LAT Environmental Test Planning and Design Review

3-4 May 2005

Thermal-Vacuum Test Configuration

Martin Nordby  Mike Foss  Rich Bielawski
Test Configuration Assembly

- **LAT is supported off of TIP and Test Stand during T-Vac testing**
  - Lower Extension Beams serve as feet for supporting cantilevered load
  - Support does not require a moment-bearing connection to the T-Vac trolley
  - Upper Extension Beams are used to hoist the LAT on the trolley, then are removed
- **SC simulator sink plates fit**
  - Top deck sink plate slips between X-LAT Plate and TIP
  - Y-side simulators slide between inside of Radiators and Test Stand
  - Both are support off the TIP/Test Stand
- **Sink Plates and infrared heater cages are mounted around the outside of the LAT after it is on the trolley**
  - These could mount to the Test Stand or be free standing
- **All thermal STE relies on radiative cooling from the chamber cold shrouds**
Test Configuration in the Thermal-Vacuum Chamber

- LAT rolls into the chamber on a table
  - Table rolls on V-groove casters off a trolley on the floor of the building
  - Issues being addressed
    - Load rating of table and rails
    - Load rating of trolley
    - Preferred method to roll LAT into chamber and control motion
    - Confirm LAT height with respect to building beam outside chamber
- Orientation of the LAT in the chamber has not been finalized
  - Radiators-first (as shown): allows easy access around ACD to integrate sink panel
  - ACD-first: provides clear access to route cable and add MLI blankets → this is the likely one
• The table below lists all known mechanical and thermal MGSE/STE needed for T-Vac testing
  – Still missing MGSE MLI blankets → once flight design is finalized, test blanket design will lay out quickly
  – Does not include equipment to move LAT or rigging → being worked as part of facility support

<table>
<thead>
<tr>
<th>MGSE Assembly</th>
<th>Use / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Interface Plate Ass'y</td>
<td>Mounts LAT to slip table/expander head</td>
</tr>
<tr>
<td>Dust Tent</td>
<td>Covers LAT in un-regulated environment</td>
</tr>
<tr>
<td>Test Stand</td>
<td>Supports LAT in T-Vac Chamber</td>
</tr>
<tr>
<td>Extension Beams</td>
<td>Used for turn-over and horiz lift/support</td>
</tr>
<tr>
<td>Spreader Bars</td>
<td>Used for turn-over</td>
</tr>
<tr>
<td>Radiator SC Strut sims</td>
<td>Simulates SC support struts for Radiators</td>
</tr>
<tr>
<td>Radiator heater frame</td>
<td>Supports cartridge heaters for Rad sinks</td>
</tr>
<tr>
<td>ACD sink plates</td>
<td>Provides equiv sink env for ACD sides</td>
</tr>
<tr>
<td>ACD sink plate support frame</td>
<td>Supports ACD sink plates</td>
</tr>
<tr>
<td>SC Simulator sink plates</td>
<td>Provides equiv sink env for Rad backsides</td>
</tr>
<tr>
<td>Top deck sink plate</td>
<td>Provides equiv sink env for X-LAT Plate</td>
</tr>
<tr>
<td>Chill Bars and Aux. Cooling</td>
<td>Cool LAT for pre-/post-test CPT's</td>
</tr>
</tbody>
</table>

List of MGSE/STE Needed for T-Vac Testing
MGSE Requirements Flowing from Thermal-Vacuum Testing

- **Test Interface Plate**
  - Accommodates installation of a SC top deck sink plate between TIP and X-LAT Plate
  - Handle LAT loads when horizontal, plus thermal stresses due to temp variations

- **Test Stand with Extension Beams**
  - Supports LAT in horizontal configuration during hoisting, transport, and on T-Vac trolley
  - Capable of leveling the LAT to an accuracy of 0.1 degrees in both principal axes
  - Functions over temp range of –TBD to +TBD degC while maintaining angular stability of LAT to within +/- 0.1 degrees
  - Extension Beams compatible with T-Vac trolley mounting and floor loading capabilities
  - Includes active heating to stabilize average temps
  - Accommodates installation of, and supports SC simulator sink plates between Test Stand and back side of Radiators
  - Design and construction compatible with cleanliness needed for T-Vac

- **Spreader Bars**
  - Each bar designed to carry entire load of LAT in T-Vac configuration
  - Two spreader bars are identical and interchangeable
  - Capable of lifting LAT in vertical or horizontal configuration
  - Capable of rotating LAT 90 degrees using only two crane hooks

- **SC Strut Simulators**
  - Provide flight-like interface and load paths to simulate SC struts that support Radiators
  - Interface with Radiator at flight interface, and with Test Stand
MGSE Requirements Flowing from Thermal-Vacuum Testing (cont. 1)

- **Dust Tent**
  - Capable of providing clean, dry environment before and after T-Vac testing
  - Designed to be dis-/re-assembled around tipped-over LAT inside T-Vac chamber

- **Chill Bars and Auxiliary Cooling**
  - Designed to be dis-/re-assembled from Grid wing before/after T-Vac test to support open-door CPT testing in air
  - X-LAT auxiliary cooling lines designed to be blown clean prior to T-Vac to prevent unnecessary offgassing of remaining working fluid
  - Working fluid should not be a contaminant for T-Vac (otherwise X-LAT aux cooling lines will need to be capped)
STE Requirements Flowing from Thermal-Vacuum Testing (cont. 2)

- **ACD Equivalent Sink Plates**
  - 3 plates independently heated to provide equivalent sink temp for +Z, +X, and -X ACD faces
  - Passively cooled by large view factor to cold shroud (including underside plate): requires high-emissivity surfaces and over-sized geometry to achieve adequate VF
  - Low mass to speed heating/cooling rates
  - Capable of accommodating thermal stresses due to internal temp gradients and externally-imposed loads from support frame

- **ACD Sink Plate Support Frame**
  - Support ACD sink plates
  - Provide thermal isolation of sink plates from each other and from support structure
  - Minimize thermally-induced loads applied to sink plates due to differential temps between frame and plates
  - Open frame to maximize view of sink plates to shroud
  - Designed to function at shroud temperature

- **SC and Top Deck Simulator Sink Plates**
  - Capable of being installed around LAT/Radiator/TIP/Test Stand assembling without any de-integration of hardware (likely requires that sink plates come in multiple pieces)
  - Passively cooled by view factors to cold shroud: requires high-emissivity surfaces and over-sized geometry to achieve adequate VF
  - Each of the 3 plates is thermally isolated from its neighbor and the Test Stand
  - Each of the 3 plates is actively heated on an independent heater circuit
  - Low mass to speed heating/cooling rates
**STE Requirements Flowing from Thermal-Vacuum Testing (cont. 3)**

- **Radiator and ACD Y-Side Heaters**
  - Cartridge heaters are small to reduce view factor from Radiators
  - Heaters are low mass to speed heating/cooling rates
  - High emissivity surfaces

- **Heater Cages**
  - Supports cartridge heaters
  - Thermally isolates heaters
  - Accommodates large temp range of heaters
  - Capable of functioning down to shroud temperature
  - Provides blinders, baffles, and MLI blanketing to block view of heaters to other sink plates and thermal surfaces
  - Self-supporting off trolley floor
STE Heating and Cooling

- Thermal test equipment along with the chamber cold shroud provides the equivalent sink temperatures needed to simulate the on-orbit radiative environment for all external surfaces of the LAT.
- Heating is provided by resistance heaters
  - Cartridge heaters for Radiator and Y-side ACD control zones
  - Strip heaters on sink plates for +Z, +/-X sides of ACD, insides of Radiators, and underside of X-LAT Plate
  - Strip heaters mounted to the Test Stand to keep it at nominal LAT temperatures
- Cooling is purely passive radiative cooling to the chamber cold shroud
  - No GN2/LN2 circuits needed (TBR)
Heater Zones and Power

- The table below shows preliminary estimates for power needs for all control zones
  - This will be updated prior to releasing the Test Plan → good numbers are needed to finalize feedthrough requirements for the chamber and scope max power for power supplies
  - Updated values will be generated as part of final pre-test analyses

<table>
<thead>
<tr>
<th>Panel</th>
<th>Type</th>
<th>Panel Temp (degC)</th>
<th>Power Density (W/m²/Zone)</th>
<th>Area (m²)</th>
<th>Max Pwr (W/Zone)</th>
<th># Zones</th>
<th>Tot Pwr (W)</th>
<th>V</th>
<th>A</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rad -Y</td>
<td>IR Heat</td>
<td>-50 -200</td>
<td>5000 -2000</td>
<td>2</td>
<td>2</td>
<td>5000</td>
<td>2</td>
<td></td>
<td></td>
<td>TBR</td>
</tr>
<tr>
<td>Rad +Y</td>
<td>IR Heat</td>
<td>-50 -200</td>
<td>5000 -2000</td>
<td>2</td>
<td>2</td>
<td>5000</td>
<td>2</td>
<td></td>
<td></td>
<td>TBR</td>
</tr>
<tr>
<td>ACD +X</td>
<td>Sink Pl</td>
<td>-76 -36</td>
<td>59.0 -63.0</td>
<td>63.0</td>
<td>2.4</td>
<td>1258</td>
<td>1</td>
<td></td>
<td></td>
<td>1572</td>
</tr>
<tr>
<td>ACD +Y</td>
<td>IR Heat</td>
<td>-79 -36</td>
<td>59.0 -63.0</td>
<td>63.0</td>
<td>2.4</td>
<td>1258</td>
<td>1</td>
<td></td>
<td></td>
<td>1572</td>
</tr>
<tr>
<td>ACD -X</td>
<td>Sink Pl</td>
<td>-82 -65</td>
<td>54.0 -78.0</td>
<td>78.0</td>
<td>4</td>
<td>312</td>
<td>1</td>
<td></td>
<td></td>
<td>390</td>
</tr>
<tr>
<td>ACD -Y</td>
<td>IR Heat</td>
<td>-82 -65</td>
<td>54.0 -78.0</td>
<td>78.0</td>
<td>4</td>
<td>312</td>
<td>1</td>
<td></td>
<td></td>
<td>390</td>
</tr>
<tr>
<td>Test Stand</td>
<td>Strip Htr</td>
<td>-10 -5</td>
<td>51.8 -60.3</td>
<td>60.3</td>
<td>4</td>
<td>312</td>
<td>1</td>
<td></td>
<td></td>
<td>390</td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20089</td>
<td></td>
<td></td>
<td>TBR</td>
</tr>
</tbody>
</table>

Notes:
Heater power based on 100 K ultimate sink on LN2 cold walls of chamber
Total power column includes 25% margin

STE Heater Circuits and Power Requirements (TBR)
T-Vac Electrical Configuration Diagram
Mechanical Handling

- Handling and mechanical operating procedures
  - LAT lifting procedure
  - LAT roll-over procedure
  - Test Stand handling and operating procedure
  - Dust tent handling and operating procedure
  - LAT auxiliary cooling system operating procedure

- Contamination control and cleanliness
  - We are just starting to work through these issues seriously, now that the basic MGSE, EGSE, and thermal configurations are understood
  - Issues to work
    - High-bay cleanliness: this is not a clean room → what are our cleanliness requirements and how will we implement them
    - MGSE/EGSE bake-out: we will need to bake out hardware going into the T-Vac chamber, but the spec’s on what needs to be done and the logistics of doing it have yet to be worked
Issues for Thermal-Vacuum Testing

• T-Vac Test Plan
  – This has barely started to stabilize, and there are still many TBX’s

• Preliminary design of thermal STE
  – Sink plates and infrared heater cages need to be designed to confirm that Test Stand and in-chamber layout is adequate
  – System needs to be sized so we can buy feedthroughs, power supplies, and close out other options that we are attempting to hold open (TCU, LN2 boil-off)

• Preliminary pre-test analyses
  – We have run some simplified cool-down scenarios, but none using actual chamber and STE thermal designs
  – This needs to be done to confirm that our current thermal design works
  – Also needed to check lines of sight and establish where blinders and MLI needs to go to block incidental IR heating coming from heater cages
  – This also will finally give us a good estimate of projected cool-down and warm-up times, including time-to-balance → this is needed before we can work on LAT functional test scenarios during transitions

• EGSE cabling
  – What issues list isn’t complete without this topic?
  – Feedthroughs are nearly spec’d out
  – Next step is to spec cable lengths and start cable design (both inside and outside chamber)
  – Also need to work details of cable installation and check-out
Conclusions

- Thermal-vacuum test planning has advanced considerably over the past four months
  - We have a working Test Plan that is getting close to ready for release
- T-Vac MGSE and STE designs and concepts are plausible, and work with the key MGSE Test Stand and TIP hardware
- EGSE cabling and feedthrough plans are nearly finalize and feedthrough orders will be placed soon
- Requirements for EGSE crates are almost fully defined and the EGSE meets them
- We have progressed considerably in the past few months, but have many details to work out still