermal interface and backup approaches were not identified.
4) The drawing/document status for the grid and X-LAT plate is immature
5) The Calorimeter to grid interface concerns must be resolved

The following represents a summary of the Review Committee Caucus, regarding the five questions posed in the Charge to the Committee.

1. **Is the design maturity, qualification and verification planning near CDR level?** With the exception of the electronics to X-LAT interface, Yes, but still missing an appropriate level of verification with the engineering models and final dynamics analysis.

2. **Has the Subsystem identified open design issues and established appropriate resolution plans to ensure closure?** Yes, the issues have been identified but issues may still develop during engineering model testing and final analysis.

3. **Is the Subsystem near readiness for manufacturing?** Many element of the subsystem are ready for manufacture (e.g. radiator), however other items need to wait until analysis and successful engineering model completion.

4. **Has the Subsystem identified open manufacturing issues and established appropriate resolution plans?** Yes. Specific concerns are captured in the RFAs.

5. **Are there other issues that should be addressed?** Mechanical assembly of the LAT will be a complex process that will require development of detailed processes and procedures.

   The mechanical team has just recently staffed up. Re-plan of work that has been delayed needs to be completed and may delay design finalization

We recommend this Peer Review be accepted as successful.

-- Dick Horn, Chair
-- John Deily, Co-Chair

**Mechanical Subsystem Peer Review, 2003 March 26-27**

# REQUESTS FOR ACTION – Nordby/Campell

## 1. Grid Design/Modeling: J. Ryan

REQUEST: Verify that Grid Finite Element Model reflects the flange cutaways for the downspout heat pipes. Assess stress concentrations at these reduced flange section areas.

REASON: Cutting away the lower grid flange for the downspout pipes could significantly effect grid stiffness.

## 2. Tracker to Grid Interface: J. Ryan

REQUEST: Provide details of tracker to grid interface. How will mounting holes be drilled? What tolerances will be obtained for shear restraints?

REASON: Eight flexures are to be mounted between the tower baseplate and grid. Obtaining tight tolerance fits for fasteners and maintaining tower alignment requirements will call for detailed planning and precise workmanship.

## 3. Fail Safe Fastener Analysis: J. Ryan

REQUEST: Recommend conducting a failsafe fastener analysis for all bolted interfaces.

REASON: Analysis assures that no single bolt failure will lead to significant degradation in LAT structural performance. Where fastener patterns are not fail safe, more detailed analysis/inspections would be required.

## 4. LAT Structural Design and Analysis: L. Mignosa/J Ryan

REQUEST: Evaluate effect of overconstraint at LAT/spacecraft interface in pointing error analysis for on orbit conditions and quantify disruption that could be imposed by spacecraft onto LAT interface.

REASON: The overconstraint of the LAT/spacecraft interface can result in distortions on orbit. Pointing error analysis should be performed for these on orbit conditions, distortion of the spacecraft interface will also effect the redundant LAT interface.

## 5. LAT Structural Design and Analysis: L. Mignosa/J. Ryan

REQUEST: Static load cases should include a zero G or tension load in the thrust direction with lateral loads

REASON: Interface loads at the LAT/spacecraft and subsystem interfaces should include maximum axial tension load case combinations or evaluate interfaces with fully reversible loads.

## 6. Mechanical LAT Internal Interface: C. Fransen/ J. Ryan

REQUEST: Demonstrate stress and distortions generated from all thermal cases on LAT for E-boxes and X-LAT Plate using updated interface design do not negatively impact thermal or structural margins (at this interface)

REASON: Recent changes to the E-box/X-LAT plate have not been finalized and analysis results on this issue have not been verified. (Or their impact on the design)

## 7. Structural Analysis - J. Ryan

REQUEST: Add to LAT Environmental Specification a loads recovery section for the TEMS to X-LAT interface loads.

REASON: This interface is being revised and, as currently envisioned, will not completely decouple the TEMS from the X-lat plate. Therefore, loads recovery is necessary here.

## 8. LAT Structural Analysis: S.Seipel/J. Ryan

REQUEST: Provide delivery date for full-up LAT FEM dynamic model (2 – weeks post CDR suggested)

REASON: Mission CLA activities need replanning based on new model delivery dates.

## 9. Mechanical – Model Integration and Checkout: S. Seipel/J. Ryan

REQUEST: Perform a continuity check of all FEM models against current baseline design (CAD models, etc.). Once subsystem models are integrated into full-up LAT model, perform standard model checks (static equilibrium, free-free, grounding, etc.) and provide descriptions. Include verification that significant modes and shapes from each subsystem are captured. Verify all model translations, whether for unit conversion or software tool.

REASON: Necessary to insure model integrity to develop flight design loads and margins.

## 10. Mechanical : S. Seipel/J. Ryan

REQUEST: Complete design and structural analysis of S/C to LAT interface. Present margins of safety for LAT side of interface hardware

REASON: CDR closure

## 11. Mechanical – ICD/IDDs: S. Seipel/J. Ryan

REQUEST: Complete ICDs and IDDs between LAT subsystems. For specific items that can not be closed by CDR, present a closure plan w/ associated schedule and risk mitigation plan

REASON: CDR Closure

## 12. Thermal - Heatpipes: T. McCarthy

REQUEST: 1) Address the intermetallic layer issue at the friction joint of the bimetallic joint for VCHPs. 2) What does LMC do from a manufacturing process point of view to preclude this layer from forming during the integration welding process, including temperature control during processing? 3) Do LMC CCHPs use a friction weld to cap off CCHPs?

REASON: NASA GSFC has learned 1st hand of the intermetallic layer formation at the friction joint and associated process requirements

## 13. Thermal Analysis Cases: T. McCarthy

REQUEST: 1) Add a stowed SA case for CDR 2) Add a "HP Anti - Freeze Heater" Fail On Case

REASON: Cases will make matrix of analyses more complete

## 14. Thermal Design -Heaters: T. McCarthy

REQUEST: Define flight heater sizing methodology/philosophy

REASON: None provided

## 15. Thermal - Tracker: S. Seipel/J. Ryan

REQUEST: Evaluate the thermal margins for a move back to the YS90 tracker sidewall material from the current K13D baseline material

REASON: Risk mitigation in case K13D material allowables turn out to not meet requirements

## 16. Thermal ACD survival limits: J. Ryan/B. Rodini

REQUEST: Raise ACD survival temperatures limit to -25C (from -40 C current limit)

REASON: The current -40 C survival limit for the ACD is driving the design of the lower scintillator tile flexures. Data shown on page 4-15 predict -19.1 C survival limit for the ACD with a 5 C uncertainty factor. Also, this predict is at the "coldest extremity" of the ACD which most likely is the "top" of the ACD (A significant distance removed from the lower scintillator tiles)

## 17.LAT Testing – Acoustic: S. Seipel/J.Ryan

REQUEST: Determine necessary interface information, including needed delivery date from vendor for design of acoustic testing MGSE to simulate S/C

REASON: Define outstanding interface requirements & schedule so project office can establish CDRL for spacecraft.

## 18.LAT Dynamic Testing: L. Mignosa/J. Ryan

REQUEST: Consider requesting a set of S/C flexures to use during dynamic testing of LAT. These flexures could (should) also be used to strength qualify the grid structure. Strength qual of full up LAT instrument is not planned. Also, recommend that tracker simulator with flexures be used to qualify the tracker interface.

REASON: S/C flexures will provide much more realistic boundary conditions & interface loads for the LAT. It will be very difficult with a rigid mount (or semi rigid mounts) to get accurate stresses (including moments) into the LAT S/C interface

## 19.LAT Environmental Test: C. Fransen/J. Ryan

REQUEST: Conduct cross-orthogonality check of test (ASET) instrumentation with full FEM (GSET). These results should pass standard criteria (In GEVS) for all modes desired to establish correlation of LAT FEM. These results may need to be re-run as instrumentation set is modified (locations changed)

REASON: Proper pre-test analysis is required to assure instrumentation (accelerometer locations) are adequate to properly resolve desired mode shapes

## 20.LAT Testing: S.Seipel/J. Ryan

REQUEST: For all instrumentation which flies, please update relevant mass report entries for these items

REASON: Ensure all flight mass is in budget

## 21.Thermal Design: H. Knudson

REQUEST: Consider addition of a backup test heater in the radiator survival heater system to prevent possible freezing of the ammonia during T/V testing to mitigate an operational anomaly

REASON: Test anomaly could damage flight hardware

## 22.Thermal Analysis: L. Fantano/T. McCarthy

REQUEST: Verify that a tracker hot design case that assumes a leaky MLI blanket (E* - 0.03), Germanium Black Kapton outer ACD blanket Layer and high emittance tracker side walls does not exceed current hot design case tracker thermal predictions

REASON: It was indicated that the current tracker design hot case assumes an effective MLI E* of 0.01. Typical uncertainty ranges from 0.01 –0.03, since germanium black kapton will run 40 C to 60 C in sun, this may produce a hotter tracker max predict on the sun side of the LAT.

## 23.Materials & Processes: B. Rodini

REQUEST: Provide the M & P list to date. List all materials pending approval and give reasons for why they are pending

REASON: Needed to assess design maturity

## 24. LAT Structural Analysis: T. McCarthy

REQUEST: Ensure that the thermal load cases chosen for analysis envelope the expected worst case ground test Qual level temperature. See Chart 3.11)

REASON: Tracker temperature 30 C / Qual survival 50 C. Do not want to expose structure to a load case that has not been considered in the analysis

## 25. Thermal Design Verification: T. McCarthy/J. Schirle

REQUEST: Ensure test instrumentation is correlated to flight thermisters, especially on the Tracker, at the unit level

REASON: This correlation is important to achieve in order to carry forward into system level testing since test instrumentation may be limited at the system level

## 26. Thermal Design - Blankets: T. McCarthy

REQUEST: Can Gaps between LAT & SC be closed out with thermal blankets? Is so, can this be incorporated, If not why?

REASON: Continued discussion from PDR, dPDR, Peer review about gap and what it means to LAT. Close out blankets would put the issue to bed.

## 27. Budget and Metrics: S. Seipel/J. Ryan

REQUEST: Please identify and capture development of process specifications for adhesive applications, painting (if any) etc….(anodize, iridite, plating, etc. if not provided by piece part vendor.

REASON: Necessary to complete documentation set.

## 28. Mechanical Systems: H. Knudson

REQUEST: Review heat pipe installation to see whether any protection covers can be used during ground handling and mechanical operations to prevent any accidental damage. Both the grid and radiator design appears to be vulnerable to damage.

REASON: Risk exists without any protection covers. If any were damaged it would cause severe cost and schedule penalty.

## 29. Requirements and Compliance:  M. Menning

REQUEST:  Establish a realistic schedule for drawing release with "buyin" from all parties required for process completion, i.e. design engineering, check, stress, configuration management, etc.

REASON:  Drawing release schedule provides valuable insight into project planning by identifying manpower needs and tasks to be completed.

## 30. Thermal Systems Analysis:  M. Menning

REQUEST:  Provide evidence/reasons why MLI thermal blankets used on the LAT will not fail due to atomic oxygen degradation/erosion at the location of micro-cracks in the Germanium plating on the kapton.

REASON:  Experience on space station and other space hardware in low earth orbit has shown failure of kapton coated with brittle coatings (silicone oxide and vapor deposited aluminum) due to atomic oxygen erosion at the location of micro-cracks in the coating.   Isn't this an issue with the LAT blankets?

## 31. Structural Design and Analysis:  M. Menning

REQUEST:   Consider cherry picking the cal plates for the GASU and PDU so that thickness differences in the plates do not induce loads in the boxes.  Design the attachment technique so that binding between the two plates I accommodated without putting excessive loads in the boxes, i.e. avoid tight fasteners or pins from both cal plates to the boxes.

REASON:  GASU and PDU span multiple cal plates on the grid.  These cal plates are most likely different thickness (tolerances on thickness), have some variation in mounting location, and displace relative to each other during ascent vibration. To prevent these electronics boxes from carrying structural loads, care needs to be taken in designing the mounting feature of these boxes onto the cal plate.

## 32.  Radiator Design Requirement:  H. Knudson

REQUEST:  Verify ESD requirements are correctly flowed down to LMC from LAT

REASON:  Currently no ESD requirements specified

## 33. Radiator Design Requirement: J. Schirle

REQUEST: The plan is to put the anti-freeze heaters on the front/FOSR side of the radiator and have the FOSR cover the heater. I recommend looking at the impact of putting the heater on the backside. At the temperatures the anti-freeze heaters will operate, the panel gradients should be small (small qdot = small delta T).
REASON: FOSR over the heaters may be an unnecessarily complex interface and result in unexpected lifting of the FOSR in the flight configuration

## 34. Thermal Interface: L. Fantano/T. McCarthy

REQUEST: Verify that proposed Vel-therm X-LAT to electronics thermal joint design thermal performance does not degrade over time (aging issue), after multiple installation/de-installations, and during the course of the mechanical vibration these program.

REASON: The proposed thermal interface material is relatively new with limited light history. Its advertised thermal performance relies on relatively low thermal contact pressure. It is not obvious that repeated installations/de-installations will not result in carbon fiber breakage and thermal performance degradation. It is also not obvious that the low pressure contact thermal performance will not degrade over time and exposure to the mechanical vibration environment.

## 35. LAT Environmental Testing: M. Menning

REQUEST: Evaluate performing LAT modal survey and sine vib testing using spacecraft flexures so that mode shapes, shear forces, strains, distortion etc. of the flexures/grid/cal plate combination matches those predicted for the hardware based on existing FEM models.

REASON: If test condition/constraints are significantly different than existing FEM models then a whole new set of intermediate (and not necessarily meaningful) modes needs to be evaluated and understood. Be careful in establishing orthogonality criteria for modes shapes so that extensive analysis does not result.

## 36. Radiator Analysis: S. Seipel/J. Ryan

REQUEST: Define allowable load transfer into LAT (or radiator strut stiffness) at connection of radiator to s/c.

REASON: Necessary to define interface requirement to insure positive radiator margins of safety.

## 37. Radiator and X-LAT :  J. Ryan

REQUEST:  Limit load tests should qualify the design (1.25 x flight limit loads)

REASON:  Limit load was specified as test level and did not include the 1.25 qual (or protoflight) level.

## 38.  X-LAT Plate Stress:  C. Franson/J. Ryan

REQUEST:  Update yield F.S. to 1.25 (currently @1.1).  Verify that this requirement has been flowed down to all other subcontractors.

REASON:  The yield FS is required to be 1.25 (not 1.1) per GEVS.  This also assures consistency with test margin of 1.25, to minimize likelihood of yielding during strength test.

## 39. Stress Analysis:  L. Mignosa/J. Ryan

REQUEST:  Provide more detailed summary of stress margins of safety for the LAT instrument.

REASON:  A detailed summary of margins of safety is typically presented at CDR peer reviews.  Detailed, CDR level, margins of safety were not presented except for the radiator subsystem.

## 40. Engineering Model:  H. Knudson

REQUEST:  Review high conductance graphic interface material available from a company named "UCAR" (formerly part of Union Carbide).  They have high conductance graphite material gaskets greater than 10 mil in thickness.   They have space experience.

REASON:  You indicated a need for a thicker material.  This company sells space qualified graphite gaskets of various thicknesses.

## 41. Flight Data Certification Packages:  L. Fantano/T.McCarthy

REQUEST: Verify that the flight data certification packages that accompany hardware delivered by Lockheed to SLAC are consistent with NASA Quality Assurance Requirements.

REASON:  Flight data certification packages are essential to mission quality assurance.  They have to be compliant with NASA standards.

## 42. Thermal Test – X-LAT Plate: T.McCarthy

REQUEST:1) What is the detailed schedule for completion of the EM Test program for the X-LAT Thermal/Mech Design, will it be complete by CDR?
2) What is the back-up design if the EM program is not successful using Vel Met? New baseline is unconventional

REASON: EM closure plan not provided. Design of the X-LAT/Electronics Box integration hinges on a success of this program, as well as successful CDR

## 43.Thermal Test : T.McCarthy

REQUEST: Consider including GRID & DSHPs in the “Complete TCS” TB test. Schedule chart 1.2-4 shows cycling of grid assy by ¾ with “complete TCS test” in 6/04. Chart on page 3.1-10 conveys this config for the TB test

REASON: Complete verification of the core of the TCS prior to instrument integration would reduce risk. Need to clearly define what is part of the TCS TB test.

## 44.Thermal Analysis - Box: T.McCarthy

REQUEST:Ensure box level thermal analysis completed using Qual level boundary conditions

REASON: Unclear what the boundary condition for box WCA is.

## 45.Thermal – Heat pipe: T.McCarthy

REQUEST: GSFC (Brad Parker/Materials Board) provide recommendation to SLAC/LM team regarding the use of bimetal element used in heatpipes

REASON: Ensure LMC manufacturing process is compliant with recent GSFC experience.

## 46.Thermal – Heat pipe: T.McCarthy

REQUEST: Consider defining a “control performance” test for each VCHP that verifies ability to entirely block off the condensor, as well as ability to run full open under spec boundary conditions

REASON: Mitigation for late find of under spec control performance found at panel level.

## 47.Cal/Grid Interface – J. Ryan

REQUEST: Recommend use of a more standard approach to carrying load at the Cal/Grid interface by incorporating slip fit shear pins. The areas of particular concern are the fasteners near the spacecraft interfaces

REASON: Current plan is to use an unconventional combination of friction, epoxied fasteners and backing plates.

## 48.Electronic Boxes Strength Qual: J. Ryan

REQUEST: Have strength qualification requirements been flowed down to the electronic boxes? Are interfaces (box to box) qualified for strength and are boxes being qualified with sine burst testing?

REASON: Missed the Peer review on this part of the LAT design