X-LAT To Electronic Boxes Thermal Joint Trade Study

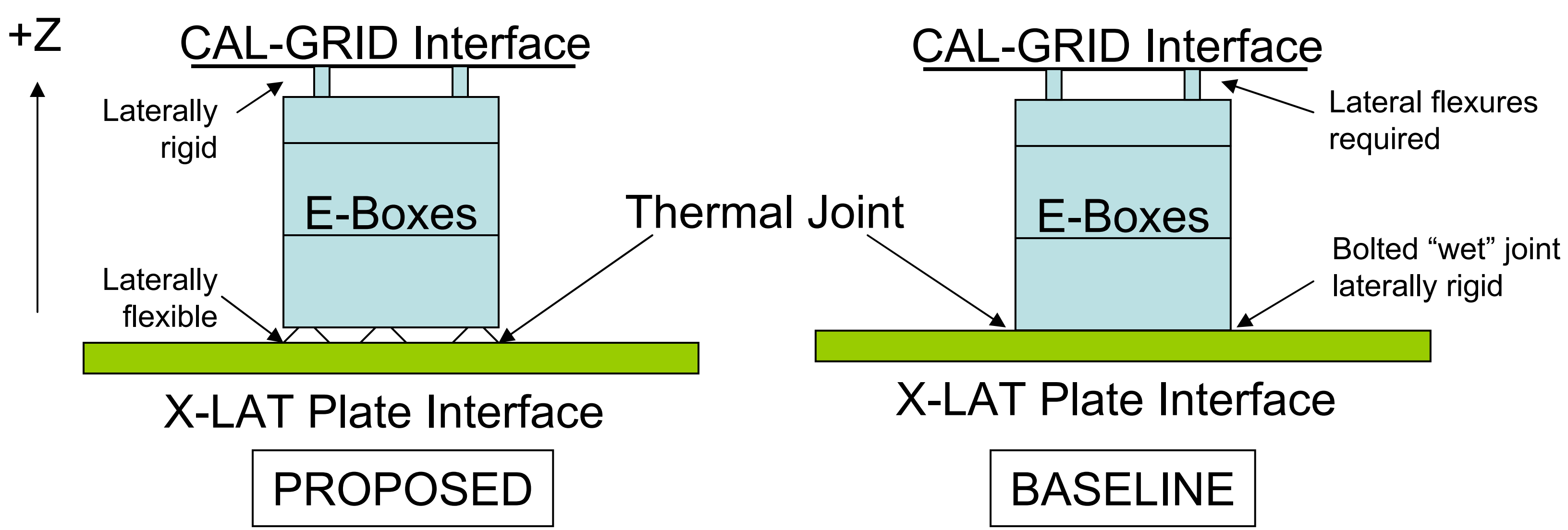
1/28/2003

Objective

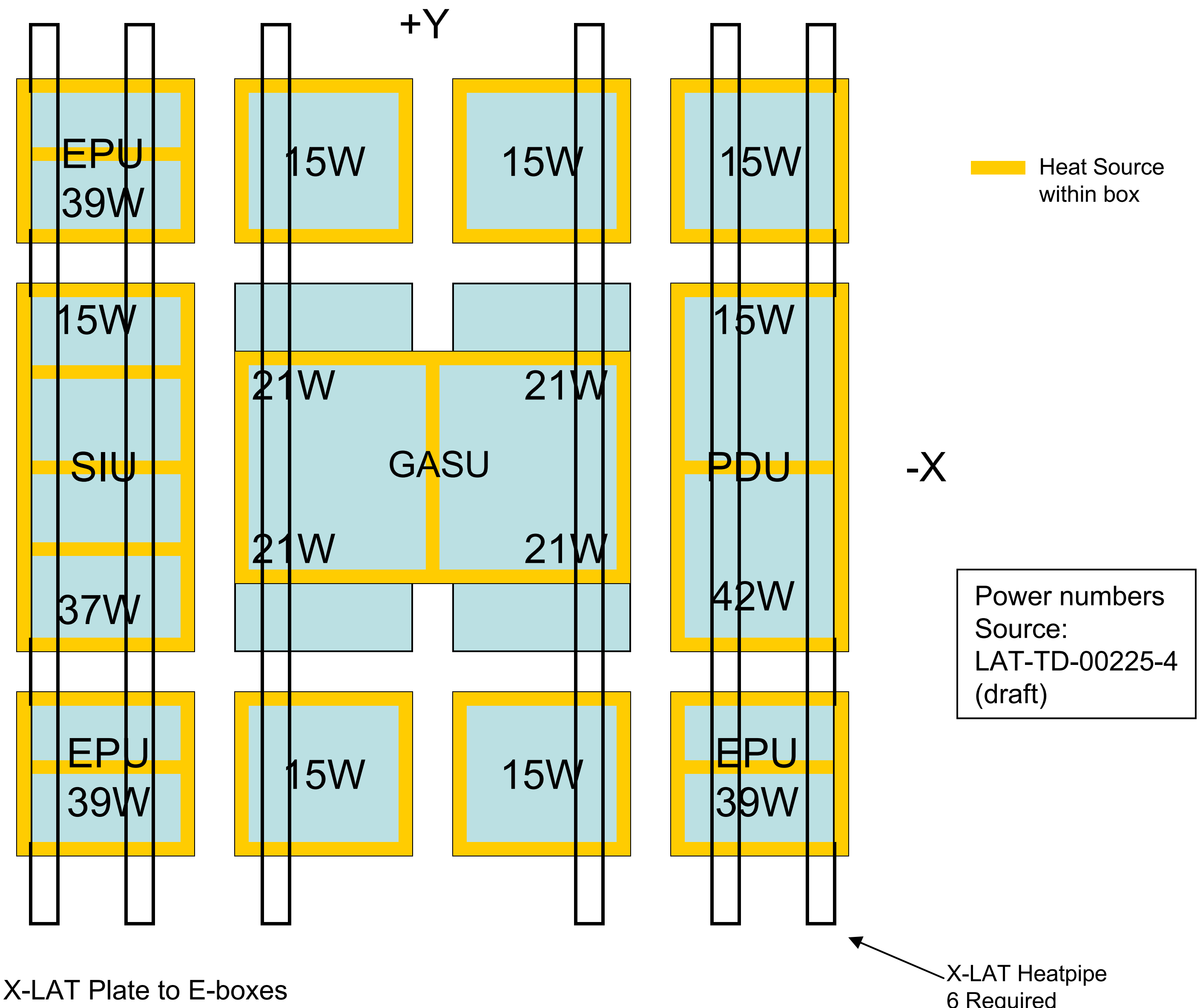
- Identify feasible thermal joint material that meets thermal, structural and integration test and assembly at next-higher-assembly

Design Drivers

	Mechanical Property	Design Drivers
1	Integration and serviceability	Verifiable thermal joint for de-integration, re-integration, and servicing after environmental tests
2	Maximize thermal conductance	2 deg C delta T across surfaces of joint; goal of 0.03 W/cm2-C minimum
3	Lateral flexibility	Need flexibility either at CAL interface or X-LAT Plate interface for launch and thermal environments
4	Ease of CAL-TEM verification testing	Lateral rigidity at CAL-TEM interface simplifies setup fixturing for verification testing
5	Low creep over life	< 10% of BOL contact pressure
6	Low-outgassing	per ASTM-E-595



Design Drivers (cont.)



Note: View from X-LAT Plate to E-boxes
Power shown include 15 W from TEM/TPS boxes

Design Candidates – "Wet" Joint

- "Wet" Joints (Baseline) Design Features
  - Conductive silicone or pads that require high clamping pressure (>100 psi) for thermal conduction
  - Tight co-planarity and parallelism (approx. 5 to 20 mils) required between surfaces
  - Rigid joint in both lateral and normal direction
  - Nusil CV2946, SilPad 2000 and K4, VO gap pad

Pros	Cons
Excellent thermal joint (standard joint for thermal surfaces)	•Adhesives difficult to applied •Require tight co-planar surfaces within small gaps •Servicing require breaking bond and reapplying •New bond require reverification
Flight experience	Joint requires boxes to mount directly to heat sink (X-LAT)
Rigid joint- all direction	Require flexure at CAL-TEM interface

Design Candidates – "Wet" Joint (cont.)

Issues/Risks:

- **Tight surface co-planarity and parallelism requirement force leveling in boxes during assembly, 16 places**
  - **Adhesive difficult to apply for baseline LAT integration plan**
  - **Mating of X-LAT to all 16 surfaces instead of vice versa**
- **Servicing of boxes, during or after all environmental tests, require breaking bond joint and re-verification of thermal property**

Design Candidates – Spring Stock

- Spring Stock Design Features
  - Metallic springs made from thin BeCu or Al foils that use low contact pressure (5 to 100 psi) for thermal conduction
  - Allow more flexibility and larger gaps (30 to 90 mils) between surfaces
  - Flexible in both lateral (X and Y) and normal direction, require constraint in normal direction for structural purposes
  - Off-the-shelf EMI shields such as spring fingers, Al foil, Cu wire mesh

Pros	Cons
Easier assembly during LAT integration -Allow larger gaps and non-parallel surfaces -More than one removal and re-install -Repeatable thermal joint	Low thermal conductance joint as compare to “wet” joints
Allow CAL-TEM interface to be rigid joint	No flight experience as thermal joint application

Design Candidates – Spring Stock (cont.)

- Issues/Risks
  - Development risks (schedule, technical) in designing a spring stock profile that provide the right contact pressure for the minimum thermal conductance
  - Require design iterations (material thickness, bend profile) and thermal testing prior to baseline

Design Candidates – Thermal Straps

- Thermal Straps Design Features
  - Highly conductive metallic foil (Ni plated Cu) that bridge across two Al surfaces without requiring contact pressure
  - Allow more flexibility and larger gaps between surfaces, but larger gaps (.09 to .25 in) are needed for mechanical fasteners
  - Flexible, within yield limits of material, in lateral (either X or Y, not both) and normal directions
  - Custom design and fabricate/plate in-house

Pros	Cons
Easier assembly during LAT integration -Allow larger gaps and non-parallel surfaces -More than one removal and re-install -Repeatable thermal joint	Low thermal conductance joint as compare to "wet" joints
Allow CAL-TEM interface to be rigid joint	Require access to mechanical fasteners to X-LAT Plate during integration
	Lateral flexibility in one direction not both; required relief in detail design

Design Candidates – Thermal Straps (cont.)

- Issues/Risks
  - Design needs verification by test for thermal conduction property and lateral flexibility
  - Design detail to ensure thermal contact and ease of assembly by minimizing number of fasteners

Thermal Conductance Comparison

	Material	Delta T (deg C)	Comments
1	Nusil CV2946	0.04	"wet" joint
2	SilPad 2000	0.09	"wet" joint
3	SilPad K4	0.07	"wet" joint
4	Al Foil/Foam	0.43	"wet" joint
5	BeCu Spring Stock - .10 in	1.0	- Spring stock - Effective contact area is reduce approx by ½ - Average conductance assumed min contact pressure is achieved
6	BeCu EMI Coil	1.4	- Spring stock - Effective contact area is reduce approx by ½ - Average conductance assumed min contact pressure is achieved
7	Thermal Strap	1.0 - 2.0	- By design of matl thkness and number of fasteners and spacing

- **Assumptions:**
  - **Worst-case power output is 25 Watts to one heatpipe (50 W per box)**
  - **Full contact area of 11 inch X 11 inch (781 cm2) of box is used as contact area**
  - **Conductance is derived by small coupon EM tests**

Trade Study Results

	"Wet" Joint					Spring stock		Thermal Straps	
Requirements	NuSil CV2946	SilPad 2000	SilPad K4	Al Foil	VO Gap Pad	BeCu Spring Stock	BeCu Wire Mesh	Ni-plated Cu	Comments
Integration and serviceability	√	√	√	√	√	√√	√√	√√	Wet joint difficult to apply and for servicing boxes during or after environmental testing
Maximize thermal conductance	√√√	√√√	√√√	√√	√√	√√	√	√√	Spring stock conductance dependent on min contact pressure
Lateral flexibily	√√	√√	√√	√√	√√	√√	√√	√√	Need flexibility either at X-LAT plate or CAL-TEM interface
Ease of CAL-TEM verification testing	√	√	√	√	√	√√√	√√√	√√√	Thin gasket-like matls reqd tighter co-planarity of boxes for even contact pressure
Low creep over life	√√√	√	√	√	√	√√	√	√√√	√ = Test required
Low outgassing	OK	OK	OK	OK	OK	OK	OK	OK	
Total	10	8	8	7	7	11	9	12	Total number of checks

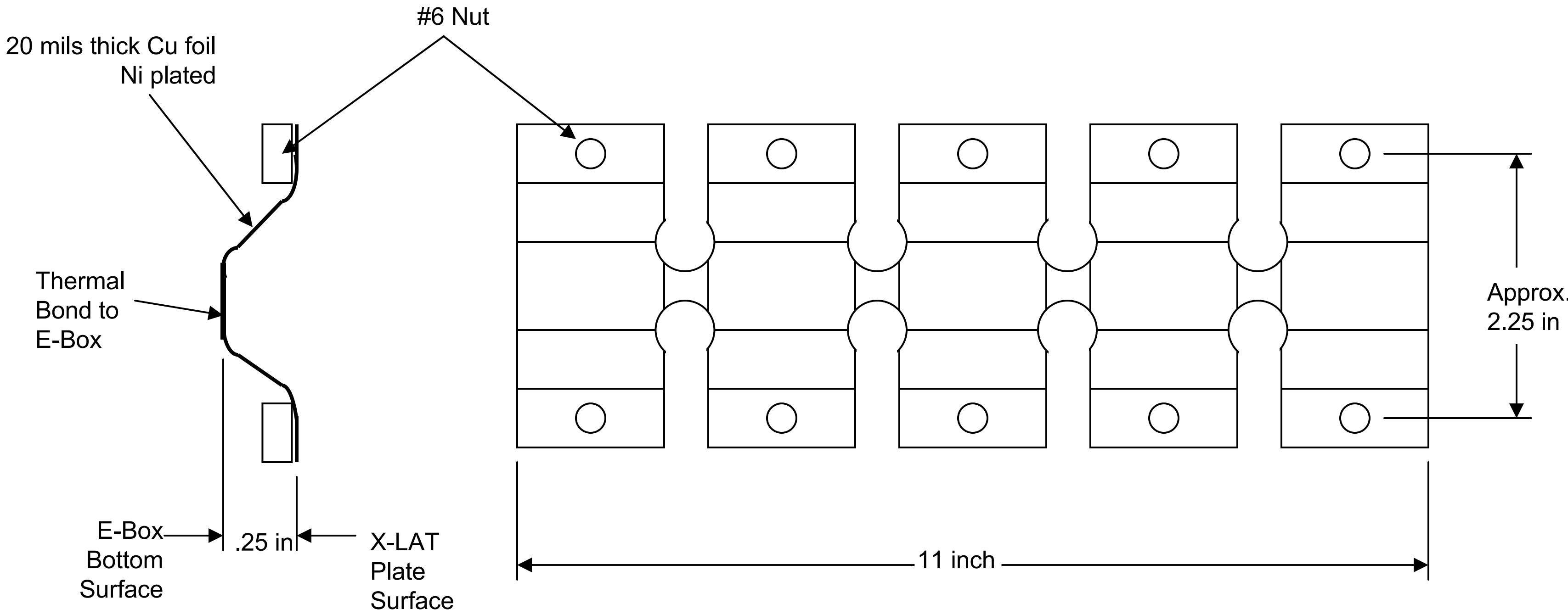
Note:
√ = Poor, √√ = Medium, √√√ = Excellent

Recommendations

- Baseline thermal strap as thermal joint across X-LAT to E-boxes
  - Allows CAL-TEM interface to be rigid structural joint
  - Can meet thermal conductance and delta T requirements depending on detail of joint design
  - Allows more than one removal and re-integration of X-LAT plate without reverifying thermal joint
  - Relatively much easier at next-higher-assembly due to looser co-planarity and parallelism tolerance requirement

Thermal Strap Preliminary Concept

Thermal Strap Concept Proposed – 3 per box



Future Work

- Optimize detail design of thermal strap for ease of integration (minimize number of fasteners) and for maximizing thermal conductance
- Optimize design for all lateral flexibility
- Fabricate in-house EM straps for thermal tests and integration evaluation
- Incorporate thermal strap into detail design of X-LAT and boxes design