1. Introduction

Marc Campell

Marc Campell  marcc@slac.stanford.edu

17 Dec 2003
Agenda

1. Introduction (Campell)
   - Agenda
   - Scope & Goals of review

2. Overview (Campell)
   - Hardware to be Fabricated
   - Summary of Tapemation Statement of Work
   - Second Grid option

3. Engineering Status (Campell, et al)
   - Changes since 1x4 Grid Fabrication
   - Drawing Status
   - Grid Interfaces, IDD & ICD Status
   - Analysis Status
   - Peer Review Status
   - Applicable RFA Closure Status
   - Risk Assessment
   - EM Test Plans (Black)
• 4. Manufacturing Plan (Hobbs, et al)
  – Block Diagram of MFG flow
  – Plating requirements
  – Documentation status
  – NC software Programming
  – Tool Requirements and Plans
  – In-process Testing
  – Inspection Plan
  – Staffing Plan

• 5. Quality Plan (Cullinan)
  – Quality Assurance Plan
  – Billet and Grid Processing to Date
  – QA Plan for Final Grid Fabrication

• 6. Conclusions (Campell)
  – Summary and Conclusions
Goals and Supporting Material

• Goals
  – Approve 4x4 Grid and Grid Box Assembly Machining for fabrication
  – Identify any design or prototyping issues that must be resolved prior to start of fab

• Supporting material (available but not presented)
  – Released SOW
  – Program Schedule
  – Tapemation Schedule (preliminary)
2. Overview
Marc Campell

Marc Campell marcc@slac.stanford.edu

17 Dec 2003
Overview

- Flight Hardware to be Fabricated
  - 4x4 Grid, EMI Shield parts (2 sets of pre-machined), Radiator Mount Brackets and Grid Box Assembly Machining
Overview

• **Summary of Tapemation Statement of Work**
  – Tapemation shall deliver the Flight hardware (pg 11). The quantities for 1 set of deliverable hardware plus 1 optional set for the Top Assemblies and Final Machined Parts and 2 sets of Detailed and Pre-Machined Parts.
  – Tapemation shall procure materials (except the Grid billets and Helicoil proof load test fixture which are SLAC provided), fabricate, in-process test, assemble, and test the units.
  – Assemble all of the components and performing the final machining operations described in the Grid Box Assembly Machining (LAT-DS-01269) drawing.
  – Tapemation shall develop manufacturing plans, in-process shop aids or tooling, repair procedures, inspection instructions, in-process heat treatments, and provide a shipping container.
  – Tapemation is responsible for the development of any in process heat treatments required to meet the material properties, dimensional tolerances and stability requirements of the 4 x 4 Grid drawing (LAT-DS-01579).
  – Tapemation is also responsible for the development of a Helicoil repair procedure (for the Helicoils on the 4x4 Grid “Datum A’ surface)

• **Second Grid option**
  – Tapemation will be quoting an option for a second Grid and Grid Box Assembly Machining.
  – A separate MRR will be held prior to start of Grid #2 production
3. Engineering Status

Marc Campell

Marc Campell marcc@slac.stanford.edu
Engineering Status

Changes since Tapemation contract award July 2003. These changes bring designs up to current Peer Review level.

- **Grid - Changes since 1x4 Grid Fabrication**
  - TRK cable chaseways modified
  - Top Flange cable notch geometry modified
  - Top Flange corner undercuts removed
  - Deleted Grid Helicoils in Bay corners (no CAL baseplate corner tabs)
  - Plating requirements revised
  - Spacecraft interface boss enlarged
  - Bosses for CAL shear plates added
  - X side grooves added for instrumentation wire egress

- **EMI Shield**
  - Minor dimensional changes, insert sizes & types
  - Added Electroless & Brush nickel plating
  - Major redesign to Radiator Mount Brackets
    - Thickness of flanges, fastener hole quantities & locations, added lateral compliance to Radiator mounting portion
  - Added EMI o-ring groove to all EMI skirt components
  - Modified for shear plates
  - Modified size and location of Tracker cable connector clearance pocket

- **Grid Box Assembly Machining**
  - Added shear plates
  - Added Match drilling requirement for Shear Plates to Grid
## Drawing Status

- **Drawing Status**
  - 33 of 35 released
  - 2 in sign-off

<table>
<thead>
<tr>
<th>Part No</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAT-DS-01579-02</td>
<td>4 x 4 Grid Machining</td>
<td>Ready to go. H/F TRK</td>
</tr>
<tr>
<td>LAT-DS-01269-02</td>
<td>Grid Box Assembly Machining</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-2658-01</td>
<td>4x4 Grid Masking Requirements</td>
<td>Released</td>
</tr>
<tr>
<td><strong>Top Assemblies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NA</td>
<td>Rough Machined Grid</td>
<td>Tapemation internal dwg</td>
</tr>
<tr>
<td>LAT-DS-02447-01</td>
<td>Grid Shear Plate</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02493-01</td>
<td>Corner Pin Retainer</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02494-01</td>
<td>Quarter Point Pin Retainer</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02495-01</td>
<td>Center Pin Retainer</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02554-01</td>
<td>Bushing, Spacecraft Interface</td>
<td>Ready to go.</td>
</tr>
<tr>
<td>LAT-DS-02580-01</td>
<td>Dowel Pin, 0.250 OD x 1.500 L</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02652-01</td>
<td>Dowel Pin, 0.250 OD x 0.875 L</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02653-01</td>
<td>Dowel Pin, 0.375 OD x 0.875 L</td>
<td>Released</td>
</tr>
<tr>
<td><strong>Detail Parts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAT-DS-01258-03</td>
<td>Y-Center EMI-Shield</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-01259-03</td>
<td>Left Hand HP Patch Panel</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-01260-03</td>
<td>Right Hand HP Patch Panel</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-01261-03</td>
<td>X-EMI Shield, Left Hand</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-01262-03</td>
<td>X-EMI Shield, Right Hand</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-01263-03</td>
<td>X-Center EMI Shield</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-01265-03</td>
<td>Left Hand Radiator Mount Bracket</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-01266-03</td>
<td>Right Hand Radiator Mount Bracket</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02444-01</td>
<td>LH Corner Shear Plate</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02445-01</td>
<td>Quarter Point Shear Plate</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02446-01</td>
<td>Center EMI Shear Plate</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02492-01</td>
<td>RH Corner Shear Plate</td>
<td>Released</td>
</tr>
<tr>
<td><strong>Pre-Machined Parts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAT-DS-02002-01</td>
<td>Y-Center EMI-Shield Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02003-01</td>
<td>X-Center EMI Shield Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02004-01</td>
<td>LH HP Patch Panel Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02005-01</td>
<td>RH HP Patch Panel Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02006-01</td>
<td>LH X-EMI Shield Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02007-01</td>
<td>RH X-EMI Shield Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02008-01</td>
<td>LH Radiator Mount Bracket Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02009-01</td>
<td>RH Radiator Mount Bracket Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02576-01</td>
<td>LH Corner Shear Plate, Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02577-01</td>
<td>RH Corner Shear Plate, Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02578-01</td>
<td>Quarter Point Shear Plate, Machined</td>
<td>Released</td>
</tr>
<tr>
<td>LAT-DS-02579-01</td>
<td>Center Shear Plate, Machined</td>
<td>Released</td>
</tr>
<tr>
<td><strong>Final Machined Parts</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Grid Interfaces

• Design Verification
  – Solid model of Grid & Grid Box is verified using LAT level solid models
  – Interface Definition Drawings are produce from LAT model to define the interfaces between Subsystems

• Risk Assessment
  – Risks are assessed in each of the following sections
    • IDD, ICD, Analysis, Open RFA’s and Other risks
## IDD Status

<table>
<thead>
<tr>
<th>IDD</th>
<th>ECD</th>
<th>Status/Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid - ACD IDD</td>
<td>Released</td>
<td>Draft is out for review. Interface design finalization continues. Current concept supports existing grid design. The TRK interface is not put in at this level at this time. <strong>Recommend: Proceed through pre-finish machining &amp; vibratory stress relief.</strong></td>
</tr>
<tr>
<td>Grid - TRK IDD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top Flange Heat Pipe SCD</td>
<td>Released</td>
<td></td>
</tr>
<tr>
<td>Downspout Heat Pipe SCD</td>
<td>9-Jan Released, minor rev pending for tolerancing callouts</td>
<td></td>
</tr>
<tr>
<td>LAT - S/C ICD</td>
<td></td>
<td>Pending CR in work at GSFC. Grid has been modified to accept either 3/8 or 7/16 dia S/C attach bolts using either extra heavy duty or heavy duty inserts with same external thread size. <strong>Recommend: Proceed</strong></td>
</tr>
<tr>
<td>CAL- Grid IDD</td>
<td>9-Jan</td>
<td>In release review cycle - needs CAL review - Paul D is out. This interface complies with current grid design. <strong>Recommend: Proceed.</strong></td>
</tr>
<tr>
<td>Radiator IDD</td>
<td>9-Jan</td>
<td>IDD updates will add sheet 4 to reflect wiring routing, envelopes, pin-outs. Corrects 2 conflicting dimensions on the location of the VCHP hole pattern. This issue has been worked with LMMS. <strong>Recommend: Proceed.</strong></td>
</tr>
<tr>
<td>X-LAT Plate IDD</td>
<td>17-Dec</td>
<td>IDD has been reviewed by 3 independent reviewers. Critical interfaces have been examined and are frozen by other designs. X-LAT Plate will be modified as necessary to fit the interface. <strong>Recommend: Proceed.</strong></td>
</tr>
</tbody>
</table>
ICD Status

- ICD’s were reviewed by Rich Bielewski for potential Grid machining liens
- Grid design is compliant with all requirements in ICD’s except
  - 5 potential liens discovered
  - Will recommend that ICD be updated as follows
## ICD Issues

<table>
<thead>
<tr>
<th>Item</th>
<th>S/S ICD</th>
<th>Para #</th>
<th>Para Heading</th>
<th>Description</th>
<th>Status</th>
<th>Resolution Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CAL</td>
<td>6.5.2</td>
<td>LAT Requirements</td>
<td>During worst-case deflection of the Grid during launch, the CAL bolting surface shall distort no more than 0.1 mm.</td>
<td>Don't comply.</td>
<td>Is .25 mm per Environmental spec. Delete this requirement and capture in Environmental Spec.</td>
</tr>
<tr>
<td>2</td>
<td>CAL</td>
<td>6.5.2</td>
<td>LAT Requirements</td>
<td>Tapped holes for mounting the CAL shall tolerate a maximum load plus pre-load of 5000 N, without adverse affects on the threads or bolts.</td>
<td>Will comply</td>
<td>8,187 N for #6 bolt preload 12,455 N for #* bolt preload.</td>
</tr>
<tr>
<td>3</td>
<td>CAL</td>
<td>10.1</td>
<td>CAL Requirements</td>
<td>The bolted joint interface with the Grid shall be the primary mechanism for transferring heat into and out of the CAL. This interface shall have an overall conductance &gt;0.03 watts/sq cm deg C.</td>
<td>Will comply</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CAL</td>
<td>10.4</td>
<td>CAL to Grid (CAL to TKR) Thermal Interface and Heat Transfer</td>
<td>The LAT grid will have a high emissivity coating (0.75&lt;emissivity&lt;0.9).</td>
<td>Don't comply</td>
<td>Revise requirement to match current masking plan approved by LAT thermal Engineer.</td>
</tr>
<tr>
<td>5</td>
<td>ACD</td>
<td>11.8</td>
<td>Tracker &amp; Grid Surface Property Assumptions</td>
<td>Grid - Black Anodize with emissivity BOL = 0.82, EOL = 0.78</td>
<td>Requirement too vague</td>
<td>Revise requirement to match current masking plan approved by LAT thermal Engineer.</td>
</tr>
</tbody>
</table>
## Analysis Status

- **John Ku’s Stress report to close all of these ECD 1/5/04.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Analysis Tasks</th>
<th>Complete?</th>
<th>Status</th>
<th>Notes</th>
<th>OK to Fab?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>SC I/F Keensert and bolt</td>
<td>Y</td>
<td>CLOSED</td>
<td>Bolt Selection open, but Grid can accommodate either bolt size. Hand-calculations and spreadsheets available</td>
<td>Y</td>
</tr>
<tr>
<td>3</td>
<td>SC I/F Bushing and Pin</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>4</td>
<td>CAL-Grid I/F</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>5</td>
<td>Shear Plate Detailed Analysis</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>6</td>
<td>ACD-Grid I/F</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>7</td>
<td>TKR-Grid I/F</td>
<td>N</td>
<td>OPEN</td>
<td>Few outstanding actions for new joint design. Positive Margins expected. Hand-calcs documentation available</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>RMB Detailed Analysis</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>9</td>
<td>RMB-Grid I/F</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>10</td>
<td>RMB-EMI Skirt/HP Patch Panel</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>11</td>
<td>RMB-X-LAT I/F</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>12</td>
<td>RMB-RAD I/F</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>13</td>
<td>EMI Skirt and HP Patch Panels</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>14</td>
<td>EMI-Grid I/F</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>15</td>
<td>EMI-X-LAT I/F</td>
<td>Y</td>
<td>CLOSED</td>
<td>Hand-calcs, Grid-CAL Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>16</td>
<td>X-LAT Plate Detailed Analysis</td>
<td>N</td>
<td>OPEN</td>
<td>SLAC Detailed analysis complete, but LMCO Confirming analysis pending. Hand-calcs, X-LAT Peer Review documentation available</td>
<td>Y</td>
</tr>
<tr>
<td>17</td>
<td>Radiator</td>
<td>Y</td>
<td>CLOSED</td>
<td>CDR Presentation, CDR Report available</td>
<td>Y</td>
</tr>
<tr>
<td>18</td>
<td>EM1x4 Test</td>
<td>Y</td>
<td>CLOSED</td>
<td>All Loadcases complete, no anomalies</td>
<td>Y</td>
</tr>
<tr>
<td>19</td>
<td>Pre-test analysis/predicts</td>
<td>Y</td>
<td>CLOSED</td>
<td>Pre-test Analysis Review, TRR Presentation available</td>
<td>Y</td>
</tr>
<tr>
<td>20</td>
<td>Test support</td>
<td>Y</td>
<td>CLOSED</td>
<td>No anomalies. Test Datasheets available</td>
<td>Y</td>
</tr>
<tr>
<td>21</td>
<td>Data Reduction</td>
<td>Y</td>
<td>CLOSED</td>
<td>Good correlation. Spreadsheets available</td>
<td>Y</td>
</tr>
<tr>
<td>23</td>
<td>LAT Strength Test Analysis</td>
<td>N</td>
<td>OPEN</td>
<td>Need to update to new CLA loads, ECD Early ’04</td>
<td>Y</td>
</tr>
<tr>
<td>24</td>
<td>Test Instrumentation Cables</td>
<td>Y</td>
<td>CLOSED</td>
<td>High confidence in Accelerometer Locations. Modal Analysis spreadsheets available.</td>
<td>Y</td>
</tr>
</tbody>
</table>
Peer Review Status (Nordby)

- X-LAT Plate Interface Design Peer review, 5 Nov 03
  - SLAC RFA responses submitted

- Tracker Interface Design Review, 28 Oct 03
  - Tiger team working interface issue

- Grid Box Structural Design Peer Review, 23 Sep 03
  - Originators have approved SLAC responses
RFA Closure Status

Process
• Open RFA’s from prior reviews were assessed to determine possible impacts to the Grid
  – The reviews included PDR, Peer reviews, CDR and post-CDR peer reviews

Summary results
  – The majority either have no or very low risk that the grid design would be impacted
    • Examples are the Grid Stress Report (Draft submitted on 5 Dec), and 6 of the 7 RFA’s from the Cal-Grid peer review
    • Entire list follows
  – There are two potential liens against the radiator mount bracket
    • Steel bushings in the radiator bracket clevis (not recommended)
    • Installation and removal of the radiator panels (may need removable pin to facilitate installation)
## Detailed RFA Status

<table>
<thead>
<tr>
<th>Review</th>
<th>RFA#</th>
<th>Request</th>
<th>Reason</th>
<th>Response</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL Grid</td>
<td>2</td>
<td>Includes short beam effect for stress analysis for key</td>
<td>Short beam effect can increase both shear &amp; bending stress compared with long beam solution. Please reference to Roark &amp; Young for guide.</td>
<td>Recalculation complete. Margins are reduced, but remain positive. Minimum margin of safety decreases from 0.29 to 0.01 for Nov 2001 CLA loads. Minimum margin of safety increases for new CLA loads from 0.01 to 2.05.</td>
<td>Approved</td>
</tr>
<tr>
<td>CAL Grid</td>
<td>3</td>
<td>Include lateral load factor w/vertical 1G for crane lifting</td>
<td>Suggest use 0.25 G's lateral within 1 G's vertical for crane lifting case</td>
<td>SLAC is not comfortable reducing the Z-direction loading to 1.0g and would like to keep the current level at 1.25g. The lateral loads have been increased (X &amp; Y axes applied separately) from 0.0g to 0.25g, as requested by Swales. Margins are reduced, but remain positive.</td>
<td>Approved</td>
</tr>
<tr>
<td>CAL Grid</td>
<td>4</td>
<td>Grid margins of safety should include stability (buckling and crippling) allowables as well as strength allowables.</td>
<td>Stability allowables can be lower than strength allowables. Stability allowables should be developed for compression and shear loading.</td>
<td>Buckling and crippling calculations were performed. The stress required to induce buckling and/or crippling is higher than the material allowable. Therefore, buckling and crippling is not an issue for the grid design.</td>
<td>Approved</td>
</tr>
<tr>
<td>CAL Grid</td>
<td>5</td>
<td>Consider using standard bolt preload of 65% of yield for all interfaces</td>
<td>Consistent torque for each size bolt reduces chance of error at assembly. Bolt analysis should be done based on the guidelines given in NASA-STD-5001. An example will be sent to SLAC.</td>
<td>65% of yield preload criterion applied nominally to all bolt locations. One exception occurs at the SC mount bolts which are loaded to 80% of yield. This standard was violated in order to increase margin against gapping. A detailed analysis was performed for the SC bolt and all margins are shown to be positive.</td>
<td>Approved</td>
</tr>
<tr>
<td>CAL Grid</td>
<td>6</td>
<td>Suggest examining design change to spacecraft mount interface to achieve 1.5 edge distance on critical fasteners in critical loading direction</td>
<td>Shouldn't deviate from standard design practice particularly at this critical interface.</td>
<td>Change approved at Spectrum CCB in November, 2003</td>
<td>Approved</td>
</tr>
</tbody>
</table>
## Detailed RFA Status (Cont)

<table>
<thead>
<tr>
<th>Review</th>
<th>RFA#</th>
<th>Request</th>
<th>Reason</th>
<th>Response</th>
<th>Status</th>
<th>Lien to start of Grid machining</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL Grid peer</td>
<td>7</td>
<td>Consider adding steel bushings to radiator bracket clevis</td>
<td>Will prevent localized deformation of clevis F.D.</td>
<td>Discussions centered around reducing pin size to make room for bushing, since 5/8&quot; pin has large shear stress margin. However, smaller diameter pin increases pin bending, increasing edge bearing stress. Shoulder bushings were considered. However, shoulders on the inside of the clevis would further increase pin bending and also reduce the width of the Grid perimeter ring (GPR) tang. To guarantee bushings do not fall out during ascent, pin should be reinserted and secured after GPR removal. RMB clevis is actually GSE feature, for which localized deformation is not critical. GPR will only be attached and removed 2 or 3 times, providing little opportunity for compound damage from pin insertions. Finally, we concluded that the advantages of employing a steel bushing are not sufficient to justify the additional required RMB design effort, considering that current margins are more than sufficient to carry all GSE load cases.</td>
<td>Approved</td>
<td></td>
</tr>
<tr>
<td>CDR</td>
<td>12</td>
<td>Provide comprehensive stress analysis report for LAT primary structure and interfaces.</td>
<td>Limited detail analyses was presented at the CDR.</td>
<td>A comprehensive stress analysis was provided as part of the September 2003 CAL-Grid Peer Review. It was considered thorough and acceptable.</td>
<td>Submitted</td>
<td>Close with stress report</td>
</tr>
<tr>
<td>CDR</td>
<td>10</td>
<td>Enhance the strength qualification testing of the grid so that sine burst testing of the LAT instrument can be eliminated. It was stated that LAT sine burst testing was being considered to complete strength qualification of Grid and Tracker joint.</td>
<td>Sine burst testing at the full instrument level is a very risky test. The test is run open loop and for such a large mass instrument there would be valid concerns that the test input can be accurately achieved. Also, strength qualification of the grid might “over-test” other components or subsystems of the LAT. An actual over-test (input loads exceeded) could be very damaging to LAT.</td>
<td>An updated strength qualification plan has been developed, that removes the need for a LAT sine burst test. Strength qualification of the Grid and key interfaces is performed at the Grid Box subsystem level, only, through static load testing. This plan was reviewed at the CAL-GRID peer review in September 2003 and was acceptable.</td>
<td>Submitted</td>
<td>No grid lien</td>
</tr>
<tr>
<td>Review</td>
<td>RFA#</td>
<td>Request</td>
<td>Reason</td>
<td>Response</td>
<td>Status</td>
<td>Lien to start of Grid machining</td>
</tr>
<tr>
<td>------------</td>
<td>------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-----------------------------</td>
<td>---------------------------------</td>
</tr>
</tbody>
</table>
| CDR        | 21   | a) Provide design of MGSE required for installation and removal of radiator panels.  
b) Provide process/method planned for making a “wet joint” at radiator heat pipe interface to grid in the vertical orientation. | This information was not provided at the CDR. | In process. This is a lien on the radiator mount bracket (may need removable pins) | Possible lien to radiator bracket. |
<p>| PDR        | 45   | LAT Instrument and subsystems should be procuring fasteners in accordance with GSFC Fastener Integrity Requirements, 541-PG-8072.1.2. | This document defines fastener integrity requirements for all fasteners used in flight hardware and for critical nuts and bolts used on GSE, including all flight hardware/GSE interfaces. | Fastener design, procurement, and test requirements are identified in the LAT-SS-00107 “LAT Mechanical Parts Plan.” These requirements are compliant with the LAT MAR. Note that this plan calls out specifically GSFC-S-313-100-B, which was the precursor to GSFC Fastener Integrity Requirements, 541-PG-8072.1.2. | Submitted we comply with an earlier version of the document. The newer document was released a few months before our mech parts plan. |
| PDR        | 48   | Generate a comprehensive strength qualification plan for the LAT instrument. | There is no instrument level strength test planned. A comprehensive document defining the strength qualification plans will ensure that all interfaces and subsystems will be adequately strength qualified. | Strength qualification plans have been added to the LAT Verification Test Plan. This plan is currently being reviewed by the Project. | Submitted Covered in CDR with other actions. Plan submitted, in NASA's court |
| Peer Review (pre CDR) | 3 | Recommend conducting a fail safe fastener analysis for all bolted interfaces. | 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. | Failure of structural components and structures is explicitly exempted in MSS 3.3.1.5.1, so none is planned. Stress analysis of all bolted interfaces has (or will) show positive margins for all joints and bolting hardware. Furthermore, qualification testing at the subsystem level will demonstrate that the design can endure loads and stresses associated with protoflight or qualification environments. Finally, all bolted joints will be subjected to verification testing at either the subsystem or LAT level (or both) to verify workmanship. The GLAST PO and LAT consider this adequate for mitigating the risk of fastener problems during launch. | Submitted Close with stress report |</p>
<table>
<thead>
<tr>
<th>Review</th>
<th>RFA#</th>
<th>Request</th>
<th>Reason</th>
<th>Response</th>
<th>Status</th>
<th>Lien to start of Grid machining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer Review (pre CDR)</td>
<td>5</td>
<td>Static load cases should include a 0 g or tension load in the thrust direction with lateral loads</td>
<td>Interface loads at the LAT/spacecraft and subsystem interfaces should include maximum axial tension load case combinations or evaluate interfaces with fully reversible loads.</td>
<td>Tension/negative thrust accelerations have been added to the list of LAT load cases, for completeness. Results of these load cases will be part of the CDR structural results.</td>
<td>Close @ CDR</td>
<td>Believe no lien. GSFC has been in the loop for all cases.</td>
</tr>
<tr>
<td>Peer Review (pre CDR)</td>
<td>10</td>
<td>Complete design and structural analysis of S/C to LAT interface. Present margins of safety for LAT side of interface hardware</td>
<td>CDR Closure</td>
<td>Analysis is in work. Draft ECD: 12/5/03</td>
<td>Close with stress report</td>
<td></td>
</tr>
<tr>
<td>Peer Review (pre CDR)</td>
<td>11</td>
<td>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</td>
<td>CDR Closure</td>
<td>The following is a list of ICD’s and IDD’s within the LAT, and their status as of the response date listed, updated status and closure plan will be provided at CDR: LAT-DS-00040-09: LAT Envelope—released (14 Apr 03) LAT-DS-00038-4: LAT Instrument Layout—first draft being checked (14 Apr 03) LAT-DS-00233-3: CAL-LAT IDD—final check prior to release (14 Apr 03) LAT-SS-00238-4: CAL-LAT Mech, Therm, Elec ICD—released LAT-DS-00309-1: ACD-LAT IDD—final check prior to release (14 Apr 03) LAT-SS-00363-4: ACD-LAT Mech, Therm, Elec ICD—released LAT-DS-00851-1: TKR-LAT IDD—first draft underway (14 Apr 03) LAT-SS-00138-5: TKR-LAT Mech, Therm ICD—released LAT- DS-01630-1: Electronics-LAT IDD—first draft underway (14 Apr 03) LAT-SS-01794-1: Elec-LAT Mech, Therm ICD—first draft underway (14 Apr 03)</td>
<td>Not Accepted</td>
<td>Individual required IDDs are on Marc’s list</td>
</tr>
<tr>
<td>Peer Review (pre CDR)</td>
<td>39</td>
<td>Provide more detailed summary of stress margins of safety for the LAT instrument.</td>
<td>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.</td>
<td>Stress analyses are in work. Draft ECD: 12/5/03</td>
<td>Submitted</td>
<td>Close with stress report</td>
</tr>
<tr>
<td>XLAT Peer</td>
<td>6</td>
<td>Critical inspection dimensions should be noted on each piece part drawing from which X-LAT tolerance study data was taken.</td>
<td>Knowledge that tolerances are within spec. is key to successful integration of X-LAT assembly.</td>
<td>Tapemation will do 100% inspection of the grid.</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
Other Risks Assessment

- MRR was dry run and list of open issues was generated. Remaining issues shown.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Resp</th>
<th>ECD</th>
<th>Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that mask grid masked areas are sufficient size for heaters &amp; thermostats</td>
<td>Goodman</td>
<td>Jan 04</td>
<td>Heaters sizes were estimated and masked areas oversized. If additional area is needed anodize can be removed. <strong>Recommend: Proceed</strong></td>
</tr>
<tr>
<td>Determine wire routing for Grid heaters and external temperature sensors</td>
<td>Campell</td>
<td>Jan 04</td>
<td>Preliminary scheme has been determined. Needs to tried on mock up. May require a wire channel in the Grid wing to protect wires. This can be added later. <strong>Recommend: Proceed</strong></td>
</tr>
<tr>
<td>resolve instrumentation wire routing on Grid interior, so that we know there is enough room</td>
<td>Campell</td>
<td>Jan 04</td>
<td>Size and quantity of wires has been determined. Wire egress channels have been added to Grid for fly away accelerometers. Internal Grid temp sensors can be accommodated. <strong>Recommend: Proceed</strong></td>
</tr>
<tr>
<td>Radiators acoustic analysis may impact Radiator mount bracket design</td>
<td>LM</td>
<td>complete</td>
<td>LM acoustic analysis completed. No significant changes to loads. Designs OK.</td>
</tr>
</tbody>
</table>
### Other Risks Assessment (cont)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Resp</th>
<th>ECD</th>
<th>Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>write helicoil proof test procedure</td>
<td>Black</td>
<td>15-Dec</td>
<td>Draft available. This test may be unnecessary as we have demonstrated adequate margin. Also all helicoils see full loads when dummy CAL baseplates are installed during MECH Assy operations prior to I&amp;T. Potential cost &amp; schedule savings. <strong>Recommend deleting requirement.</strong></td>
</tr>
<tr>
<td>Complete brush nickel approval process</td>
<td>Black</td>
<td>Jan 04</td>
<td>This process is in the GLAST approval process. There is plenty of Flight heritage on NASA programs, so approval should not be an issue. Approval is required before using the process, but not for MRR. Thermal cycle testing is underway. <strong>Recommend: Proceed.</strong></td>
</tr>
<tr>
<td>provide detail on contamination control when performing Grid Box Machining</td>
<td>Hobbs</td>
<td>30-Jan</td>
<td>A general plan will be presented at MRR. The final details need to be resolved prior to Grid Box Machining operations. There is ample time to finalize the plan. <strong>Recommend: Proceed at risk.</strong></td>
</tr>
<tr>
<td>Detail design of shear plate drill template is in work</td>
<td>Hobbs</td>
<td>19-Dec</td>
<td>Concept has been reviewed with Tapemation and the design is in work. They currently believe some minor modification to the pin tolerancing will be required. If it is determined that a tolerance change is required on the Grid drawing (none known), then this will be accommodated. The features are put into the Grid with this tool, so the tool &amp; drawing will be made to agree. This is needed during Grid Box Machining operations. <strong>Recommend: Proceed at risk.</strong></td>
</tr>
<tr>
<td>Review vibratory stress process with GSFC</td>
<td>Cullinan</td>
<td>5-Dec</td>
<td>This is a process that Tapemation and the industry has been using for many years. The low level forces involved cannot damage the Grid. Reviewed with Mike Barthelmy &amp; John Ku. <strong>Recommend: Proceed.</strong></td>
</tr>
<tr>
<td>Tapemation to find plating shop</td>
<td>Hobbs</td>
<td>19-Dec</td>
<td>RFQ's have been issued. Awaiting replies. SLAC QE to perform site survey of selected vendor. Not needed until end of Grid Machining operations. <strong>Recommend: Proceed</strong></td>
</tr>
<tr>
<td>Radiator installation process may impact radiator mount bracket design</td>
<td>Herzberg</td>
<td>Jan 04</td>
<td>Radiator mount bracket locating may need to be removable. Installation study is underway. <strong>Recommend: Put hold on Radiator Mount Bracket piece part only.</strong></td>
</tr>
<tr>
<td>Steel bushing may be required in the radiator mount bracket clevis for ground handling operations.</td>
<td>Nordby</td>
<td>complete</td>
<td>RFA approved that recommended using current design.</td>
</tr>
</tbody>
</table>
Grid EM Testing

Several Tests have been or will be performed to verify the integrity of the Grid Design

- **Fastener/Joint Testing**
  - Spacecraft Interface Insert Strength Verification
    - Strength Test of KNH616J-11 Inserts (LAT-TD-002657-01)
  - Helicoil torque testing
  - Helicoil Pull-Out Strength (LAT-TD-02720-01 and LAT-TD-02721-01)
  - Grid Corner EM Strength Verification Test (LAT-TD-02641-01)
  - Grid Shear Plate Strength Verification Test (LAT-TD-02642-01)

- **Stiffness/Model Validation**
  - 1 X 4 Stiffness verification (LAT-TD-02400-02 EM Grid Test Proc)
Spacecraft Interface Insert Strength Verification

- This test validates the tensile strength of the inserts
- The data is used to calculate the allowable margin on pullout
- The test shows that the insert strength is near that of the fastener
- Ultra high strength (200 ksi ultimate) fasteners were required to yield the inserts
Helicoil torque vs preload

- This test is used to set the torque requirement for the Cal to Grid interface
- The test measures the joint preload at a given torque
- Tests completed so far
  - Black Oxide 180ksi
  - A286 CRES 160ksi
  - A286 CRES 200ksi
- Test yet to be completed for flight hardware
Helicoil Pull-Out Strength

- This test validates the tensile strength of the inserts
- The data is used to calculate the allowable margin on pullout
- The test shows that the insert strength is equal to or greater than that of the fastener
- Screw failure was observed in initial testing using 160 ksi cap screws
- Flight type fasteners were used for the test (200 ksi)
- Screw failure was observed in final testing using 200 ksi cap screws

Flight type helicoils installed with similar grid thickness and spacing
P/N’s 1185-06CNHG-276 & 1185-2CNHG-328
Grid Corner EM Strength Verification

- This test is to validate the joint/insert strength of the grid corner
- The load is applied at the location of the handling clevis
- Loads are intended to simulate the worst case earthquake handling loads
- Grid Corner EM Strength Verification Test Procedure (LAT-TD-02641-01)

![Image of test setup]

- Attach plate
- Load Adapter
- Grid Corner Simulator
- Load
- UTM
Shear Plate Strength Test

- This test is to validate the joint strength of the shear plate to grid and Cal Plate shoulder bolt to shear plate interfaces.
- The load is applied at a location such that worst case expected moments and forces are introduced.
- Loads are intended to simulate the worst case earthquake handling loads.
- Grid Shear Plate Strength Verification Test (LAT-TD-02642-01)
1 X 4 EM Stiffness Test

- This test is to validate/correlate the FEM model stiffness predictions
- Loads where applied such that bending and rotational stiffness could be measured
- Loads are intended to simulate the worst case earthquake handling loads
- EM Grid Test Proc(LAT-TD-02400-02)
4. Manufacturing Status

Rick Hobbs, Tapemation

Rick Hobbs rick@tapemation.com

17 Dec 2003
Continued from previous page

- Attach EMI parts, torque and identify LAT-DS-01269
- Install remaining inserts Grid and EMI
- Install dowel pins & bushings Record Dia.
- 100% visual Inspection of Holes
- 100% visual Inspection of Inserts
- Match Mark Skirt Pieces per LAT-DS-01269
- 100% Dimensional Inspection
- Vendor Inspection with SLAC Review
- Vendor Inspection
- Vendor Inspection with SLAC witness/approval
- Pre-Ship Review
- Package and Ship to SLAC

Legend:

- **Vendor Process**
- **Vendor Process with SLAC Review**
- **Vendor Inspection**
- **Vendor Inspection with SLAC witness/approval**
Plating Requirements

Three different surface finishes are required

- Alodine
- Black Anodize
- Nickel

The Surface finishes are to be applied in the following steps:

- **Grid**
  - After machining but prior to insert installation the entire grid will be alodined
  - After alodining all surfaces will be masked except those surfaces to be anodized (black)
  - After anodizing the masking will be removed, the surfaces to be nickel plated will be lightly abraded, cleaned and masking will be applied locally.
  - The brush nickel plating will then be applied
  - The inserts required for EMI skirt installation will be installed
  - Remaining inserts installed after Grid Box Assy Machining

- **EMI Skirts**
  - The Pre-Machined EMI skirt pieces will be Electroless Nickel plated.
  - The EMI skirt pieces will be assembled to the grid and match machined
  - The machined surfaces will be Brush nickel plated
  - The X-LAT inserts will be installed
Plating Requirements (cont.)

Plating Type Descriptions

• **Alodine (Chromate conversion coating, MIL-C-5541, Class 3)**
  – Corrosion protection
  – Good primer for bonding
  – Simple and economical to apply
  – No masking required,
  – May be applied to surfaces that will subsequently be anodized or nickel plated

• **Black Anodize (MIL-A-8625 Type II, Class 2, Color Black)**
  – Good Corrosion Protection
  – Thermal Control Surface
  – Required on the majority of the exposed exterior surfaces of the grid.
  – Non-conductive
  – Difficult to bond to
  – Immersion process requires masking of all non-anodized surfaces
Plating Requirements (cont.)

Plating Type Descriptions (cont).

• Nickel Plating
  – “Brush Nickel” (AMS 2451/1)
    • Provides highly conductive corrosion resistant surface
    • Applied locally to minimizes Masking Requirements and reduces risk of hole contamination
    • Well established process with significant flight heritage
    • Selected vendor has long history of supplier certification from many aerospace companies
    • Preliminary approval for use from Goddard
    • Test Coupons to be thermal cycled from -40 to +50 C for twelve cycles before final approval

  – Electroless Nickel (AMS-C-26074)
    • Provides highly conductive corrosion resistant surface
    • Well established process with significant flight heritage
    • Chemical bath plating process best applied to all part surfaces
Manufacturing Documentation Status

- Shop orders
  - Complete
- Project Schedule
  - Estimated working days – need start date
- Internal drawings
  - Rough machine drawing released
  - Shear plate drill fixture concept developed
- Procedures/Processes
  - CAL-Grid helicoil proof test procedure draft in work (at SLAC)
  - Vibratory Stress procedure – draft complete
  - Processes are per MIL specs, Industry standards or Manufacturers instructions
- QA plan
  - Detailed plan to be released 3 days after drawing package issued to Tapemation
- Quality Manual
  - Submitted and reviewed by SLAC
- MFG plan
  - Block diagram exists
- CAD
  - SLAC will generate wire frame and IGES files from released grid model & provide to Tapemation to assist in machine programming.
CNC Programming/Tool Path Verification

Rough Machining

1. An IGES file created in Solid Edge is imported into SurfCam (CAM program)
2. A rough machining model is created based on the IGES that adds .25” of material all around.
3. The IGES model is compared to the roughing model to verify all thickness.
4. A tool path in simulation is run in SurfCam to verify the rough machine tool paths. This is an animated simulation that shows the actual tool paths and the material being removed.
5. A single bay simulator is machined prior to machining the end item. The same code and machine is used that will be used to machine the entire grid. (this will also help to verify feeds and speeds.)
6. The first actual machining step is to scribe an outline on the billet with a ball end mill to show where the final cuts will be made. (these scribe lines will be removed with the final machining)
7. Each tool change is verified by making a tool pass around “Fail Safes”. This is a post set-up outside of the grid. The post is located such that the tool will hit if an oversize cutter or extra offset was incorporated during the tool change.
8. All changes made to the code after export from SurfCam are made via a 2 man edit process. This step is rarely done if at all, and only for minor changes such as speed and feed adjustments.
CNC Programming/Tool Path Verification (cont.)

Finish Machining

1. An IGES file created in Solid Edge is imported into SurfCam (CAM program)
2. A tool path in simulation is run in SurfCam to verify the rough machine tool paths. This is an animated simulation that shows the actual tool paths and the material being removed.
3. An additional software check is made with independent software. The independent software was written specifically for the SNK model machine that will be used. The code re-verifies the tool path and verifies that no rapid moves are made through the part. The verification is done visually and numerically. The code also checks for interferences with the machine itself and the fixturing; clamps, hold downs, knees, pallets etc.
4. A single bay simulator is machined prior to machining the end item. The same code and machine is used that will be used to machine the entire grid. (this will also help to verify feeds and speeds.)
5. The first actual machining step is to scribe an outline on the billet with a ball end mill to show where the final cuts will be made. (these scribe lines will be removed with the final machining)
6. Each tool change is verified by making a tool pass around “Fail Safes”. This is a post set-up outside of the grid. The post is located such that the tool will hit if an oversize cutter or extra offset was incorporated during the tool change.
7. All changes made to the code after export from Surfcam are made via a 2 man edit process. This step is rarely done if at all, and only for minor changes such as speed and feed adjustments.
Tool Requirements & Plans

- Tapemation Tooling – Shear Plate Drill Template (Campell)
  - SLAC has imposed a requirement for multiple sets of interchangeable shear plates. Originally, 1 set of shear plates were to be used on the flight Grid during static load test and replaced with a new set (in case of overloading). Now there is a second Grid for Static Load test.
  - Tapemation has proposed elimination of the interchangability requirement and instead match machine and serialize shear plates to Grid.
  - Expect significant cost and schedule savings.
  - Under consideration by SLAC.

- Customer Tools availability (Campell)
  - These operations can be performed anytime after Grid fabrication & plating
    - ACD – BFA for match drilling Grid available early Mar & Apr 04
    - S/C I/F Tool for match drilling Grid available mid Jan 04
In-Process Testing

- **CAL – Grid Helicoil Testing**
  - Proof Loading requirements per drawing note
  - Detailed procedure will be written
  - Test Equipment demonstrated on 1 x 4 Grid

- **Grid Vibratory Stress Relief**
  - Used between Pre-finished and Finished Machining operations
**Inspection Plan**

Inspection (verification of dimensions)

- 100% inspection of Grid dimensions using CMM machine

- CMM capabilities

- Orientation of part on CMM
  - *To be defined in detailed inspection plan*
Staffing Plan

• Key personnel

• Number of shifts
  – The five axis machining of the bays would be the best opportunity to run a second shift if necessary, as this would be repetitive, and proven programs.
  – Finding a competent machinist who is available and willing to work second shift is not easy.
  – Baseline use of extended shifts (50-60 hr/week)
LAT-PR-02590: Grid Manufacturing Readiness Review

5. Grid Fabrication
Quality Assurance

Joe Cullinan cullinan@slac.stanford.edu

17 Dec 2003
Quality Assurance Plan for Grid Fabrication

- Approve quality system, process control and documentation of all vendors performing work on grid
- Verify vendors possess capabilities and expertise to perform work to LAT program requirements
- Witness and document critical processes performed on grid
  - grid flattening, vibratory stress relief, brush Ni plating, proof load testing of inserts, and grid dimensional inspections
- Verify test, measurement and inspection data meets LAT program requirements
- Ensure non-conformances are documented and resolved
- Review, approve and retain data packages from each grid manufacturing sequence
- Photo documentation
  - Photos taken to document discrepant hardware
  - At mandatory inspect points
Billet and Grid Processing to Date

- 6061-T6 billets (2ea) fabricated by Alcoa
  - Certificate of conformance verified composition, TS, YS, %elong per QQ-A-250/11
- Ultrasonic testing performed on both billets by Mitchell Labs
  - C-scan performed per AMS-STD-2154 N/C, Type I, Class A verified no flaws
- Rough machining of billet #1 performed at Tapemation
  - Completed Tapemation survey; NC programming process, rough machined grid drawing and work order were approved prior to start of rough machining
  - Mandatory inspection points are identified in work order
- Full anneal and flattening to 0.25in overall of rough machined grid by Bodycote
  - Completed Bodycote survey; approved heat treatment per AMS-2770G and in-house flattening process prior to start of work; witnessed and documented grid flattening
  - Achieved overall flatness to 0.175in
- Solution heat treat, quench, and age rough machined grid back to T6 condition
  - No additional flattening required after quench or aging at Bodycote
  - Post-age hardness measurements per AMS 2658B show grid meets T6 condition
Billet and Grid Processing to Date (cont)

- Rough machined grid shipped to Tapemation following processing at Bodycote
  - Completed receiving inspection
  - Data package from Bodycote includes flatness maps, heat treat time/temp charts, hardness data, certification of heat treatment and straightening
- Tensile tested three samples from rough machined grid following processing at Bodycote
  - Samples have been tested at Anamet Labs per ASTM-B557.
  - TS, YS and %elongation exceed minimum T6 condition requirements per QQ-A-250/11.
  - Additional samples will be stored at SLAC for further analysis as required
- Reviewed grid assembly drawings for approval
  - LAT QA will continue to participate in all grid assembly drawing reviews, approvals and changes
QA Plan for Final Grid Fabrication

- Verify correct NC programming on Tapemation machining equipment
  - LAT QA and Mechanical Systems will approve machined dimensions of single bay simulator before start of grid final machining (reference charts 31 & 32).

- Vibratory stress relief process required to prevent grid distortion during final machining
  - Process performed at Tapemation using in-house process and equipment
  - Grid is subjected to vibration at sub-harmonic frequency prior to final machining of grid
  - Vibrational energy relieves stress; harmonic frequency of grid changes as stress is relieved
  - Stress relief complete when grid harmonic frequency no longer changes with applied vibration
  - Will approve Tapemation’s in-house process before start of work
  - Will witness and document the stress relief process performed on grid

- Verify grid dimensions and flatness prior to surface treatment and plating
  - Will review and approve Tapemation inspection plan to verify dimensions
  - Tapemation will perform inspection
  - LAT QA and Mechanical Systems will review and approve measurements before surface treatment and plating can begin

- Verify grid dimensions and flatness after surface treatment and plating
  - Tapemation will perform inspection after EMI shields and radiator brackets are installed, and again after completing final machining of installed shields and brackets
  - LAT QA and Mechanical Systems will review and approve measurements
QA Plan for Final Grid Fabrication (cont)

- Qualify vendors for alodining, anodizing and Ni plating processes
  - Will complete vendor surveys and materials/processes approval prior to start of work
  - Alodine per MIL-C-5541 Class 3; Black Anodize per MIL-A-8625F, Type II, Class 2; Brush Ni plate per AMS 2451/1.
  - LAT QA will inspect masking of grid prior to surface treatments
  - LAT QA will witness and document brush Ni plating on grid

- Approve Tapemation processes for helicoil insert and dowel pin installation and rework
  - Inserts will conform to GSFC fastener requirement 541-PG-8072.1.2
  - 100% visual inspection of machined holes for cleanliness prior to installation of inserts
  - 100% visual inspection of inserts for cleanliness/damage after installation

- Proof load testing of inserts
  - Tapemation will perform proof loading of inserts per grid drawing using SLAC-provided load testing equipment and approved Tapemation test procedure.
  - Tapemation QA will document proof load testing with LAT QA witness

- Final inspection of grid at Tapemation
  - Review and approve complete data package provided by Tapemation at completion of work

- Develop plan for receiving and incoming inspection of grid at SLAC
  - Identify what receiving and incoming inspections need to be performed on the grid when delivered to SLAC

- Conduct Pre-ship review
LAT-PR-02590: Grid Manufacturing Readiness Review

6. Conclusions

Marc Campell  marcc@slac.stanford.edu
Summary

- All MFG drawings are released except Grid and Spacecraft Bushing.
- Interfaces are well understood and IDD’s are to sufficient level of maturity except the TRK – Grid IDD.
- Risk assessment of open items is complete.
- Tapemation is at a sufficient level of readiness to proceed with a plan in place to complete the open items.
- LAT Quality Plan is in place.

Conclusion

- Release Grid drawing as is (snap shot in time).
- Proceed with the manufacturing of the Grid through vibratory stress relief until TRK interface is finalized and Stress report is released.
- Place hold on the manufacturing of the Radiator Mount Bracket until open issues resolved (~ mid – Jan).
LAT-PR-02590: Grid Manufacturing Readiness Review

Back-up

Marc Campell  marcc@slac.stanford.edu

17 Dec 2003
Tapemation Verification Plan

• Verification and Test Procedures for part number LAT-DS-01269

• Tapemation shall complete a manufacturing plan which includes all operations necessary to produce, verify, and document the LAT Mechanical Systems Grid Box Assembly Machined. We at Tapemation refer to this plan as our Production Routing Order. Our current PRO consists of 49 separate operations starting with the release of the raw material and ending with the delivery of the finished Flight Grid. Subsequent planning will be created and released for the subordinate drawings specified in the parts list.

• The routing is followed top to bottom in numerical sequence. Each operation is verified by Q.A. and stamped accordingly for acceptance to proceed to the next operation. The required inspection and test are stated as individual operations. Tapemation encourages our customers to participate in the inspection process as this is mutually beneficial.

• Objective evidence of all inspections and test will be maintained as separate documents in the master job file. Mechanical inspection results will be recorded on Tapemation form 111 Final Inspection Report. The acceptance criteria are defined as the limits of tolerance specified on the drawing. The print dimension, location, actual measurement, tolerance, inspection feature number, and s/n of tool used will be recorded on this form. All tools including the CMM used for final inspection will be calibrated and traceable to national standards. Calibration reports are on file and will be made available upon request.

• Drawing features defined only by the CAD Database shall have a geometric tolerance specified by drawing notes or other appropriate means. These will be inspected by gathering data with the CMM in the IGES format using the part to establish datum reference. This data then will be compared to the master CAD file supplied by SLAC. The actual measurement shall be recorded as the maximum difference between these two items as a profile measurement. A print out of these points along with the data base will made available upon request. The number and location of data points required to establish acceptance of a surface is at the discretion of the inspector.

• All drawing revisions must be incorporated by purchase order changes from the SLAC Purchasing Officer. The changes will be reviewed and accepted by Tapemation for addition to the manufacturing process via an upgraded PRO. The modified PRO will be made available for SLAC approval prior to manufacturing release. The original PRO will be removed from the manufacturing area at this time and maintained with the master job file.
1 x 4 Grid Lessons Learned

Engineering
• Improved dimensioning scheme for hardware
• Additional views added to 4 x 4 drawing

Manufacturing
• 5 axis machining approach verified
• Methods to reduce machining time were determined

I&T
• CAL baseplates successfully integrated
• Fit check of Shear plates
• Shear plate epoxy injection demonstrated
  – Procedure drafted
  – Shear plate design modified
Impact of Vibratory Stress Relief

• Point Load applied to the center of the grid. (308 lbs, 40% of 770 lbs max)
• Assume Q=25, peak stress 6.35 ksi, run out per Fig. 3.6.2.2.8 of MIL-HDBK-5. (Grid mounted on rubber pads for isolation)
• At Q=78 (conservative), S-N curve equates life of 1e+6 cycles, which means > 8 times or almost 3 hours of vibration at 100 Hz.
• Vibration input will most likely be approx. 30 Hz.
• Conclusion: the Grid will not be damaged by the Vibratory Stress Relief Process.
Fatigue Analysis

GLAST LAT Project

Subsystem: GRID MACHINING

Title: VIBRATION STRESS RELIEF EVALUATION ON GRID

Analyst: J.KU

Page 1 of 3

Date: 12/14/03

META-LAX 2A FORCE INDUCED ENERGY LEVEL 770# @ 100Hz.

ASSUME OPERATING @ 100Hz. (IN REALITY, IT WILL BE MORE LIKE 50Hz.)

ASSUME Q = 10 (RUBBER PADS FOR ISOLATION)

ASSUME INPUT = 40% MAX = 770 (0.40) = 308#

PEAK LOAD INTO GRID = 3080#

FROM CURRENT GRID MODEL, PEAK STRESS AT CENTER = 1.28 kPa

→ 3080# = 13700 N

→ PEAK STRESS = 17.54 MPa.

BY MIL-HDBK-5, 17.54 MPa = 2.54 ksi, FATIGUE CYCLES RUN OUT.

WHAT IF Q IS DIFFERENT?

IF Q = 100 (\(\frac{5}{9} = 0.115\)), 85.4 ksi, CYCLES = 150000.

MARGINAL.

100 Hz = 100 cycles/sec → 120000 cycles

20 min runtime = 1200 sec

IF Q = 2500 (\(\frac{5}{9} = 0.02\)), 635 ksi, CYCLES = RUN OUT

IF CYCLES IS LIMITED TO 1 x 10^6 CYCLES, \(\gamma \text{max} = 20\) ksi.

ALLOWABLE Q = 78 (\(\frac{5}{9} = 0.0064\))

→ Conservative Assumption.
Worst Case Point Load Application

MSC.Patran 2003  16-Dec-03 10:37:18
SC1:DEFAULT, A1:Static Subcase: Displacements, Translational-(NON-LAYERED)
FIGURE 3.6.2.2.8. Best-fit S/N curves for unnotched 6061-T6 aluminum alloy, various wrought products, longitudinal direction.

Correlative Information for Figure 3.6.2.2.8

Product Form: Drawn rod, 3/4-inch diameter
Rolled bar, 1 x 7-1/2 inch

Properties: TUS, ksi  TYS, ksi  Temp, F
45  40  RT

Specimen Details: Unnotched
0.200-inch net diameter

Surface Condition: Not specified

Reference: 3.2.1.18(a)

Test Parameters:
Loading: Axial
Frequency: 2000 cpmp
Temperature: RT
Environment: Air

No. of Heats/Lots: Not specified

Equivalent Stress Equation:
Log Nf = 20.68 - 9.84 log (S_eq)
S_eq = S_max (1-R)0.68

Standard Error of Estimate = 0.48
Standard Deviation in Life = 1.18
R² = 83%

Sample Size = 55

[Caution: The equivalent stress model may provide unrealistic life predictions for stress ratios beyond those represented above]

Supersedes page 3-242 of MIL-HDBK-5E.

3-242