GLAST/ACD Micrometeoroid Shield and Thermal Blanket Specifications and Conceptual Design **September 24, 2003**

Draft 2

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1.0 Purpose

The purpose of this document is to define requirements, provide procedural information, recommend manufacturing techniques, and propose a conceptual design for the GLAST/Anti-coincidence Detector (ACD) Micrometeoroid Shield (MMS) and Thermal Blanket/Multi-layer Insulation (MLI). This shall be a living document, updated to reflect changes throughout the development process.

2.0 Scope

This document addresses issues of fabrication, materials, handling, and requirements for design, contamination control, venting, and EMC for the GLAST/ACD. It should be used as a guide for GLAST subsystems during component build and I & T. Many blanketing approaches are used in the aerospace community which achieve similar successful results.

This document is not all-inclusive and details for variations can be added in the future.

3.0 Goals and minimum requirement summary

3.1 Micrometeoroid Shield/MMS. To protect the scintillator from penetrations by space debris or micrometeoroids.

3.1.1 To prevent light leaks to the TDA's.

3.2 Thermal Blanket/MLI. To provide thermal protection.

3.3 The GLAST mission lifetime is 5 years with a goal of 10 years.

3.4 The number and type of layers shown in the figure in section 4.8.3 reflect designs for the MLI and MMS specified to meet thermal and reliability requirements. MMS design parameters are in the JSC document (…….)

3.5 MINIMUM REQUIRMENT SUMMARY collected from the various sections below. They are in bold in their various sections.

- **There must be MMS between every scintillator and space.**
- **The MMS needs to extend 3.3 cm below the bottom of the lowest ACD tile in order to assure that any micrometeoroid must penetrate a full**

thickness of shield before reaching a scintillator. With the exception of possible BEA connectors cutouts

- **Thickness/ Depth of total stack-up MMS not to be greater than 3.27 cm. See design document …. For MMS design implementation.**

- **The mass per unit areal density must be below 0.3g/cm2 not including attachments to avoid background generation problems.**

- **Weight allotment for the MMS & MLI is 30.1 Kilograms (without fasteners).**

- **The MMS and MLI must be capable of withstanding all conditions associated with a Delta 2 launch.**

- **The MMS and MLI need to be designed to allow them to be removed from the ACD without compromising the science or construction, and with a minimum of impact to the schedule**

- **MLI - The ACD MLI shall have an effective thru emittance, e* where 0.01<e*<0.03. High emissivity (>0.78), low alpha (<0.55) on outer layer MLI blankets. See figure in section 4.8.3 for current implementation.**

- **The MMS and MLI blanket cover the ACD per drawing LAT-DS-00309, LATACD IDD and the LAT-ACD Outline drawing.**

- **There are no special requirements for Atomic Oxygen protection. However, the properties of the Germanium coated outer layer of MLI and the grounding system for the outer layer of MLI will effectively increase survival against AO. AO requirement is in the LAT Environmental Specification.**

- **All pieces will have to break apart during reentry into the earth's atmosphere. Reference ORDEM (Orbital Debris Environment Model). See next two items below**

- **The Nextel fabric is the material of greatest concern. Nextel layers should be cut and joined to reflect the 5 sides of the ACD. (Max dimension TBD, refer to D Thompson email)**

- **A thread that will melt at low temperatures will be used to join seams. (270C Polyester or nylon thread.)**

- **MMS. The inside layer of the MMS will be metalized (Kapton surface facing the hardware) and grounded (refer to grounding spec table in appendix) to the Base Electronics Assembly/BEA/Chassis. For**

reference The GLAST grounding document is 433-rqmt-00005, EMI reqs document

- **MLI grounding requirement is for the purpose of ESD.**

- **ICD 11.6 Multi-Layer Insulation - The ACD MLI blanket shall be grounded at the Grid per drawing LAT-DS-01151, LAT-ACD Outline Drawing. The blanket shall be grounded at eight locations, two per side. The thermal blanket is currently assumed to end at the bottom of the ACD.**

- **There will be redundant grounding of all metalized layers. Implemented this means there will be 2 ground tabs per blanket, attachment at 2 points per side of the BEA. Figure 4 and 5.**

- **ICD 14.1. Venting. - During launch, air from the ACD shall be vented outward, away from the inside of the LAT. No ACD venting shall be allowed into the volume surrounding the TKR modules or down past the Grid perimeter. (May ask for change in wording in ICD)**

- **The MMS and MLI will conform to the requirements set forth in the GLAST Contamination Control Plan 443-PLAN-0010.**
- **Materials will meet parameters for outgassing as set in NASA Reference Publication 1124/Reference Outgassing Data for Selecting Spacecraft Material. <1.0% TML and <0.10% CCVCM**

- **There would be minimum penetrations to the MMS or MLI. Any penetrations to the MLI shall be covered with a thermal cap. Any penetrations in the MMS shall be capped be made in a way that allows the MMS layers to remain integral.**

- **We will write bagging procedure which does not harm the MLI.**

4.0 Specifications/Requirements

4.1 Geometric Parameters

4.1.1 There must be MMS between every scintillator and space.

4.1.2 Keep the MMS and MLI as close to the scintillator as possible.

4.1.3 The MMS does not need to conform to the tile 'step down' on the top or side surfaces.

4.1.4 Anticipate building additional foam into dimensions on sides to bring the MMS our beyond the furthest tile dimension.

4.1.4.1 *What dimension should be used to build corner side seams to square?*

4.2 **Dimensional Requirements**

4.2.1 The MMS needs to extend 3.3 cm below the bottom of the lowest ACD tile in order to assure that any micrometeoroid must penetrate a full thickness of shield before reaching a scintillator. With the exception of possible BEA connectors cutouts?
What is the impact to the lifting fixture?

4.2.2 Thickness/ Depth of total stack-up MMS not to be greater than 3.27 cm. See design document …. For MMS design implementation
(Total shield standoff not to exceed 3.27cm.)

4.2.3 *ICD 7.1 Nominal Stay-Clear Dimensions* *The ACD subsystem components shall stay within the stay-clear volume described in LAT-ACD IDD drawing LAT-DS-00309.*

4.2.4 *ICD 7.2 Nominal Stay-Clear* *10mm outward motion of the MLI shielding.*

4.3 **Construction**

4.3.1 Ideally, MMS and MLI seams should butt with no gaps. (Overlapped seams have to be considered. Overlaps add bulk/dimension/mass)

4.3.2 Ideally, seams of all layers are staggered or seam location is varied.

4.3.3 Joining of seams/construction techniques should be reversible.

4.3.4 Remove threads/stitching to open fabric seams.

4.3.5 Slit tape that holds seams together (Generally, adhesive residue cannot be removed from film surfaces.) Must buy-off on additional weight/tape layers.

4.3.6 Adjoining Solimide foam seams will need to be fastened together to prevent shifting and gapping. Spot bonding with an adhesive is proposed.

4.3.7 If Solimide seams are bonded, it will not be possible to open these seams.

4.3.8 Gaps in the Solimide foam are acceptable.

4.3.9 The weakest area of the MMS will be the 4 top corners, inside and outside. It is a difficult geometry to wrap without any gaps.

4.4 **Mass/Weight**

4.4.1 The mass per unit areal density must be below 0.3g/cm2 not including attachments to avoid background generation problems.

4.4.2 Weight allotment for the MMS & MLI is 30.1 Kilograms (without fasteners).

4.5 **Durability**

4.5.1 The MMS and MLI must be capable of withstanding all conditions associated with a Delta 2 launch.

4.6 **Removability**

4.6.1 **The MMS and MLI need to be designed to allow them to be removed from the ACD without compromising the science or construction, and with a minimum of impact to the schedule**.

4.6.2 The minimum number of handlings (remove and reinstall) would be one; from the fabrication fixture to the flight hardware.

4.6.3 The best design for this is to have the MMS and MLI handled as one unit and to be able to slide the MMS/MLI off in one piece without opening seams. Figure 9.

4.6.4 Attachment points for MMS are under MLI

4.6.5 The schedule should plan for installation of the MMS/MLI as late in the schedule as possible

4.6.6 Anticipate needing a 'holding fixture' for MLI until it is needed

4.6.7 There is no requirement to test hardware with the MMS and no MLI.

4.6.8 *NOTES from ICD – ICD. 13.1. Integration Stay-clears and Access Requirements.*
The ACD shall be integrated to the LAT vertically, from above.

The ACD shall be capable of being de-integrated from the Grid at any time. The de-integration of the ACD from the LAT will not require disassembly or invalidating verification of any other subsystem.

ICD 13.4.. Integration GSE due to crane ops (height limitations @ SLAC, not possible to use Multi-Purpose Sling for ACD @ GSFC.

4.6.9 There will be some height limitations which probably prevent the MMS/MLI from being removed in the LAT clean room by crane. See LAT ACD ICD LAT-SS-00363

4.7 **Science**

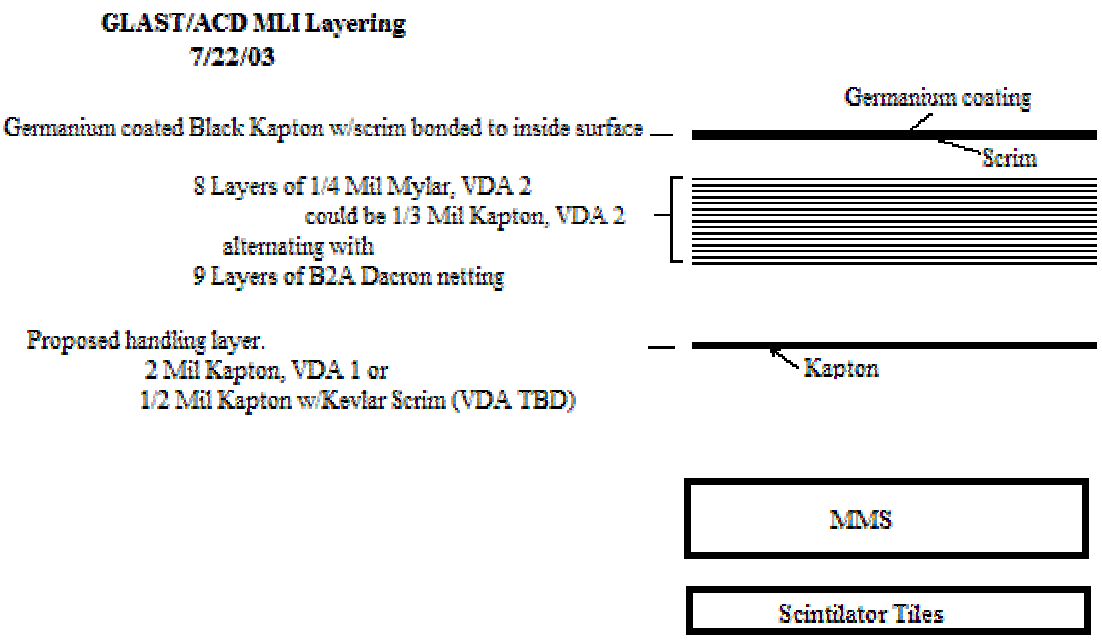
4.7.1 The MMS design is driven by reliability, background, and efficiency requirements. See level 3 requirements document (LAT-SS-…).

4.8 **Thermal**

4.8.1 The MMS and MLI blanket cover the ACD per drawing LAT-DS-00309, LATACD IDD and the LAT-ACD Outline drawing.

4.8.2 MMS - There are no thermal requirements for the MMS, although the Shield does provide some thermal protection.

4.8.3 MLI - The ACD MLI shall have an effective thru emittance, e* where 0.01<e*<0.03. High emissivity (>0.78), low alpha (<0.55) on outer layer MLI blankets. See figure in below for current implementation.



- *Note : Will there be enough thermal expansion/contraction (temperature transitioning) that may warp or tear the MLI or MMS or dislodge fasteners? We are considering large areas of material where 1 or 2 % is a large factor. Mechanical will examine this.*
  - *ICD. 7.2. Stay-Clear for Dynamic and Thermal Motions.*
    Thermal contraction/dialation of the interfaces to the Grid, consistent with the thermal expansion coefficient of aluminum.

- *ICD. 11.6. Multi-Layer Insulation.*
  The entire blanket assembly shall be sandwiched between a 3 Mil thick Germanium Black Kapton (with scrim) sheet and a 1 mil thick VDA Kapton sheet.

4.9 Atomic Oxygen Protection

4.9.1 There are no special requirements for Atomic Oxygen protection. However, the properties of the Germanium coated outer layer of MLI and the grounding system for the outer layer of MLI will effectively increase survival against AO. AO requirement is in the LAT Environmental Specification.

4.10 Demisability

4.10.1 All pieces will have to break apart during reentry into the earth's atmosphere. Reference ORDEM (Orbital Debris Environment Model). See next two items below

4.10.2 The Nextel fabric is the material of greatest concern. Nextel layers should be cut and joined to reflect the 5 sides of the ACD. (Max dimension TBD, refer to D Thompson email)

4.10.3 A thread that will melt at low temperatures will be used to join seams. (270C Polyester or nylon thread.)

4.11 Grounding/EMI/RF

4.11.1 MMS. The inside layer of the MMS will be metalized (Kapton surface facing the hardware) and grounded (refer to grounding soec table in appendix) to the Base Electronics Assembly/BEA/Chassis. The LAT grounding document is …….

Recommended: The outside layer of the MMS should also be a metalized (aluminized) film which will enclose the MMS in a groundable, ESD safe environment, reducing static charge on the shield from air flow or lifting operations during I & T.

Recommended: One or both of these added layers can function as an EMI/RF shield if seams are properly joined. Refer to Section 4.3.3 and Figure 5.

- Adds weight and density to the MMS.
- Special grounding points will need to be provided to the BEA.

4.11.2 MLI grounding requirement is for the purpose of ESD.

- ***ICD 11.6 Multi-Layer Insulation The ACD MLI blanket shall be grounded at the Grid per drawing LAT-DS-01151, LAT-ACD Outline Drawing. The blanket shall be grounded at eight locations, two per side. The thermal blanket is currently assumed to end at the bottom of the ACD.***

4.11.3 There will be redundant grounding of all metalized layers. Implemented this means there will be 2 ground tabs per blanket, attachment at 2 points per side of the BEA. Figure 4 and 5.
(It was discussed in the meeting that being grounded to the BEA provides ESD and RF grounding during I & T and would be independent from the grounding proposed to the LAT.)

4.11.4 The requirement stated is <3.0 ohms. (This is our baseline.)
Open Issue - This is a bit difficult to achieve. Is there a reason that we cannot consider a <10ohms requirement? I talked to Fred Blanchette who referred me back to a SLAC/Dave Nelson grounding document which I could not locate.

4.11.5 RF shielding can be provided in a single layer whether it is a layer of the MMS or MLI.

4.11.6 RF shielding will require a 2 inch wide connection between the shield and BEA and a specific grounding lug TBD.

4.11.7 The Germanium Black Kapton outer layer and the tape used to seal the Germanium seams shall be grounded.

4.11.8 Metalized layers will have to be tested/measured as they are built. Access to MLI pieces will be lost during construction.

4.11.9 Measurements and individual layer resistance. See attached chart.

4.12 **Venting**

Mechanical will be working these issues.

- *Has someone calculated the velocity/volume of air flow @ launch? Need to check both MMS & MLI. How will this affect the venting?*
- *Will there be a 'blast' of air thru the MMS fasteners (holes in the shield) that may affect the MLI above it?*
- *Consider the use of MLI perforated inner layers to help with air escape*
- *It is possible that we would require filtered vents in the bottom of the ACD to control any particulates coming from the MMS in the direction of the LAT.*
- *Sample testing?*

- **ICD 14.1. Venting. During launch, air from the ACD shall be vented outward, away from the inside of the LAT. No ACD venting shall be allowed into the volume surrounding the TKR modules or down past the Grid perimeter. (May ask for change in wording in ICD)**

4.12.1 The vent path will be in the direction of the BEA.
Except in area of Star Trackers. This will need to be defined.

4.13 **Contamination Control**

4.13.1 The MMS and MLI will conform to the requirements set forth in the GLAST Contamination Control Plan 443-PLAN-0010.

4.13.2 Existing fabrication methods developed for other missions will be utilized for limiting contamination throughout all mission phases.

4.13.3 During fabrication and assembly phases, surfaces will be kept clean and if debris is generated it will be cleaned/vacuumed off. A bagging procedure will be written to avoid damage to the MLI during bagging operations.

4.13.4 Materials will meet parameters for outgassing as set in NASA Reference Publication 1124/Reference Outgassing Data for Selecting Spacecraft Material. <1.0% TML and <0.10% CCVCM

4.13.5 As practical, a bake out of bulk materials prior to construction will be performed.
This would eliminate most of the volatiles and pre-shrink the materials. The TML will be mostly water vapor, and there is little that can be done to prevent this from returning to materials.

4.13.6 The ACD shall prevent any venting or shedding of particulates down, or out the bottom of its stayclear, to avoid possible contamination of the spacecraft star tracker. At issue here is a possible containment of the solimide foam at the bottom edge of the MMS and the vent path. Just close off tracker side?Is this in the ICD Is this a min req?

4.14 **Instrumentation**

4.14.1 There is no instrumentation on the MMS or MLI layers that will affect the build of the MMS/MLI or require removal of the MMS or MLI for installation or removal.

4.15 **Fastening**

4.15.1 There would be minimum penetrations to the MMS or MLI. Any penetrations to the MLI shall be covered with a thermal cap. Any penetrations in the MMS shall be capped be made in a way that allows the MMS layers to remain integral.

4.15.2 Need to design or use fasteners that offer little or small penetration.

4.15.3 Inner layers of MLI can be joined w/transfer adhesive to keep from shifting.

4.15.4 MMS minimum # of fasteners per weight/area needs to be calculated?

4.15.5 1-4 fasteners are available per tile.

- *Questions of Viton washers or other fastener damaging the Black Tedlar tile covers as the hardware is torqued (the washer will twist.)*

4.15.6 Interface/attachment points with the BEA TBD.

4.15.7 Interface/attachment points to LAT TBD.

4.15.8 Hole pattern on bottom row of tiles is different per side.

4.15.9 MLI fastening is being negotiated.

ICD States:

- Bolts, washers, and any other hardware needed to attach the ACD to the Grid. All bolts, washers and other hardware used on the flight article shall be from the NASA/GSFC approved parts list.
- Thermally conductive material, as needed to meet the interface requirements described in this document (ICD) to be used at the ACD-Grid interface joint.

4.16 **Bagging**

- **We will write bagging procedure which does not harm the MLI.**
- *Assume bagging is an issue at all levels up through S/C.*
- *Double bagging requirement?*
- *How is this to rest on the MMS/MLI?*
- *What are the restrictions to the weight of the bag?*
- *How will it be installed and removed? Will a fixture be needed?*

4.17 **Documentation**

4.17.1 Templates. None are required, but some will need to be made.

4.17.2 Documentation of locations of seam overlaps would be important as well as details of corner treatments.

4.17.3 Coordinate layering, dimensions, construction techniques with a designer.

4.17.4 Figure out format/drawing for this to be done.

4.18 **Quality Assurance**

5.0 Miscellaneous Items

5.1 A High fidelity mock-up will be required to build the ACD MMS/MLI.
5.2 A lifting fixture will need to be designed.
5.3 If the MMS needs to be removed, a holding fixture will most likely be needed.
5.4 Facility and Equipment
  5.4.1 Requirement for a regular straight stitch sewing machine and possibly a merrow machine.
  5.4.2 Facility space for fabrication will need to be generous as each layer consumes a great deal of area when cut and sewn. Also, multiple layers should be under construction coincidentally.

Temporary Appendix

GLAST/ACD MLI Design Concept- Proposed **July 22, 2003**