Failure Mode Effect Analysis (FMEA) & Critical Items List (CIL) GLAST LAT Anti-Coincidence Detector (ACD) Report

Credit: Hytec

LAT-TD-00913-01
ACD-RPT-000042

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Goddard Space Flight Center
Greenbelt, Maryland

Anti-Coincidence Detector FMEA & CIL for PDR
ACD-RPT-000042

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ACD FMEA &CIL Report
ACD-RPT-000042

REVISION PAGE

REVISION	DESCRIPTION	DATE	INITIALS
(Rev -)	Initial CM Release		

1.0 INTRODUCTION

1.1 Scope

This analysis provides an assessment for the proposed hardware configuration of the Anti-Coincidence Detector (ACD) that will be mounted over the Large Area Telescope (LAT) of GLAST.

The Failure Mode & Effect Analysis (FMEA) analysis provides a “bottoms-up” look at each ACD component in order to identify potential failures and their effects on a local, ACD, and overall LAT system level. Specific attention is given to identification of any Single Point Failures (SPFs) that could cause failure of the GLAST Mission, and to recommend corrective actions or methods to alleviate their occurrence.

This qualitative report will answer these questions as each component of the ACD is analyzed.

1. How can the component fail? (It might be possible there is more than mode of failure.)
2. What are the effects of the failure?
3. How critical are the effects?
4. How is the failure detected?
5. What are the safeguards against significant failures?

The Critical Items List (CIL) analysis provides a summary of selected hardware related items whose related failure modes can result in serious injury, loss of life (flight or ground personnel), loss of launch vehicle; or the loss of one or more mission objectives (when no redundancy exists) as defined by the GSFC project office. Specific criteria for hardware being included in the CIL are contained within this report.

This FMEA & CIL report is intended to be a living document that will be updated again to reflect any changes that are made throughout the development process.

1.2 DEFINITIONS, ACRONYMS AND ABBREVIATIONS

ACD: Anti-coincidence Detector

ADC: Analog-Digital Converter

AEM: Anti-coincidence Detector Electronics Module

ASIC: Application Specific Integrated Circuit

BEA: Base Electronics Assembly

CDR: Critical Design Review

Channel: A functional path between an ACD tile and the TEM.

FMEA: Failure Mode & Effect Analysis

MMS: Micrometeoroid Shield

PDR: Preliminary Design Review

PHA: Pulse Height Analysis

PMT: Photo Multiplier Tube

SAA: South Atlantic Anomaly

SPF: Single Point Failure

TEM: Transfer Electronics Module

TSA: Tile Shell Assembly

RN: Resistor Network

1.3 CONCLUSIONS AND RECOMMENDATIONS

One hardware item, the Micrometeoroid Shield (MMS), has been identified as an item that requires placement on the Critical Items List (CIL). The MMS has been reclassified since PDR with a severity classification of 2 (i.e., critical failure mode that could result in loss of one or more mission objectives). The CIL and corresponding analysis/ rationale for the level 2 classification is provided below in Table 1.3-1.

TABLE 1.3-1: CRITICAL ITEMS LIST (CIL)

2 SEVERITY CLASSIFICATION – COMPONENT, FAILURE MODE AND MISSION EFFECT	FAILURE MODE ID.
Component – Micrometeoroid Shield; **Failure Mode –** Light leakage/Damage to two or more tiles; **Mission Effect –** Inability to achieve the Diffuse Background Rejection Objective as defined in Table 2.3.1-1, Item 15, of the GLAST Science Requirements.	**12.01**

The Micrometeoroid Shield is addressed more in the Worse Case Analysis & Reliability Assessments Report (ACD-RPT-000047).

2.0 FMEA AND CIL ANALYSIS METHODOLOGY

2.1 GENERAL

This functional FMEA and CIL Analysis is conducted in accordance with GSFC specification S-302-89-01, February 1990, "Procedures for Performing a Failure Mode and Effects Analysis (FMEA)" and GLAST LAT procedure LAT-MD-00039-1, "Performance Assurance Implementation Plan".

The specific process used to perform this analysis is provided below.

2.2 ASSUMPTIONS/ GROUND RULES

In order to perform the FMEA, the following assumptions/ground rules are made:

- Failure modes will be assessed at the component interface level.
- Each failure mode will be assessed for the effect at that level of analysis, the next higher level and upward
- A failure mode will be assigned a severity category based on the most severe effect caused by a failure
- All mission phases (e.g. launch, deployment, on-orbit operation, and retrieval) will eventually be addressed as applicable.
- Redundancies will be analyzed to ensure that redundant paths are isolated or protected such that any single point failure that causes the loss of a functional path will not affect the other functional path(s) or the capability to switch operation to that redundant path.
- All failures with a severity classification of 2 or higher shall be placed on a Critical Item List (CIL)
- All inputs to the item being analyzed are present and at nominal values
- Temperatures are within specified limits
- Nominal power is available

2.3 MISSION SUCCESS CRITERIA

The mission success criteria section is broken out into three sub-sections: Mission Success Objectives, Reliability (Success Path) Block Diagrams and Allocations, and Refinement of Questions required for CDR. The criteria presented in this section are essential for making determinations regarding failure effects and severity classification definition.

2.3.1 MISSION SUCCESS OBJECTIVES

The mission success objectives, used for purposes of this FMEA report and analysis, are provided below in Tables 2.3.1-1 and 2.3.1-2. Table 2.3.1-1 provides a summary of the LAT/GLAST Mission Level Objectives as defined in GLAST Document 433-SRD-

001 Science Requirements Document. These are the requirements used to determine the severity classifications at the mission and LAT levels.

TABLE 2.3.1-1 GLAST MISSION SUCCESS OBJECTIVES

REQUIREMENT	REFERENCE PARAGRAPH	REFERENCE DOCUMENT
Energy Range, Low Limit, less than 20 MeV	Table 1, Item 1	GLAST Project – Science Requirements Document (433-SRD-0001)
Energy Range, High Limit, greater than 300 GeV	Table 1, Item 2	GLAST Project – Science Requirements Document (433-SRD-0001)
Effective Area, greater than 8000 cm^2	Table 1, Item 3	GLAST Project – Science Requirements Document (433-SRD-0001)
Energy Resolution (on –axis, 100 MeV – 10 GeV), less than 10%	Table 1, Item 4	GLAST Project – Science Requirements Document (433-SRD-0001)
Energy Resolution (on –axis, 10-300 GeV), less than 20%	Table 1, Item 5	GLAST Project – Science Requirements Document (433-SRD-0001)
Energy Resolution (>60° incidence, >10 GeV)	Table 1, Item 6	GLAST Project – Science Requirements Document (433-SRD-0001)
Single Photon Angular Resolution – 68% (on-axis, E>10GeV), less than 0.15°	Table 1, Item 7	GLAST Project – Science Requirements Document (433-SRD-0001)
Single Photon Angular Resolution – 68% (on-axis, E=10GeV), less than 0.15°	Table 1, Item 8	GLAST Project – Science Requirements Document (433-SRD-0001)
Single Photon Angular Resolution – 95% (on-axis), less than 3 x □$_{68\%}$	Table 1, Item 9	GLAST Project – Science Requirements Document (433-SRD-0001)
Single Photon Angular Resolution (off axis at 55°C), less than 1.7 times on-axis	Table 1, Item 10	GLAST Project – Science Requirements Document (433-SRD-0001)
Field of View, greater than 2 sr	Table 1, Item 11	GLAST Project – Science Requirements Document (433-SRD-0001)
Source Location Determination, less than 0.5 arcmin	Table 1, Item 12	GLAST Project – Science Requirements Document (433-SRD-0001)
Point Source Sensitivity (> 100 MeV), less than 6 x 10^{-9} $cm^{-2}s^{-1}$	Table 1, Item 13	GLAST Project – Science Requirements Document (433-SRD-0001)
Instrument Time Accuracy, less than 10 □sec	Table 1, Item 14	GLAST Project – Science Requirements Document (433-SRD-0001)
Background Rejection (Contamination of high latitude diffuse sample in any decade of energy for >100 MeV.), less than 10%	Table 1, Item 15	GLAST Project – Science Requirements Document (433-SRD-0001)
Dead Time, less than □s/ event	Table 1, Item 16	GLAST Project – Science Requirements Document (433-SRD-0001)
GRB Location Accuracy On-Board, less than 10 arcmin	Table 1, Item 17	GLAST Project – Science Requirements Document (433-SRD-0001)
GRB Notification Time to Spacecraft, less than 5 sec	Table 1, Item 18	GLAST Project – Science Requirements Document (433-SRD-0001)

Table 2.3.1-2 provides a summary of the GLAST LAT ACD Level IV requirements as defined in LAT Document LAT-SS-00352-01-D11. These are requirements used to determine effects as the ACD local level.

TABLE 2.3.1-2 ACD MISSION SUCCESS OBJECTIVES

OBJECTIVE	REFERENCE PARAGRAPH	REFERENCE DOCUMENT
Average detection probability for minimum ionizing particles shall be at least 0.9997 over the entire area of the ACD	5.4	LAT ACD Subsystem Specification – Level III Specification (LAT-SS-00016-D10)
No single failure in the ACD electronics shall result in the loss of signal from both PMTs on any single tile.	5.13	LAT ACD Subsystem Specification – Level III Specification (LAT-SS-00016-D10)
The loss of any one detector element (tile or ribbon) shall not result in the loss of any other detector element	5.14	LAT ACD Subsystem Specification – Level III Specification (LAT-SS-00016-D10)
The probability of the loss of both VETO signals from any scintillator due to electronics failures shall be less than 1.0% in 5 years. The probability of the loss of VETO signals from any scintillator ribbon due to electronics failure shall be less than 5% in 5 years.	5.15	LAT ACD Subsystem Specification – Level III Specification (LAT-SS-00016-D10)

2.3.2 RELIABILITY (SUCCESS PATH) BLOCK DIAGRAMS AND ALLOCATIONS

A top-level flow down of reliability allocations from the spacecraft to the LAT to the ACD, which was provided by SLAC, is provided below in Figure 2.3.2-1. A flow down of the 0.96 ACD Reliability Target to each of its major components, including the Base Electronics Assembly components, is provided below in Figure 2.3.2-2. Finally, a diagram showing the level of redundancy in each of the Base Electronic Assembly components is shown in Figure 2.3.2-3.

2.3.3 REMAINING QUESTIONS

AT PDR, a question was raised regarding the extent of allowable channel and/or tile performance degradation before mission objectives are considered lost. Due to shear complexity of this question, a conservative assumption was made for CDR that only 1 full tile could be lost for charged particle detection information to be adequately processed.

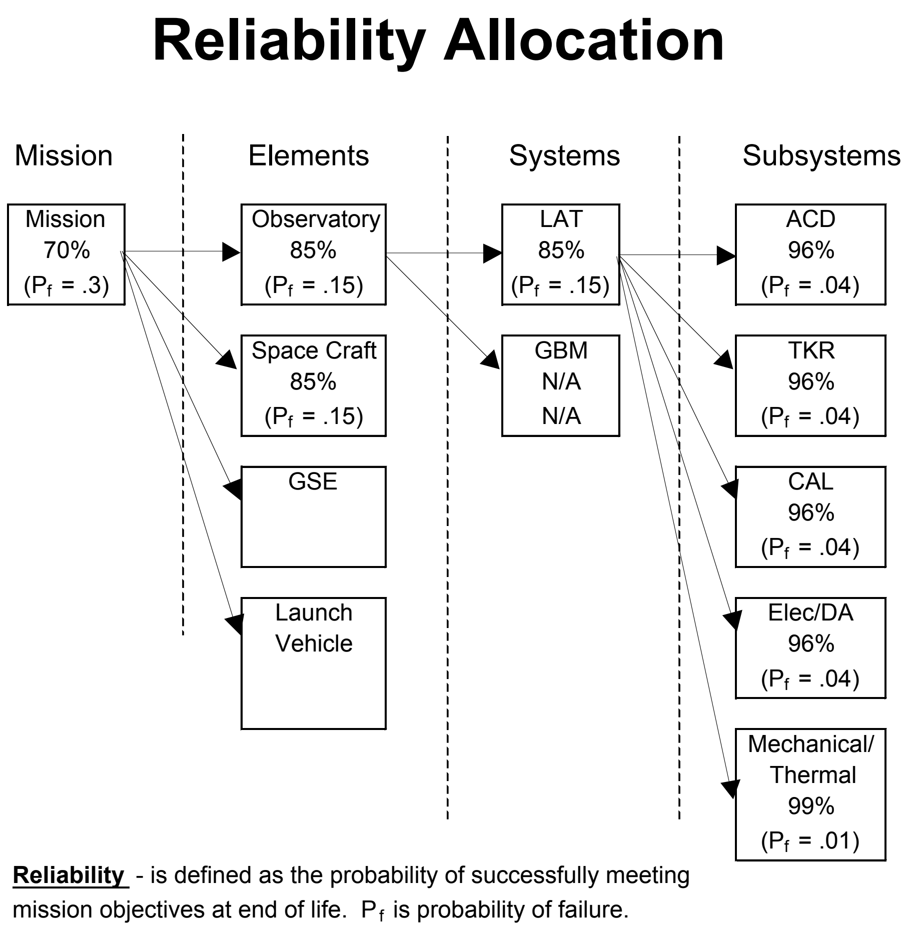

Figure 2.3.2-1 SLAC GLAST Reliability Allocation Flow Down

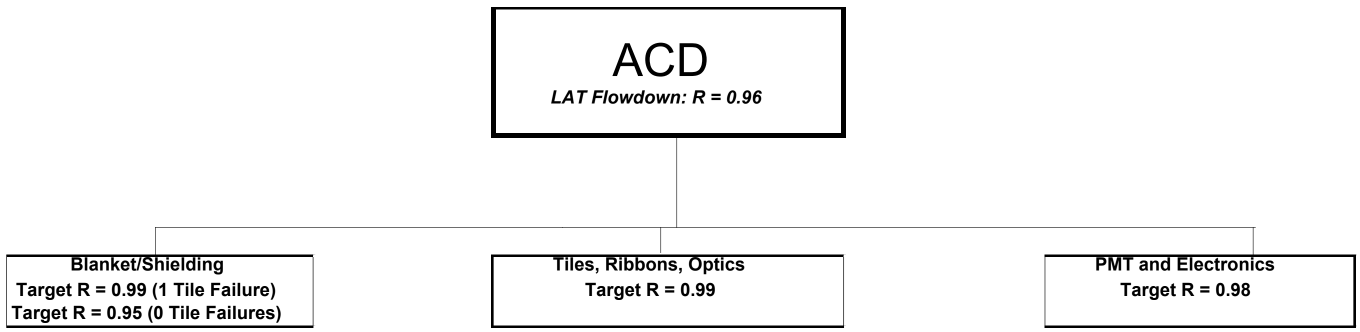

Figure 2.3.2-2 ACD Reliability Allocation Flow Down

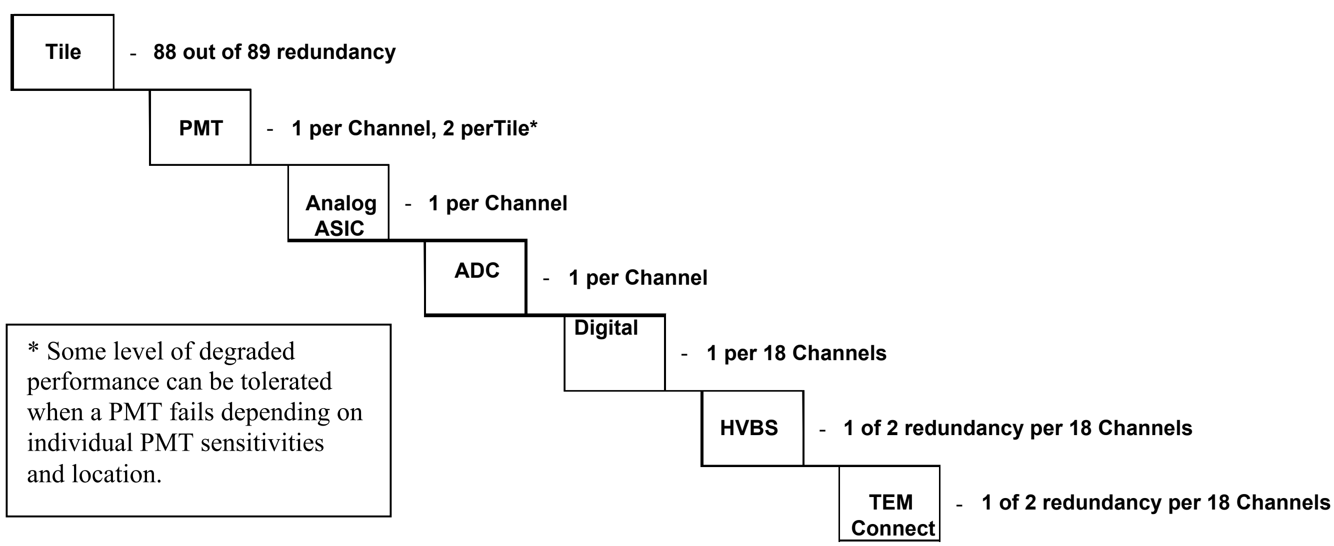

Figure 2.3.2-3 ACD Channel Configurations

2.4 FMEA WORKSHEETS

An example of the worksheet is depicted in Figure 2.4-1. The categories addressed in the worksheet, and the process for analyzing, are as follows:

- ***Failure Mode Reference Number –*** The failure mode reference number is a unique identifying number assigned to each component of the system being analyzed
- ***Component –*** The name of the component under analysis
- ***Function –*** The function of the component being analyzed
- ***Operational Mode –*** The FMEA is conducted for the following GLAST space flight missions:
  - **All Sky Scan** – Science collection from the entire, detectable, universe in order to establish a baseline of cosmic Gamma Ray sources
  - **Pointed mode** – Science collected from specific areas/regions in the universe where particular information is sought
- ***Failure Mode & Cause –*** Potential failure modes, for each function, are determined by examination of the functional outputs contained on the system functional block diagram. A bottoms-up approach is used where by analysis begins at the component level, followed by analysis of subsequent or higher system levels
- ***Failure Effects –*** The consequences of each postulated failure mode is identified, evaluated, and recorded on the FMEA worksheets. Most failures not only affect the function under analysis, but also impact higher indenture levels. Therefore, "Local", "Next Higher", and "End Item or Mission" levels are also examined. The "Local" effect addresses the consequences a failure mode has on the component's ability to perform properly. The "Next Higher" level effect examines the impact of the failure mode on the performance of the next higher assembly. The "Mission" effect addresses the impact relative to predefined mission success criteria
- ***Severity Classification –*** Using the definitions provided in section 2.5, the effects of each component failure mode are analyzed and the appropriate classification is assigned. Mission success criteria and redundancy schemes must be included as part of this analysis
- ***Detections/ Redundancy Screens/ Compensating Provisions –*** Provisions such as redundancy, workarounds, etc
- ***Remarks/ Actions –*** Pertinent comments, references, or actions

TABLE X.X-1: FAILURE MODES AND EFFECTS ANALYSIS

MISSION: **DATE:**

SYSTEM: **SUBSYSTEM:**

PERFORMED BY:

REFERENCE COMPONENT REMARKS/ ACTIONS NUMBER	FUNCTION	OPERATIONAL MODE	FAILURE MODE AND FAILURE CAUSE	FAILURE EFFECTS	SEVERITY CLASS	DETECTIONS AND COMPENSATING PROVISIONS
0.00			Failure Mode: Failure Cause:	Local Effect: Subsystem Level Effect: Mission Level Effect:		Detections/ Redundancy Screens Compensating Provisions
0.00			Failure Mode: Failure Cause:	Local Effect: Subsystem Level Effect: Mission Level Effect:		Detections/ Redundancy Screens Compensating Provisions

Figure 2.4-1 A Failure Modes & Effects Analysis Worksheet

2.5 SEVERITY CLASSIFICATION DEFINITIONS

The following section presents definitions for the various Severity Classifications:

- ***Category 1*** – Catastrophic failure modes that could result in serious injury, loss of life (flight or ground personnel), or loss of launch vehicle
- ***Category 1R*** – Failure modes of identical or equivalent redundant hardware items that, if all failed could result in category 1 effects
- ***Category 1S*** – Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition to fail to operate during such condition and lead to Severity Category 1 consequences
- ***Category 2 –*** Critical failure modes that could result in loss of one or more mission objectives as defined by the GSFC project office
- ***Category 2R*** – Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed
- ***Category 3*** – Significant failure modes that could cause degradation to mission objectives
- ***Category 4*** – Minor failure modes that could result in insignificant or no loss to mission objectives

3.0 FUNCTIONAL DESCRIPTION OF THE ACD

3.1 GENERAL

The ACD is part of the LAT science instrument, and is the LAT's first line of defense against the enormous charged particle background from cosmic ray primary and Earth albedo secondary electrons and nuclei.

The ACD detects energetic cosmic ray electrons and nuclei for the purpose of removing these backgrounds. It is the principle source for detection of other than gamma-ray particles. This detector element can be thought of a cap that covers the LAT Tracker towers.

The ACD is made up of three primary functional elements: tile detectors, electronics, and ACD Electronics Module (AEM) interface. The tiles consist of an array of 89 plastic scintillator tiles (1 cm thick, various sizes), plus 8 scintillating fiber "ribbons" that cover the gaps between the tiles.

A top-level functional block diagram for the ACD is shown in figure 3.1-1.

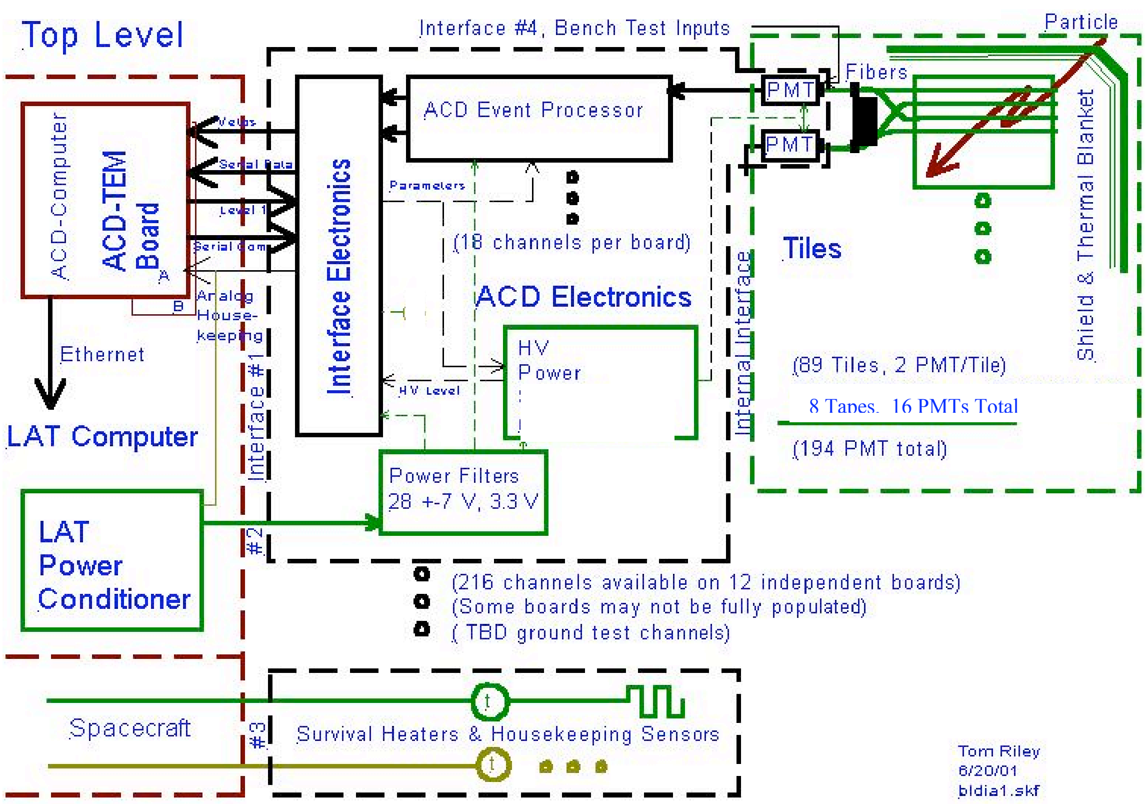

Figure 3.1-1 ACD Functional Block Diagram

3.2 TILES / MICROMETEROID SHIELD (MMS)

The Tiles/Micrometeoroid Shield section is shown in more detail in Figure 3.2-1, GLAST ACD Electronic Functional Block Diagram, Level 2, Tiles. Most of the scientific requirements placed on the ACD instrument fall on the design of the tiles. These requirements are subsequently passed on to the ACD Electronics Boards through the internal Interface.

The tiles are covered with a micrometeoroid shield and thermal blanket. This protects them from orbital debris damage and stabilizes the internal temperature.

The tiles scintillate when a subatomic particle passes through them, but not when a gamma ray does the same. This allows particle events to be discarded, or vetoed, from the science readings.

The photons from the tiles are picked up by wave shifting fibers that direct them to the PMT. Long fibers are joined to clear fibers to reduce loses. An event important to science may consist of only a few photons.

The fibers are grouped at the face of the PMT. Each PMT has a dynode resistor string to provide the appropriate voltage distribution. The high voltage from a single high voltage supply may be adjusted for groups of 18 PMTs to compensate for changes in tube gain.

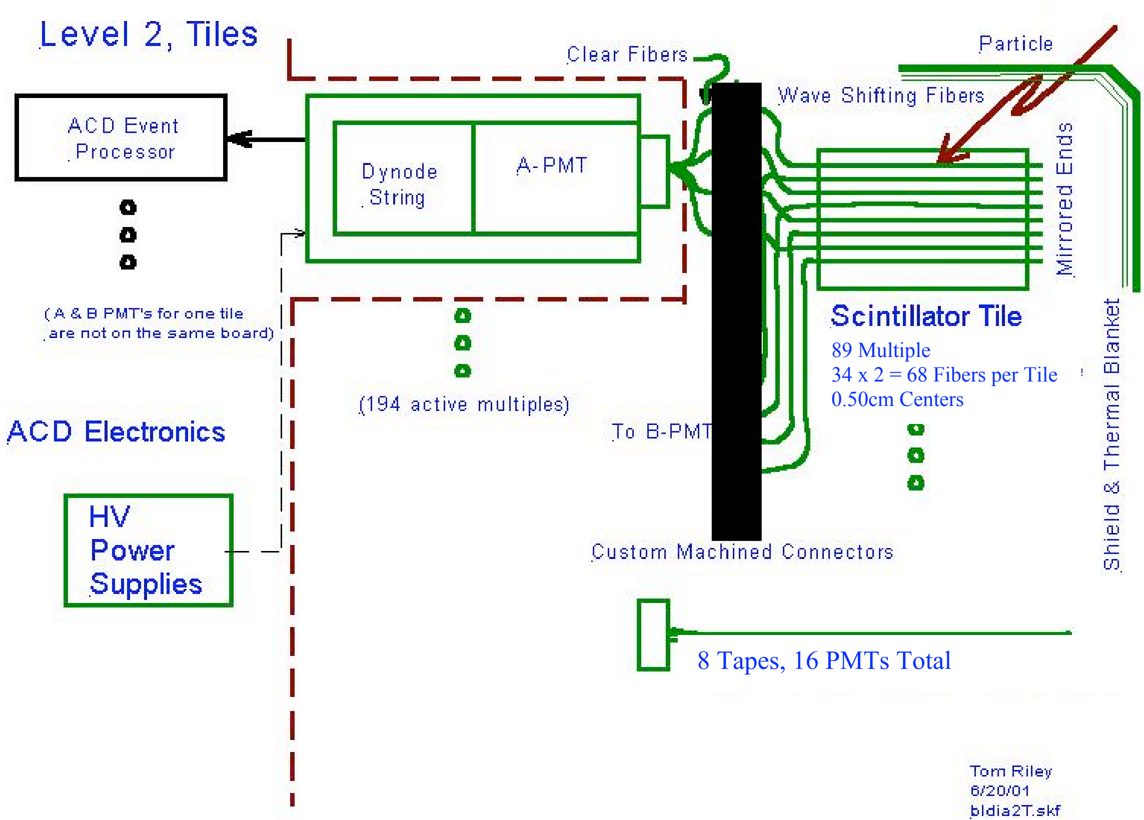

Figure 3.2-1 ACD Tile Electronic Functional Block Diagram

3.3 ACD ELECTRONIC'S SECTION (BASE ELECTONICS ASSEMBLY)

The ACD Event Processor circuit receives PMT signals and measures single amplitudes. It detects a particle event by comparing pulse amplitudes to thresholds. The gain of the PMT and the threshold levels may be adjusted in flight in order to compensate for signal variation/degradation over time. The ACD Electronics section is shown in more detail in Figure 3.3-1. A functional block diagram for the ACD Event Processor board is shown in Figure 3.3-2.

Each ACD Event Processor board, mounting 18 PMTs (generally assigned to 18 distinct tiles), contains one High Voltage (HV) power supply that supports all 18 PMT electronic channels. Each board is paired with an identical partner in order to provide a single level of active channel electronics redundancy; paired boards working simultaneously provide for higher efficiency. The HV may be commanded off to a low level for passage through the South Atlantic Anomaly (SAA), and to any level in the effective high voltage range of the PMT. Power to the board is filtered. The HV power supplies run off 28 volts. All other electronics run off 3.3 volts.

There are a total of 12 Event Processor boards distributed around the bass of the ACD, but not all boards need be fully populated.

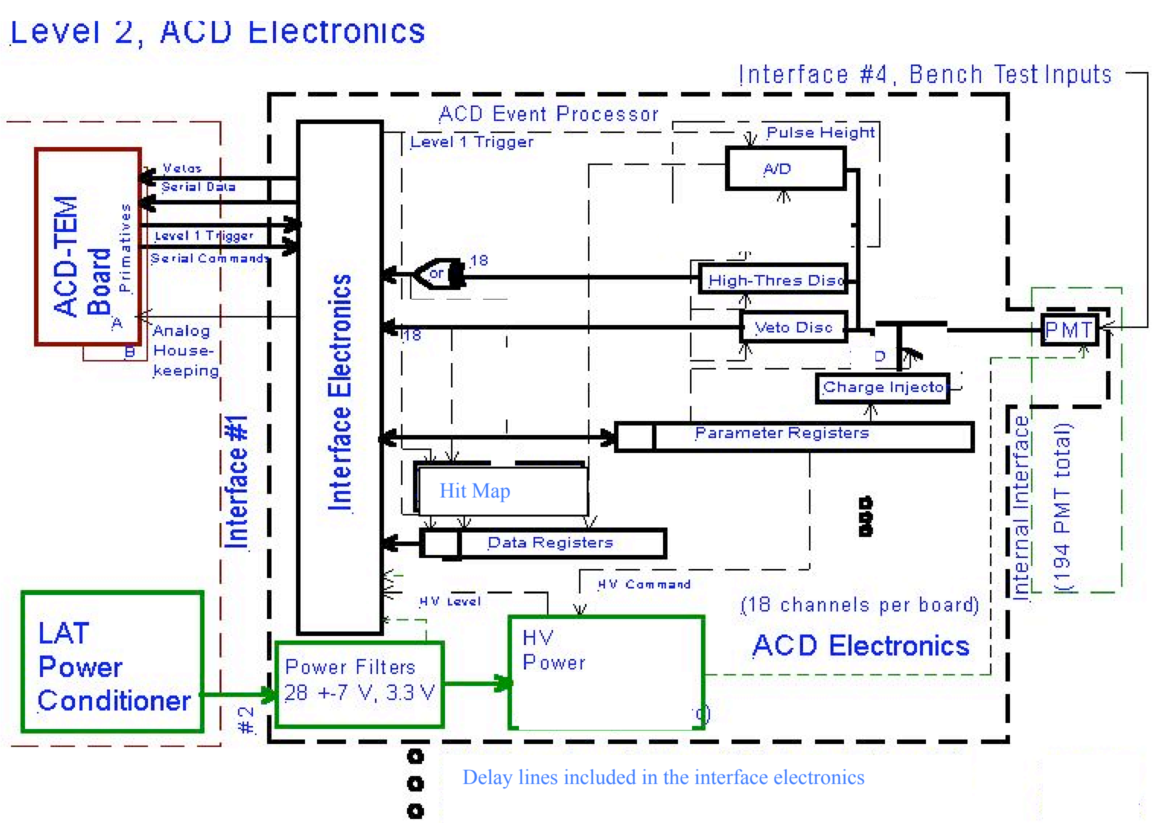

Figure 3.3-1 ACD Electronics Section

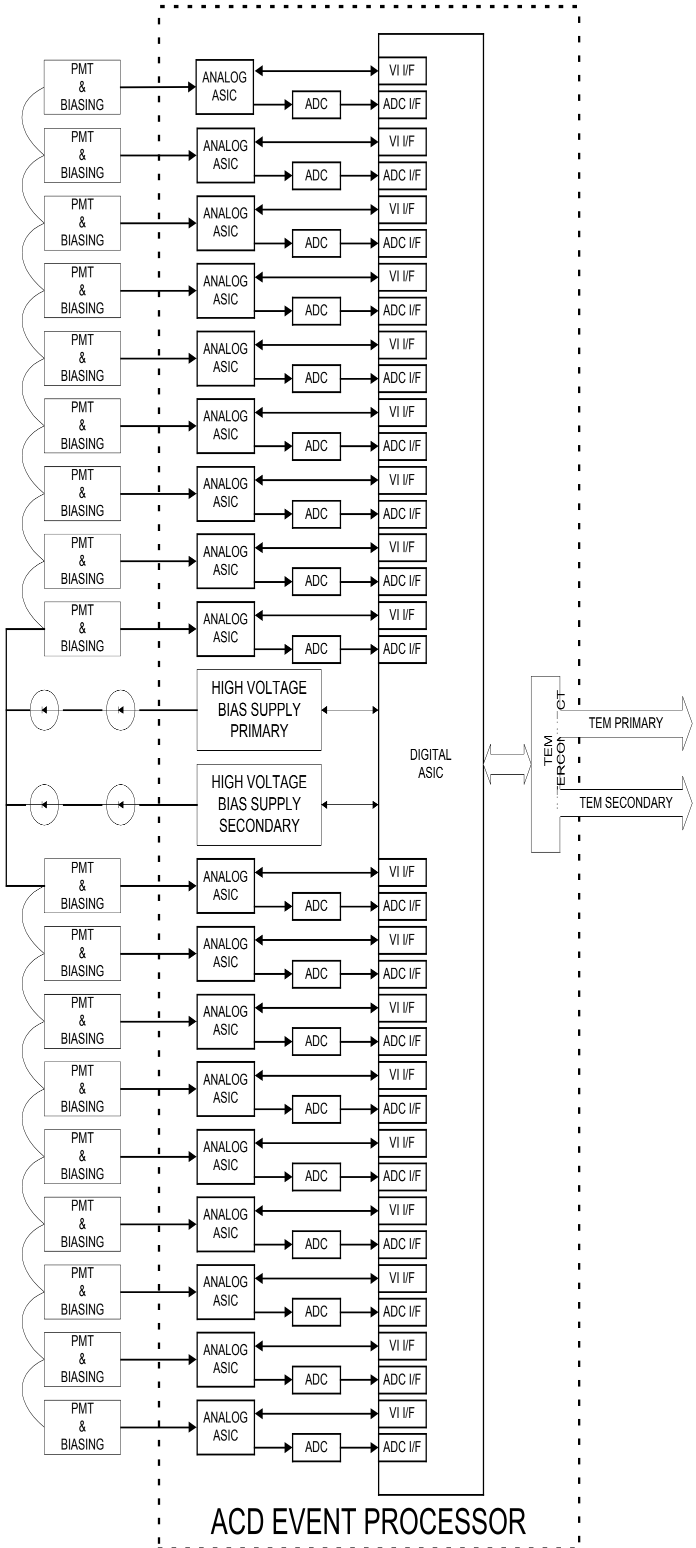

Figure 3.3-2 ACD Event Processor Board Functional Block Diagram

3.4 COMPUTER INTERFACE

Figure 3.4-1 shows the ACD-AEM interface between the ACD Electronics board and the ACD-TEM Board. All data interfaces between the ACD and GLAST go through this interface. The ACD-TEM is provided by SLAC and is a generic design used for all of the subsystems on the LAT. The B ACD-TEM board is a cold backup but has a full set of cables. Important data lines are high speed, low power current loops running on a pair of copper wires.

When any tile connected to a board detects an event, a signal on the corresponding VETO line is quickly sent. If any event on the board exceeds the high threshold, the adjacent (OR) line is also triggered.

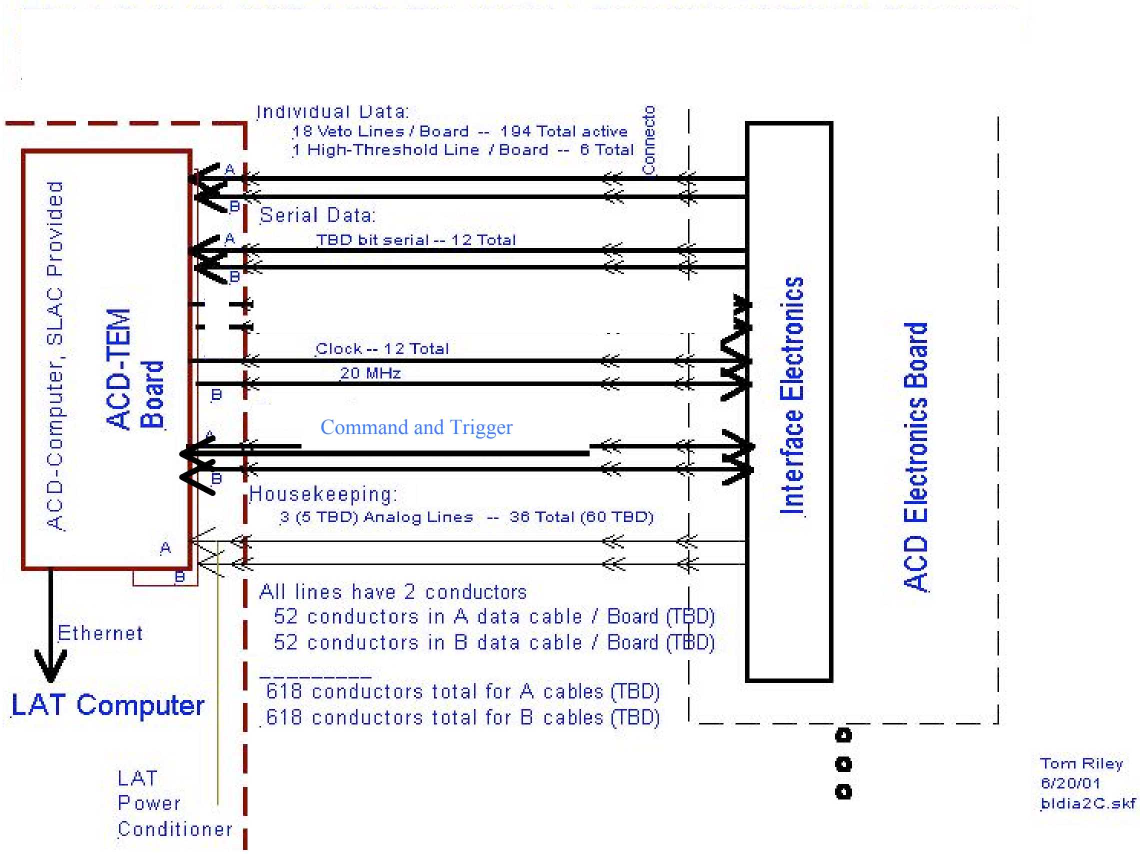

Figure 3.4-1 ACD-AEM Interface

3.5 MECHANICAL SYSTEM (TILE SHELL ASSEMBLY)

An illustration of the ACD Mechanical System is shown in Figure 3.5-1. The ACD is mechanically mounted only to the LAT instrument base plane (GRID). The ACD does not touch any other subsystems, nor does it touch the launch vehicle fairing.

The active part of the instrument is completely covered with tiles. The tiles are supported by a composite grid structure. Each tile is wrapped with opaque material to make it light tight and the few gaps are covered with scintillator ribbons. The electronics boards are mounted on the ACD BEA around the base of the instrument.

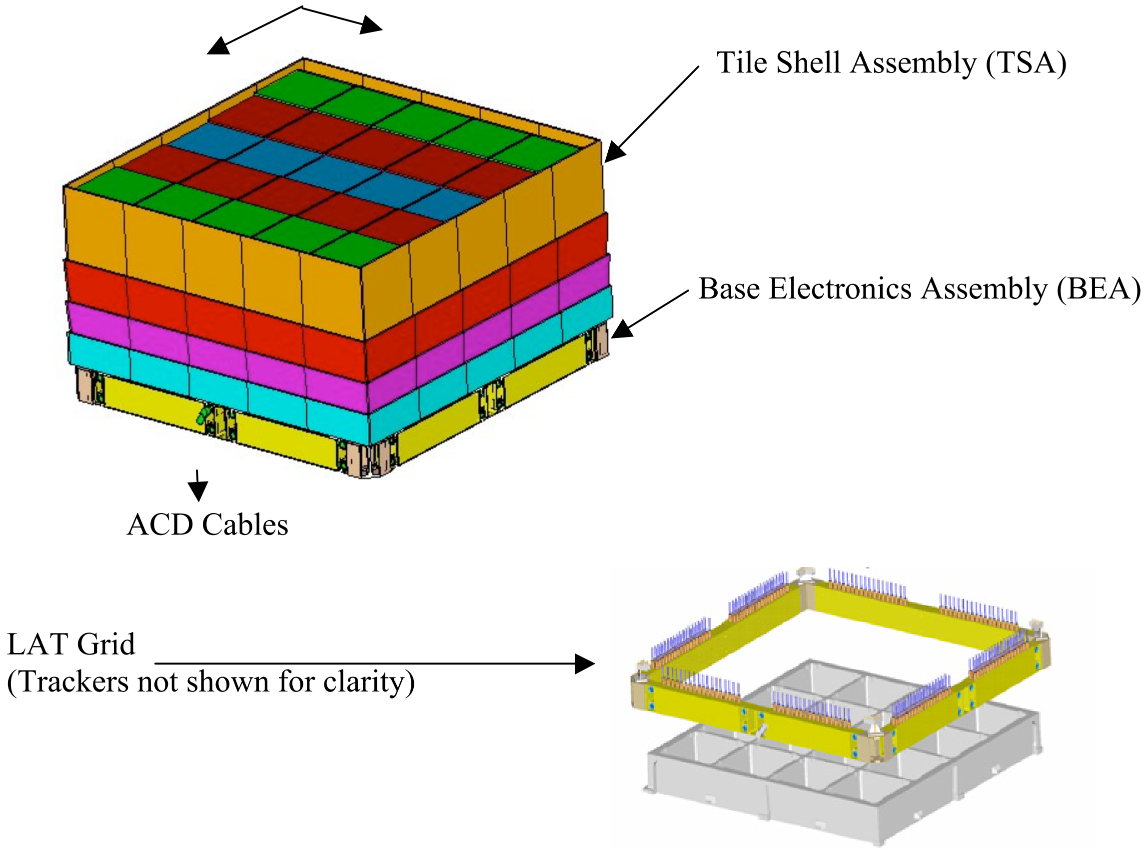

Figure 3.5-1 ACD Mechanical System

4.0 ACD FMEA ANALYSIS - CDR

4.1 GENERAL

The ACD FMEA Analysis, performed to date in preparation for CDR, is provided in Table 4.1-1 below.

TABLE 4.4-1 FAILURE MODES AND EFFECTS ANALYSIS

MISSION: Space Flight **DATE:** 10/31/02

SYSTEM: GLAST **SUBSYSTEM:** ACD

PERFORMED BY: T. DiVenti

REFERENCE NUMBER	COMPONENT	FUNCTION	OPERATIONAL MODE	FAILURE MODE AND FAILURE CAUSE	FAILURE EFFECTS	SEVERITY CLASS (MISSION)	DETECTIONS AND COMPENSATING PROVISIONS	REMARKS/ ACTIONS
L.ACD.1.01	PMT	Converts light to electrical signal.	All Sky Scan; Pointed Mode	Failure Mode: Gain degradation Failure Cause: Degradation is inherent over time	Local Effect: Reduced signal amplitude. Subsystem Level Effect: Cosmic Ray detection efficiency slightly reduced. Mission Level Effect: None	4	Detections/ Redundancy Screens Compensating Provisions 1) Raise voltage or lower thresholds; 2) Provide adequate PMT burn-in screening and selection	
L.ACD.1.02	PMT	Convert light to electrical signal	All Sky Scan; Pointed Mode	Failure Mode: No output Failure Cause: Cracked/damage PMT or Power Supply connection	Local Effect: No signal Subsystem Level Effect: Potential loss of Tile Function Mission Level Effect: 1) DAQ Filtering Efficiency decrease (1 tile fails) 2) Won't achieve background rejection (2 tiles fail)	2R	Detections/ Redundancy Screens 1) 88 out of 89 tiles required 2) 2 PMTs per tile (only provides redundancy when single PMT sensitivity is adequate) Compensating Provisions LAT level software	

MISSION: Space Flight **DATE:** 10/31/02

SYSTEM: GLAST **SUBSYSTEM:** ACD

PERFORMED BY: T. DiVenti

REFERENCE NUMBER	COMPONENT	FUNCTION	OPERATIONAL MODE	FAILURE MODE AND FAILURE CAUSE	FAILURE EFFECTS	SEVERITY CLASS	DETECTIONS AND COMPENSATING PROVISIONS	REMARKS/ ACTIONS
L.ACD.2.01	Optical Fiber	Transport light from the Scintillator Tile	All Sky Scan; Pointed Mode	Failure Mode: Signal reduction Failure Cause: Damaged or disconnected cable	Local Effect: Signal loss or degradation Subsystem Level Effect: Reduced efficiency for Cosmic Ray detection Mission Level Effect: None	4	Detections/ Redundancy Screens 32 fibers per P MT Compensating Provisions None	
L.ACD.3.01	Waveshifting Fiber	Transport light from the scintillator tile to the fiber coupling	All Sky Scan; Pointed Mode	Failure Mode: Signal loss Failure Cause: Damaged or disconnected cable	Local Effect: Signal loss or degradation Subsystem Level Effect: Reduced efficiency for Cosmic Ray detection Mission Level Effect: None	4	Detections/ Redundancy Screens 68 fibers per tile Compensating Provisions None	

MISSION: Space Flight **DATE:** 10/31/02

SYSTEM: GLAST **SUBSYSTEM:** ACD

PERFORMED BY: T. DiVenti

REFERENCE NUMBER	COMPONENT	FUNCTION	OPERATIONAL MODE	FAILURE MODE AND FAILURE CAUSE	FAILURE EFFECTS	SEVERITY CLASS	DETECTIONS AND COMPENSATING PROVISIONS	REMARKS/ ACTIONS
L.ACD.4.01	Fiber Coupling	Transfer light energy from the waveshifting fibers to the optical fibers	All Sky Scan; Pointed Mode	Failure Mode: No light transfer Failure Cause: Damaged or disconnected coupling	Local Effect: Loss or degradation of signal Subsystem Level Effect: Potential loss of Tile Function Mission Level Effect: 1) DAQ filtering efficiency decrease (1 tile fails) 2) Won't achieve background rejection (2 tiles fail)	2R	Detections/ Redundancy Screens 1) 88 out of 89 tiles required 2) Partial loss of fiber connects Compensating Provisions LAT level software	
L.ACD.5.01	Scintillator Tile	Detect charged particles via scintillator light	All Sky Scan; Pointed Mode	Failure Mode: No light generation Failure Cause: Damaged tile	Local Effect: No signal from either PMT Subsystem Level Effect: Loss of tile function Mission Level Effect: 1) DAQ filtering efficiency decrease (1 tile fails) 2) Won't achieve background rejection (if 2 tiles fail)	2R	Detections/ Redundancy Screens Tolerance for 1 tile failure out of 89 tiles Compensating Provisions LAT Level Software	

MISSION: Space Flight **DATE:** 10/31/02

SYSTEM: GLAST **SUBSYSTEM:** ACD

PERFORMED BY: T. DiVenti

REFERENCE NUMBER	COMPONENT	FUNCTION	OPERATIONAL MODE	FAILURE MODE AND FAILURE CAUSE	FAILURE EFFECTS	SEVERITY CLASS	DETECTIONS AND COMPENSATING PROVISIONS	REMARKS/ ACTIONS
L.ACD.5.02	Scintillator Tile or Ribbon	Detect charged particles via scintillator light	All Sky Scan; Pointed Mode	Failure Mode: Outside light exposure Failure Cause: Failure of light tight wrap	Local Effect: Overwhelming noise from both PMTs Subsystem Level Effect: Loss of tile function Mission Level Effect: 1) DAQ filtering efficiency decrease (1 tile fails) 2) Won't achieve background rejection (2 tiles fail)	2R	Detections/ Redundancy Screens Tolerance for 1 tile failure out of 89 tiles Compensating Provisions LAT Level Software	
L.ACD.6.01	High Voltage Bias Supply HVBS	Activate 18 PMTs	All Sky Scan; Pointed Mode	Failure Mode: No power Failure Cause: Loss of input power Connection, P/S failure, or command failure	Local Effect: 18 PMTs inoperable Subsystem Level Effect: Loss of 18 fully functional tiles (If 2 paired Bias Supplies fail) Mission Level Effect: Failure to achieve several GLAST objectives (if 2 paired HVBS fail)	2R	Detections/ Redundancy Screens Two HVBS (1 active, 1 stand-by) Compensating Provisions Reduce thresholds in paired channels.	

MISSION: Space Flight **DATE: 10/31/02**

SYSTEM: GLAST **SUBSYSTEM: ACD**

PERFORMED BY: T. DiVenti

REFERENCE NUMBER	COMPONENT	FUNCTION	OPERATIONAL MODE	FAILURE MODE AND FAILURE CAUSE	FAILURE EFFECTS	SEVERITY CLASS	DETECTIONS AND COMPENSATING PROVISIONS	REMARKS/ ACTIONS
L.ACD.7.01	Analog ASIC	Process 2 PMT analog signals	All Sky Scan; Pointed Mode	Failure Mode: Erroneous or no output Failure Cause: Loss of power signal or internal ASIC failure	Local Effect: Incomplete or no signal transfer to ADC and/or Digital ASIC Subsystem Level Effect: Partial or complete loss of one electronic channel Mission Level Effect: None	4	Detections/ Redundancy Screens Compensating Provisions Reduced VETO thresholds for the paired PMT	
L.ACD.8.01	ADC	Digitizes signals from 18 Analog ASICs	All Sky Scan; Pointed Mode	Failure Mode: Erroneous or no output Failure Cause: Loss of power signal or internal ASIC failure	Local Effect: No pulse height analysis of the analog signal Subsystem Level Effect: Partial loss of an electronic channel Mission Level Effect: None	3	Detections/ Redundancy Screens Compensating Provisions Might need to reduce VETO detection threshold for the PMT	

MISSION: Space Flight **DATE:** 10/31/02

SYSTEM: GLAST **SUBSYSTEM:** ACD

PERFORMED BY: T. DiVenti

REFERENCE NUMBER	COMPONENT	FUNCTION	OPERATIONAL MODE	FAILURE MODE AND FAILURE CAUSE	FAILURE EFFECTS	SEVERITY CLASS	DETECTIONS AND COMPENSATING PROVISIONS	REMARKS/ ACTIONS
L.ACD.9.01	Digital ASIC	Collect information from 18 analog ASICs for transmission to TEM	All Sky Scan; Pointed Mode	Failure Mode: Erroneous or no output Failure Cause: Loss of power signal or internal ASIC failure	Local Effect: No signal transfer to TEM Subsystem Level Effect: Loss of 18 electronic channels Mission Level Effect: 1) Some loss of DAQ filtering efficiency (if 1 ASIC fails); 2) Failure to complete most mission objectives (when 2 paired ASICs fail)	2R	Detections/ Redundancy Screens Board pairs are partially redundant Compensating Provisions 1) Reduce thresholds for paired channels (if 1 ASIC fails); 2) None (if 2 paired ASICs fail)	
L.ACD.11.01	ACD to TEM Connection	Transmit information from Digital ASIC to TEM	All Sky Scan; Pointed Mode	Failure Mode: No output Failure Cause: Damaged or disconnected cables or connectors	Local Effect: No information transfer to the TEM Subsystem Level Effect: Loss of function for all 18 board channels Mission Level Effect: 1) Some loss of DAQ filtering efficiency (if 1 of 2 connections from a board pair fail); 2) Failure to achieve most LAT mission objectives (if 2 of 2 connections for a board pair fail)	2R	Detections/ Redundancy Screens Each 18-channel board has Separate connections to 2 redundant TEMs Compensating Provisions 1) Reduced thresholds for paired channels (if 1 ASIC fails); 2) None (if 2 ASICs fail)	

MISSION: Space Flight **DATE:** 10/31/02

SYSTEM: GLAST **SUBSYSTEM:** ACD

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REFERENCE NUMBER	COMPONENT	FUNCTION	OPERATIONAL MODE	FAILURE MODE AND FAILURE CAUSE	FAILURE EFFECTS	SEVERITY CLASS (MISSION)	DETECTIONS AND COMPENSATING PROVISIONS	REMARKS/ ACTIONS
L.ACD.12.01	Micrometeoroid & Debris Shield	Protects the ACD from orbital debris	All Sky Scan; Pointed Mode	<u>Failure Mode:</u> Light leakage into tile <u>Failure Cause:</u> Shield penetration	<u>Local Effect:</u> Overwhelming noise from both PMTs on affected tile. <u>Subsystem Level Effect:</u> Loss of tile(s) function if debris/ meteoroid fully penetrates shield <u>Mission Level Effect:</u> 1) Some loss of DAQ filtering efficiency (if 1 tile fails); 2) Will not fully achieve the background rejection objective (if 2 or more tiles fail). Example – If debris penetrates shield at interface between two tiles.	2	<u>Detections/ Redundancy Screens</u> Tolerant to one penetration to one tile <u>Compensating Provisions</u> LAT Level Software	See Worse Case Analysis