LIMITED-LIFE ITEMS ANALYSIS FOR THE GLAST Anti-Coincidence Detector (ACD)

Credit: Hytec

LAT-TD-01123-01
ACD-RPT-000039
Revision -

October 21, 2002

Goddard Space Flight Center
Greenbelt, Maryland

Anti-Coincidence Detector Limited-Life Items List
ACD-RPT-000039

Prepared by: _____ _____
Anthony DiVenti Date
ACD Reliability Engineer

Reviewed by: _____ _____
Pilar Joy Date
ACD Materials Engineer

Reviewed by: _____ _____
Ken Segal Date
ACD Lead Mechanical Engineer

Reviewed by: _____ _____
Glenn Unger Date
ACD Lead Electrical Engineer

Reviewed by: _____ _____
Alex Moiseev Date
ACD Scientist

Approved by: _____ _____
Dave Thompson Date
ACD Project Manager

Approved by: _____ _____
Tom Johnson Date
ACD Sub-system Manager

Approved by: _____ _____
Patricia Huber Date
System Assurance Manager

Anti-Coincidence Detector Limited-Life Items List
ACD-RPT-000039

REVISION PAGE

REVISION	DESCRIPTION	DATE	INITIALS
(Rev -)	Initial CM Release		

1.0 INTRODUCTION

1.1 SCOPE

This document is the Limited Life Items Analysis for the Gamma Large Area Space Telescope (GLAST) Anti-Coincidence Detector (ACD) subsystem. This document was prepared in accordance with paragraph 8.4, Limited-Life Items, and Contract Data Requirements List (CDRL) 319 of LAT-MD-00039-1, Performance Assurance Implementation Plan.

The Limited Life Items List provides a summary of items considered that may have a useful life period that is potentially less than what is required for the overall mission. Specific information relating to the item part/ specification number, rationale for considering a part as a limited-life item, expected item life, required item life, potential impact of an failure on mission parameters, overview of evaluation/qualification plans and results, and responsibilities for activities are provided.

The Limited Life Items List is intended to be a living document that may be updated again, following CDR and possibly at other stages, to reflect changes that are being made throughout the development process.

1.2 APPROACH

For the second submittal of the ACD Limited-Life Items Analysis, prior to CDR, a more realistic approach is being taken to identify ACD limited-life items. Only items known to have limited-life characteristics as defined in the Large Area Telescope (LAT) Performance Assurance Implement Plan (PAIP) will be identified on the Limited-Life Analysis. This is in contrast to the more conservative approach taken prior to PDR when all known items that may potentially have a limited life with respect to what is required by the mission were listed. As the system design continued and more information relating to life characteristics was collected, the AntiCoincidence Detector (ACD) team periodically evaluated potential limited-life items identified prior to PDR for inclusion on to the Limited-Life Analysis.

As defined in the PAIP, the limited-life criterion is that items include selected structures, thermal control surfaces, solar arrays and electromechanical mechanisms that do not comply with mission lifetime requirements. Atomic oxygen, solar radiation, shelf life, extreme temperatures, thermal cycling, wear and fatigue should be used to identify limited-life thermal control surfaces and structure items. Mechanisms such as batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators, and scan devices should be included when aging, wear, fatigue and lubricant degradation limit their life.

1.3 ACRONYMS AND ABBREVIATIONS

ACD: Anti-Coincidence Detector
MPML: Mechanical Parts and Materials List
CDR: Critical Design Review
CIL: Critical Items List
EGRET: Energetic Gamma Ray Experiment Telescope
FMEA: Failure Mode and Effect Analysis
HVBS: High Voltage Bias Supply
GLAST: Gamma Large Area Space Telescope
JSC: Johnson Space Center
LAT: Large Area Telescope
MMS: Micrometeoroid Shield
PAIP: Performance Assurance Implementation Plan
PDR: Preliminary Design Review
PMT: Photo Multiplier Tube
TDA: Tile Detector Assembly
TEM: Tower Electronics Module

2.0 APPLICABLE DOCUMENTS

Documents listed below are applicable to the preparation of this document:

ACD-MPML-1001	ACD Mechanical Parts and Materials List (MPML)
LAT-MD-00039-1	Performance Assurance Implementation Plan
ACD-RPT-00913	Failure Mode Effect Analysis (FMEA) & Critical Items List (CIL) GLAST LAT Anti-Coincidence Detector (ACD) Report
ACD-RPT-TBD	Optical Performance Analysis

3.0 LIMITED-LIFE ANALYSIS

Only the Photo Multiplier Tube remains as an element that may constitute a limited-life item. However, based on the rationale provided in section 3.1, it is recommended that the PMT be removed from this list given the fault tolerance and redundancy features that are part of the ACD design and allow for successful operation/functionality of the PMTs beyond the minimum 5-year mission life requirement.

All other ACD elements that were previously considered for inclusion on to the Limited-Life Item List are included for reference in Appendix A.

3.1 PMT LIMITED-LIFE ITEM ANALYSIS

Given that the 5-year mission life requirement is for successful science operations, the mission life requirement is for the combination of GLAST elements that include PMTs, ACD electronics, and power supplies. As a result, the design was developed so that the limited-life characteristic of the PMT could be mitigated through fault tolerance/redundancy at the ACD level. The particular fault tolerant elements of the ACD design, which provide the necessary gain decrease margin for the PMTs, include: redundant PMTs assigned to a majority of the scintillating tiles, stand-by redundant High Voltage Bias Supply (HVBS) added to each group of 18 tiles (without a the redundant bias supply, failure of a HVBS would leave only 1 functional PMT on each of the 18 tiles), gain adjustability for each group of 18 PMTs, and individual PMT gain calibration adjustments that can be made utilizing the flight software.

The current design will accommodate a PMT gain decrease of at least a factor of 8, and at least a factor of 5 difference in gain degradation between the PMTs serviced by a single HVBS, over a 10 year period. Based on PMT gain degradation characteristics provided by Hamamatsu (the PMT Manufacturer), net performance analysis, and PMT degradation compensation analysis; it is estimated that PMT gain degradation-induced failure would not occur for at least 10 years. This is well in excess of the 5-year GLAST mission life requirement.

Lastly, thermal evaluations were also performed to show that the temperature cycling that will be performed during LAT Integration & Test (I&T) will not cause any significant changes to the PMT gain degradation characteristics.

APPENDIX A – ITEMS CONSIDERED FOR INCLUSION ON THE LIMITED-LIFE ANALYSIS

ITEM	PART/ SPEC NUMBER	RATIONALE FOR SELECTING ITEM	LIFE REQUIREMENTS	POTENTIAL IMPACT ON MISSION PARAMETERS	PLANS, RESPONSIBILITY, & RESULTS
A. MicroMeteoroid Shield (MMS)/ Thermal Shield		Need to evaluate if debris, radiation, atomic oxygen, or thermal breakdown could cause a failure of the shield within the mission life.	At least 5 years	2 or more debris/ meteoroid penetrations may allow damage of a TDA, thus resulting in a ionizing particle detection efficiency reduction	Reliability allocations/targets established to insure mission life requirements will be met. JSC will confirm that reliability targets are met. With respect to atomic oxygen and radiation, review of MMS and Thermal Shield heritage on EGRET confirm that design is sufficient to meet requirements.
B. Scintillating Tile & Fiber interface	Tile (BC-408) Fiber (BCF91AMC) Adhesive (BC600)	The interfaces exist on all 89 ACD tiles and are integral to ACD operation.	At least 5 years	Failure of ACD to meet ionizing particle detection efficiency goals if widespread (i.e. inherent) breakdown of the interfaces occur	Materials Lab Qualification at stress levels above what will be observed during the actual mission to demonstrate that thermal and mechanical design margins are sufficient to meet mission requirements.

.

ITEM	PART/ SPEC NUMBER	RATIONALE FOR SELECTING ITEM	LIFE REQUIREMENTS	POTENTIAL IMPACT ON MISSION PARAMETERS	PLANS, RESPONSIBILITY, & RESULTS
C. TDA & Fiber Cable Wrapping	Tape (Black Kapton) Adhesive Film Tedlar (Opague Wrapping)	The wrappings are essential to prevent light leakage into the TDA's or fiber cables	At least 5 years	Light leakage will result in failure of a TDA.	Code 661 to perform qualification testing similar to that for item B.
D. Scintillating Fiber Ribbon Wrapping	Tape (Black Kapton) Adhesive Film Tedlar (Opague Wrapping)	The wrappings are essential to prevent light leakage into the fiber ribbon.	At least 5 years	Light leakage will result in failure of a ribbon.	Code 661 to perform qualification testing similar to that for item B.
E. Fiber Connector Assemblies	GD2054495 GD2054480	Transmits light between the wave-shifting and clear fibers, and between the fibers and PMTs	At least 5 years	Substantial light losses can result in a reduction in ionizing particle detection efficiency.	Code 661 to perform qualification testing similar to that for items B and C.
F. ACD to TEM Connectors	Mil-C-38999	Transmits information from Digital ASIC to TEM	At least 5 years	Loss of ACD information can result in a reduction in ionizing particle detection efficiency.	Electronics Lab incorporating connector savers during the integration and test phases.

.

ITEM	PART/ SPEC NUMBER	RATIONALE FOR SELECTING ITEM	LIFE REQUIREMENTS	POTENTIAL IMPACT ON MISSION PARAMETERS	PLANS, RESPONSIBILITY, & RESULTS
G. PMTs	Hamamatsu R4443	To evaluate the effect of temperature on PMT degradation	At least 5 years	PMT degradation could eventually exceed the HVBS and electronics adjustability margin at elevated temperatures.	PMT Thermal Evaluations, Optical Performance Analysis, review of reliability allocations, and review of Hamatsu data show that mission lifetime requirements will be met (see Section 3.1)

.