433-MAR-0003

# GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST) PROJECT

# SPACECRAFT MISSION ASSURANCE REQUIREMENTS (MAR)

April 24, 2002

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

CHECK THE GLAST PROJECT WEBSITE AT
http://glast.gsfc.nasa.gov/project/cm/mcdl TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

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# SPACECRAFT

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*GLAST Project Spacecraft Mission Assurance Requirements (MAR)*

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# Table of Contents


1.0 GENERAL ..... 1

1.1 SCOPE ..... 1
1.2 APPLICABLE DOCUMENTS (SECTION 9) ..... 1
1.3 ACRONYMS (SECTION 10) ..... 1
1.4 OVERALL SYSTEM SAFETY AND MISSION ASSURANCE (S&MA) REQUIREMENTS ..... 1
1.5 SURVEILLANCE OF CONTRACTOR ..... 2
1.6 S&MA-RELATED DELIVERABLES (APPENDIX A) ..... 2

2.0 QUALITY ASSURANCE ..... 3

2.1 OVERVIEW OF QUALITY ASSURANCE PROGRAM ..... 3
2.2 MATERIAL REVIEW BOARD (MRB) ACTIVITIES ..... 4
2.3 NONCONFORMANCE REPORTS ..... 5
2.4 WORKMANSHIP AND PROCESSES ..... 5
2.5 AS-BUILT HARDWARE ITEM CONFIGURATION LISTS ..... 6
2.6 FLIGHT AND GROUND SOFTWARE ASSURANCE ..... 6

3.0 System Safety ..... 7

3.1 OVERVIEW OF SYSTEM SAFETY PROGRAM ..... 7
3.2 SYSTEM SAFETY DELIVERABLES ..... 7
3.3 ORBITAL DEBRIS ASSESSMENT ..... 7

4.0 Technical Reviews ..... 8

4.1 OVERVIEW OF TECHNICAL REVIEW PROGRAM ..... 8

5.0 Performance Verification ..... 9

5.1 OVERVIEW OF PERFORMANCE VERIFICATION PROGRAM ..... 9
5.2 SPACECRAFT AND OBSERVATORY INTEGRATION AND TEST (I&T) PLAN ..... 9
5.3 OBSERVATORY PERFORMANCE VERIFICATION PLAN ..... 10
5.4 PERFORMANCE VERIFICATION REQUIREMENTS ..... 10
*5.4.1 Functional Test Requirements ..... 11*
*5.4.2 Structural and Mechanical Requirements ..... 13*
*5.4.3 Electromagnetic Compatibility (EMC) Requirements ..... 15*
*5.4.4 Thermal Vacuum Verification Testing ..... 16*

6.0 Parts, Materials, Lubrication, and Processes Program ..... 20

6.1 OVERVIEW OF PARTS, MATERIALS, LUBRICATION, AND PROCESSES PROGRAM ..... 20
6.2 PARTS, MATERIALS, LUBRICATION, AND PROCESSES CONTROL PLAN (PMLPCP) ..... 20
6.3 PARTS, MATERIALS, LUBRICATION, AND PROCESSES LISTS ..... 21
6.4 GIDEP RESPONSES ..... 21
6.5 PRINTED WIRING BOARD (PWB) COUPONS ..... 21
6.6 FASTENERS ..... 21
6.7 SOLAR ARRAY ..... 22

7.0 Contamination Control Program ..... 23

7.1 OVERVIEW OF CONTAMINATION CONTROL PROGRAM ..... 23
7.2 CONTAMINATION CONTROL PLAN (CCP) ..... 23

8.0 Reliability and Risk Management Program ..... 24

8.1 OVERVIEW OF RELIABILITY AND RISK MANAGEMENT PROGRAM ..... 24


CHECK THE GLAST PROJECT WEBSITE AT
http://glast.gsfc.nasa.gov/project/cm/mcdl TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

8.2 RELIABILITY ANALYSES ..... 24
*8.2.1 Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) ..... 24*
*8.2.2 Probabilistic Risk Assessment (PRA) ..... 26*
*8.2.3 Reliability Assessments and Predictions ..... 26*
*8.2.4 Fault Tree Analysis (FTA) ..... 27*
*8.2.5 Trend Analyses ..... 27*

9.0 Applicable Documents ..... 28

10.0 Acronyms ..... 29

Appendix A - SAFETY AND MISSION ASSURANCE RELATED SPACECRAFT AND OBSERVATORY DELIVERABLES

DID A - DISCREPANCY REPORTS (DR'S) AND MATERIAL REVIEW BOARD (MRB) REPORTS ..... A-5
DID B - NON-CONFORMANCE REPORTS (NCR'S) AND ANOMALY REVIEW BOARD (ARB) REPORTS ..... A-6
DID C - AS-BUILT HARDWARE AND SOFTWARE CONFIGURED ITEMS LISTS ..... A-7
DID D - SYSTEM SAFETY DOCUMENTATION ..... A-8
DID E - MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE (MSPSP) ..... A-9
DID F - DEBRIS GENERATION ANALYSIS REPORT ..... A-10
DID G - TECHNICAL REVIEWS ..... A-11
DID H - SPACECRAFT AND OBSERVATORY INTEGRATION AND TEST (I&T) PLAN ..... A-12
DID I - OBSERVATORY PERFORMANCE VERIFICATION PLAN ..... A-14
DID J - ELECTROMAGNETIC INTERFERENCE CONTROL PLAN (EMICP) ..... A-15
DID K - ELECTROMAGNETIC INTERFERENCE/COMPATIBILITY TEST PLAN (EMICTP) ..... A-17
DID L - PARTS, MATERIALS, LUBRICATION, AND PROCESSES CONTROL PLAN (PMLPCP) ..... A-19
DID M - AS-DESIGNED/AS-BUILT PARTS, MATERIALS, LUBRICATION, AND PROCESSES LISTS ..... A-20
DID N - GOVERNMENT INDUSTRY DATA EXCHANGE PROGRAM (GIDEP) ALERT RESPONSES ..... A-24
DID O - PRINTED WIRING BOARD (PWB) COUPONS OR REPORTS ..... A-25
DID P - OBSERVATORY CONTAMINATION CONTROL PLAN (CCP) ..... A-26
DID Q - FAILURE MODES AND EFFECTS ANALYSIS (FMEA) AND CRITICAL ITEMS LIST (CIL) ..... A-28
DID R - PROBABILISTIC RISK ASSESSMENT (PRA) ..... A-29
DID S - RELIABILITY ASSESSMENTS AND PREDICTIONS ..... A-30
DID T - FAULT TREE ANALYSIS (FTA) ..... A-31

# LIST OF TABLES

Table 2-1: Quality Assurance Deliverables ..... 3
Table 3-1: System Safety Deliverables ..... 7
Table 4-1: Technical Review Deliverables ..... 8
Table 5-1: Performance Verification Deliverables ..... 9
Table 5-2: Structural and Mechanical Verification Requirements ..... 12
Table 6-1: Parts, Materials, Lubrication, and Processes Deliverables ..... 20
Table 7-1: Contamination Control Deliverables ..... 23
Table 8-1: Reliability and Risk Management Deliverables ..... 24
Table 8-2: Failure Mode Severity Categories ..... 25
Table A-1: Summary of Safety and Mission Assurance Related Deliverables ..... A-2

# 1.0 GENERAL

This document, referred to as the “Spacecraft MAR” or the “MAR,” defines supplemental Safety and Mission Assurance requirements for the GLAST delivery order (implementation phase) under the RSDO Rapid II contract. Additional mission assurance requirements are defined in the Rapid II Contract and the GLAST Statement of Work (SOW).

References to the “developer” or "contractor" in this document are directed to the GLAST spacecraft contractor. References to the “SAM” refer to the NASA GSFC GLAST Project Systems Assurance Manager. References to the “Government” or the “GLAST Project Office” refer to the NASA GSFC GLAST Project Office.

## 1.1 SCOPE

The requirements stated in this attachment apply to all work accomplished by the spacecraft bus contractor and their subcontractors and suppliers of deliverable space flight hardware and software.

Non-flight deliverable hardware that interfaces directly with flight hardware shall be designed and fabricated using space flight materials and processes for any portion of the assemblies that mate with the flight hardware or that will reside with the space flight hardware in environmental chambers or other test facilities that simulate a space environment (e.g., connectors and test cables).

## 1.2 APPLICABLE DOCUMENTS (SECTION 9)

To the extent referenced herein, applicable portions of the documents listed in Section 9 form a part of this document (i.e., the GLAST Spacecraft S&MA Requirements). The latest version of each document, at the time of the issue of the GLAST RFO, is applicable. In the event of a conflict between the documents listed in Section 9 and this requirements specification, the contents of this specification shall be considered the superseding requirements. In the event of a conflict between this Mission Assurance Requirements document and the Spacecraft Statement of Work (SOW), the SOW shall take precedence. In the event of any other unresolved conflict, the contracting officer shall be notified, and the order of precedence will be as directed by the contracting officer. (Also, refer to Section 2.1 for document conflict clarification.)

## 1.3 ACRONYMS (SECTION 10)

Section 10 defines the acronyms used in this document.

## 1.4 OVERALL SYSTEM SAFETY AND MISSION ASSURANCE (S&MA) REQUIREMENTS

The contractor is required to plan and implement an organized S&MA Program that encompasses:

a. All flight hardware, either designed/built/provided by the contractor or furnished by GSFC from project initiation through launch and mission operations

b. The ground system that interfaces with flight equipment to the extent necessary to assure the integrity and safety of flight items
c. All software critical for mission success

Managers of the contractor assurance activities shall have direct access to contractor management independent of project management, with the functional freedom and authority to interact with all other elements of the project. Issues requiring project management attention shall be addressed with the contractor(s) through the Project Manager(s) and/or Contracting Officer Technical Representative(s) (COTR).

## 1.5 SURVEILLANCE OF CONTRACTOR

The work activities, operations, and documentation performed by the contractor and/or his suppliers are subject to evaluation, review, audit, and inspection by Government-designated representatives from GSFC, the Government Inspection Agency (GIA), or an independent assurance contractor (IAC). GSFC will delegate in-plant responsibilities and authority via a letter of delegation or the GSFC contract with the IAC. The contractor and/or suppliers shall grant access for NASA and/or NASA representatives to conduct an assessment/survey upon notice. Resources shall be provided to assist with the assessment/survey with minimal disruption to work activities. The contractor, upon request, shall provide government assurance representatives with the documents, records, and equipment required to perform their S&MA activities. The contractor shall also provide the government assurance representative(s) with an acceptable work area within contractor facilities.

## 1.6 S&MA-RELATED DELIVERABLES (APPENDIX A)

Appendix A of this document contains Data Item Descriptions (DID's) that describe S&MA-related data deliverable to the Government; i.e., the NASA GSFC Project Office. The "DID letters" cited throughout this document refer to the numbers listed on the DID's contained in Appendix A. Deliverables may be received/reviewed by GSFC personnel at either GSFC or at the contractor's facility as specified in the respective DID.

The following definitions apply with respect to S&MA deliverables:

| | |
|---|---|
| Deliver for Approval: | Documents in this category require written GSFC approval prior to use. Requirements for resubmission shall be as specified in the letter(s) of disapproval. |
| Deliver for Information/Review: | Documents in this category require receipt by GSFC for the purpose of determining current program status, progress, and future planning requirements. When Government evaluations reveal inadequacies, the contractor will be directed to correct the documents. |

## 2.0 QUALITY ASSURANCE

In addition to the requirements listed in the GLAST Spacecraft SOW and the Rapid II Contract, the Spacecraft Quality Program shall adhere to the requirements delineated in this section.

### 2.1 OVERVIEW OF QUALITY ASSURANCE PROGRAM

The contractor shall have a Quality Management System (QMS) that is compliant with the minimum requirements of ANSI/ISO/ASQ Q9001. Certificates issued to ISO 9001: 1994 will have a maximum validity of 3 years from the publication date of ANSI/ISO/ASQ Q9001: 2000.

The contractor's Quality Manual and associated documentation shall be made available (preferably electronically or on a website) for Government information upon request. Specific procedures/processes/plans noted in this document, including Appendix A, and/or listed in the spacecraft CDRL shall be reviewed for Government approval as required. The contractor's GLAST spacecraft/observatory S&MA Program shall adhere to the contractor's standard Quality/S&MA Plan for a Rapid II spacecraft bus, supplemented by documentation as necessary to implement the additional GLAST S&MA requirements delineated in this document. Where there is a conflict between contractor's documentation and this document, this document shall take precedence. (Also, refer to Section 1.2 for document conflict clarification.) Additionally, the following deliverables are associated with the GLAST Spacecraft Quality Program:

| DID LTR. | DESCRIPTION | Due Date, Maturity | A/I |
|---|---|---|---|
| A | Discrepancy Reports (DR's) and Material Review Board (MRB) Reports | DR - Within 16 Work Hours of Preparation, Preliminary<br>DR - At Completion of Analysis & Assignment of Corrective Action, Current<br>Class 2 DR – After MRB Closure, Final<br>Class 1 DR - After MRB Closure, Final<br>Notice Within 5 Work Days of DR on Similar Hardware, Current<br>MRB Report - 5 Work Days After Each MRB Meeting, Final | I<br>I<br>I<br>A<br>I<br>I |
| B | Non-Conformance Reports (NCR's) and Anomaly Review Board (ARB) Reports | NCR - Within 16 Work Hours of Occurrence, Preliminary<br>NCR - At Completion of Analysis & Assignment of Corrective Action, Current<br>"Non-Significant" NCR – After ARB Closure, Final<br>"Significant" NCR - After ARB Closure, Final<br>Notice Within 5 Work Days of NCR on Similar Hardware, Current<br>ARB Reports - 5 Work Days After Each ARB Meeting, Final | I<br>I<br>I<br>A<br>I<br>I |
| C | As-Built Hardware and Software Configured Items Lists | 60 Days Prior to Hardware/Software Shipment, Final<br>As Generated, Updates | I |

TABLE 2-1: QUALITY ASSURANCE DELIVERABLES

## 2.2 MATERIAL REVIEW BOARD (MRB) ACTIVITIES

The contractor shall withhold discrepant products from further processing in a controlled area until disposition. Discrepancy reports (DR's) shall be completed and maintained. Discrepant products shall be reviewed by contractor quality assurance and engineering personnel. They shall be processed in accordance with the contractor's discrepant product/MRB procedures and processes. Discrepant materials may be dispositioned as/for:

a. Return for rework or completion of operation using established and approved documents and operations including resubmission to normal inspection and tests during rework
b. Scrap in accordance with contractor procedures for identifying, controlling, and disposing of scrap
c. Return to its supplier with nonconformance information and assistance, as necessary, to permit remedial and preventive action
d. Submit to MRB for final disposition when the above disposition alternatives are not appropriate

Nonconformances not dispositioned by preliminary review shall be referred to the MRB for disposition. MRB dispositions shall include scrap, rework, return to supplier, repair by standard or non-standard repair procedures, use-as-is, or request for major waiver. MRB dispositions shall not adversely affect the safety, reliability, durability, performance, interchangeability, weight, or other basic features of GLAST hardware.

The MRB shall be chaired by a contractor representative who is responsible for ensuring that MRB actions are performed in compliance with this document and implemented per contractor procedures. The MRB core team shall consist of the appropriate functional and project representatives who are needed to ensure timely determination, implementation, and close-out of recommended MRB disposition. The MRB shall be supplemented with representatives of additional disciplines as necessary. The GLAST SAM or their representative shall be a non-voting member of the MRB and shall be given 8 work hours notice prior to each MRB meeting.

All DR's and MRB reports shall be provided to the Government in accordance with **DID A**. After closure by the MRB, Class 2 DR's shall be provided to the GLAST SAM or their representative for information only. After closure by the MRB, Class 1 DR's shall be provided to the GLAST SAM or their representative for concurrence. (Note: A Class 1 DR shall be defined as a significant report which may affect the material's/part's safety, form, fit, function interchangeability, cost, and/or schedule thus having a negative impact on the spacecraft's reliability and/or quality and hence its ability to meet mission requirements. Any DR that requires the generation of a waiver/deviation shall be considered to be Class 1.)

If relevant, discrepancy reports for similar contractor buses shall be reported to the GLAST Project Office within 5 workdays of initiation. Only the pertinent information (e.g., part/material type and datecode, discrepancy, and corrective/preventive action) need to be reported. Information deemed non-essential such as spacecraft name and customer name need not be reported in order to honor proprietary/privacy agreements with other customers.

## 2.3 NONCONFORMANCE REPORTS

The GLAST spacecraft contractor shall maintain a process for promptly documenting and reporting nonconformances to the Government for information and the contractor's internal Anomaly Review Board (ARB) for disposition and corrective action. (Note: In this context, a "nonconformance report" is defined as a failure, anomaly, or problem report.) The contractor shall ensure that a closed-loop reporting system is used to assure corrective action is implemented to preclude recurrence and to provide verification of the adequacy of implemented corrective action by inspection and/or test as appropriate.

The spacecraft contractor shall report nonconformances relative to the spacecraft to the Government in accordance with **DID B**. Additionally, the GLAST SAM or their representative shall serve as a non-voting member of the contractor's ARB and shall receive 8 work hours notice prior to each ARB meeting.

All NCR and ARB reports shall be delivered to the Government in accordance with **DID B**. After closure by the ARB, "non-significant" NCR's shall be provided to the SAM or their representative for information only. After closure by the ARB, "significant" NCR's shall be provided to the SAM or their representative for concurrence. (Note: "Non-significant" NCR's shall be defined as reports covering anomalies that were attributable to the test equipment or to operator error.)

The contractor shall document failure reports in accordance with company standards. However, these failure reports shall include the risk rating of the problem/anomaly to identify significant problems/failures. Contractor format, generation, review, disposition, and/or approval of failure reports shall be described in applicable procedure(s) included or referenced in the contractor's Quality/S&MA Plan.

Anomalies/failures on similar contractor buses shall be reported to the GLAST Project Office within 5 workdays of occurrence. Only the pertinent information (e.g., related hardware, anomaly, and corrective/preventive action) needs to be reported. Information deemed non-essential such as spacecraft name and customer name need not be reported in order to honor proprietary/privacy agreements with other customers.

## 2.4 WORKMANSHIP AND PROCESSES

The GLAST observatory contractor shall be compliant to the following workmanship standards:

a. NASA-STD-8739.1, "Requirements for Conformal Coating and Staking of Printed Wiring Boards"
b. NASA-STD-8739.2, "Requirements for Surface Mount"
c. NASA-STD-8739.3, "Requirements for Soldered Electrical Connections"
d. NASA-STD-8739.4, "Requirements for Cabling and Crimping"
e. ANSI/ESD S20.20-1999, "Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)"
f. IPC-2221, "Generic Standard on Printed Board Design"
g. IPC-2222, "Sectional Design Standard for Rigid Organic Printed Boards"
h. IPC-6011, "Generic Performance Specifications for Rigid Printed Wiring Boards"
i. IPC-6012, "Qualification and Performance Specification for Rigid Printed Wiring Boards"

j. GSFC Supplement S-312-P003, "Process Specification for Rigid Printed Wiring Boards for Space Applications and Other High Reliability Uses"

Refer to Section 6.3 and **DID M** for additional information on workmanship and fabrication processes/procedures.

## 2.5 AS-BUILT HARDWARE ITEM CONFIGURATION LISTS

The As-Built Hardware Configured Items List shall be developed and delivered to the Government in accordance with **DID C**.

## 2.6 FLIGHT AND GROUND SOFTWARE ASSURANCE

The contractor shall conduct a Flight and Ground Software Assurance Program in accordance with the requirements of the GLAST Spacecraft SOW, Section 4.3.6, and related deliverables/ documentation. Additionally, an As-Built Software Item Configuration List shall be developed and delivered to the Government in accordance with **DID C**.

## 3.0 SYSTEM SAFETY

In addition to the requirements listed in the GLAST Spacecraft SOW and the Rapid II Contract, the Spacecraft System Safety Program shall adhere to the requirements delineated in this section.

### 3.1 OVERVIEW OF SYSTEM SAFETY PROGRAM

The Spacecraft System Safety Program shall be conducted in accordance with EWR 127-1, "Eastern and Western Range Safety Requirements." Additionally, the following deliverables are associated with the GLAST Spacecraft System Safety Program:

| DID LTR. | DESCRIPTION | Due Date, Maturity | A/I |
|---|---|---|---|
| D | System Safety Program Plan | 45 Days After Contract Award, Initial<br>45 Days Prior to MCDR, Final | A |
| | Preliminary Hazard Analysis (PHA) | 30 Days Prior to MPDR, Preliminary<br>30 Days Prior to MCDR, Final | A |
| | Safety Noncompliance Reports | As Generated, Final | A |
| | Hazards Control Verification Log | When Requested, Current | I |
| | Ground Operations Plan (GOP) Including Hazardous and Safety Critical Procedures | GOP - 45 Days Prior to MCDR, Initial<br>GOP - 45 Days Prior to Observatory's Delivery to the Range, Final<br>Procedures – 15 Days Prior to First Run of Procedure, Final | A |
| E | Missile System Prelaunch Safety Package (MSPSP) | 13.5 Months Prior to Observatory Shipment to Range, Initial<br>75 Days Prior to Observatory Shipment to Range, Final | A |
| F | Debris Generation Analysis Report | 30 Days Prior to MPDR, Initial<br>65 Days Prior to MCDR, Final<br>As Generated, Updates | I |

TABLE 3-1: SYSTEM SAFETY DELIVERABLES

### 3.2 SYSTEM SAFETY DELIVERABLES

Safety documentation shall be prepared and delivered to the Government in accordance with **DID D** and **DID E**.

### 3.3 ORBITAL DEBRIS ASSESSMENT

The Debris Generation Analysis Report shall be prepared and delivered to the Government in accordance with **DID F**.

# 4.0 TECHNICAL REVIEWS

In addition to the requirements listed in the GLAST Spacecraft SOW, Section 4.3.1.3, and the Rapid II Contract, the Spacecraft Technical Review Program shall adhere to the requirements delineated in this section.

## 4.1 OVERVIEW OF TECHNICAL REVIEW PROGRAM

Technical reviews shall be conducted in accordance with the GLAST Spacecraft SOW and the Rapid II Contract. Information related to these reviews shall be prepared and delivered to the Government in accordance with **DID G**.

| DID LTR. | DESCRIPTION | Due Date, Maturity | A/I |
|---|---|---|---|
| G | Technical Reviews | GSFC Chaired/Co-Chaired Review Technical Material - 7 Work Days Prior to Review, Final | I |
| | | Minutes and Action Items for Peer Reviews – 10 Work Days After Review, Final | I |
| | | Responses to Government Requests for Action - Per Schedule Established at/for Review, Final | A |
| | | Responses to Peer Review Action Items– After Closure, Final | I |

TABLE 4-1: TECHNICAL REVIEW DELIVERABLES

# 5.0 PERFORMANCE VERIFICATION

In addition to the requirements listed in the GLAST Spacecraft SOW and the Rapid II Contract, the Spacecraft Performance Verification Program shall adhere to the requirements delineated in this section.

## 5.1 OVERVIEW OF PERFORMANCE VERIFICATION PROGRAM

The requirements in this section cover the performance verification program and related documentation at both the spacecraft bus and observatory levels. The following deliverables are associated with the Spacecraft Performance Verification Program:

| DID LTR. | DESCRIPTION | Due Date, Maturity | A/I |
|---|---|---|---|
| H | Spacecraft and Observatory Integration and Test (I&T) Plan | 60 Days Prior to the MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates<br>Verification Procedures, Test Results, and Test Reports – Upon Request | A<br>A<br>A<br>I |
| | Observatory-Level Thermal Vacuum Test Plan | 90 Days Prior to the Commencement of Observatory Level Thermal Vacuum Testing, Current<br>As Generated, Updates | A |
| | Observatory-Level Thermal Vacuum Test Correlation Report | 21 Days After the Completion of Observatory Level Thermal Balance Vacuum Testing, Current<br>As Generated, Updates | I |
| I | Observatory Performance Verification Plan | 60 Days Prior to the MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates<br>Test Results/Reports - Within 60 days of Test Completion, Current | A<br>A<br>A<br>I |
| J | Electromagnetic Interference Control Plan (EMICP) | 30 Prior to the MPDR, Preliminary<br>90 Days After MPDR, Final<br>As Generated, Updates | I<br>A<br>A |
| K | Electromagnetic Interference/ Compatibility Test Plan (EMICTP) | 90 Days After MPDR, Preliminary<br>90 Days Prior to the MCDR, Final<br>As Generated, Updates | I<br>A<br>A |

TABLE 5-1: PERFORMANCE VERIFICATION DELIVERABLES

## 5.2 SPACECRAFT AND OBSERVATORY INTEGRATION AND TEST (I&T) PLAN

The approach for accomplishing the Performance Verification Program shall be described as part of the Spacecraft and Observatory I&T Plan in accordance with the GLAST Spacecraft SOW and **DID H**. This shall include a description of the management approach as well as

references to applicable plans, specifications, procedures, and reports that define the technical aspects of the Performance Verification Program.

The Spacecraft and Observatory I&T Plan shall include the definition of specific tests and analyses that collectively demonstrate that the hardware and software/firmware complies with this and other GLAST Project documentation related to this procurement. This plan shall include the overall approach to accomplishing the Verification Program in addition to the other requirements listed in **DID H**. For each performance verification test, it shall include the level of assembly, configuration of the item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, necessary functional operations, personnel responsibilities, and requirements for procedures and reports. It shall also define a rationale for retest determination that does not invalidate previous verification activities. When appropriate, the interaction of the test and analysis activity shall be described. For each analysis activity, the plan shall include objectives, a description of the mathematical model, assumptions on which the models will be based, required output, criteria for assessing the acceptability of the results, the interaction with related test activity (if any) and requirements for reports.

For each functional and environmental test activity conducted at the component, subsystem, spacecraft bus and observatory level, verification procedures shall be prepared that describe the configuration of the test article and how that particular test activity contained in the Spacecraft and Observatory Integration and Test Plan will be implemented. The procedures shall describe details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, quality control checkpoints, pass/fail criteria, data collection, and reporting requirements. The procedures shall also have attached test predictions and shall address safety and contamination control provisions and measures to protect the hardware (e.g., connector savers). Procedures for calibrations and performance tests shall provide for the real-time display of data in easily recognized engineering terms to the maximum extent practicable. Verification procedures, test results, and test reports shall be made available for the Government's review upon request in accordance with **DID H**.

## 5.3 OBSERVATORY PERFORMANCE VERIFICATION PLAN

The Observatory Performance Verification Plan shall summarize all tests and analyses that will be performed on each component, each subsystem, the spacecraft bus, and the observatory as a whole. The contractor shall update the test matrix as the contractor/subcontractor tests are actually accomplished throughout the program and present it at pertinent GSFC reviews. The Observatory Performance Verification Plan shall be prepared and delivered in accordance with **DID I**. Additionally, as noted in **DID I**, test results and reports shall be provided to the Government within 60 days of test completion for information.

## 5.4 PERFORMANCE VERIFICATION REQUIREMENTS

The spacecraft bus contractor shall plan, manage, and execute spacecraft bus and observatory level interface verification, system testing, and environmental testing to ensure that the GLAST spacecraft bus and observatory meet the specified mission requirements. The Performance Verification Program shall begin with the functional testing of assemblies and continue through functional and environmental testing, supported by appropriate analysis, at the component and subsystem levels of assembly and at the fully integrated spacecraft bus and observatory levels. The methods for implementing the requirements of this MAR Section, if not specified herein,

shall be based on the expendable launch vehicle (ELV) payload requirements of the "General Environmental Verification Specification for Space Transportation System (STS) and ELV Payloads, Subsystems and Components" (GEVS-SE), Revision A. For the purposes of this document, the activities included in the Performance Verification Program shall include electrical functional tests, structural and mechanical tests, electromagnetic compatibility tests, vacuum and thermal tests, and pre-launch flight operations.

The contractor shall establish specific environmental test requirements for the GLAST mission based upon the ELV payload requirements of GEVS-SE and mission requirements. Test levels shall encompass predictions based on launch vehicle information. Test requirements shall be updated if necessary based on spacecraft bus and observatory structural analyses and modal surveys.

### *5.4.1 Functional Test Requirements*

Functional testing shall include electrical interface tests, performance tests (comprehensive and limited), and trouble free performance testing.

#### *5.4.1.1 Electrical Interface Tests*

Before the integration of an assembly, component, or subsystem into the next higher hardware assembly; electrical interface tests shall be performed to verify that all interface signals are within acceptable limits of applicable performance specifications.

#### *5.4.1.2 Performance Tests*

Both comprehensive and limited performance testing shall be performed.

##### *5.4.1.2.1 Comprehensive Performance Tests (CPT's)*

Upon the completion of integration of all assemblies, a CPT shall be conducted on each subsystem and component. Additionally, CPT's shall be performed on both the spacecraft bus and the fully integrated observatory before the start of the environmental test program as well as after its completion. During thermal vacuum testing, additional CPT's shall be conducted during the hot and cold extremes.

The CPT shall be a detailed demonstration that the hardware meets its performance requirements within allowable tolerances. The CPT shall demonstrate the operation of all redundant circuitry. It shall also demonstrate satisfactory performance in all operational modes within practical limits of cost, schedule, and environmental simulation capabilities. The initial CPT shall serve as the baseline against which the results of all later CPT's are compared.

At the spacecraft bus and observatory levels, the CPT shall demonstrate that, with the application of known stimuli, the system will produce the expected responses. At lower levels of assembly, the test shall demonstrate that, when provided with appropriate stimuli, internal performance is satisfactory and outputs are within acceptable limits.

##### *5.4.1.2.2 Limited Performance Tests (LPT's)*

As appropriate, LPT's shall be conducted before, during, and after environmental tests to demonstrate that functional capability was not degraded through environmental testing. LPT's shall be used in cases where a CPT is not warranted or not practicable. LPT's shall demonstrate that the performance of selected functions is within acceptable limits.

*5.4.1.2.3 Trouble Free Performance*

At the conclusion of the performance verification program, the observatory shall demonstrate "minimum reliability acceptability" through trouble-free performance for at least the last 350 hours of combined testing prior to its shipment to the launch site. Trouble-free operation during thermal vacuum test exposure and testing of the integrated observatory may be included as part of this demonstration. Hardware or software changes during or after the verification program shall invalidate the previous demonstration. CH-04

| Requirement | Observatory | Spacecraft Bus | Component of the Spacecraft Bus |
|---|---|---|---|
| Structural Loads: | | | |
| Modal Survey | | T | |
| Load Tests: | | | |
| Design Qualification | | T | |
| Structural Reliability | A/T | A/T | A/T |
| Vibroacoustics: | | | |
| Acoustics | T | T1 | T1 |
| Random Vibration | | | T |
| Sine Vibration | T2 | T2 | T2 |
| Mechanical Shock | T | | T3 |
| Mechanical Function | T | T | |
| Pressure Profile | | A/T1 | |
| Mass Properties | A/T | T | |

Key:

A = Analysis is required.
A/T = Analysis and/or testing is required.
T = Testing is required.
T1 = Testing must be performed unless analysis and preliminary test results (e.g., frequency verification prior to modal survey testing) can be used to justify deletion.
T2 = Testing performed to simulate any sustained periodic mission environment or to satisfy other requirement (e.g., loads, shock) is required.
T3 = Testing is required per Section 5.4.2.4 if the spacecraft subsystem contains shock producing devices.

Component = A functional subdivision of a subsystem and generally a self-contained combination of items performing a function necessary for the subsystem's operation; e.g., electronic box, transmitter, gyro package, actuator, motor, battery. For the purposes of this document, "component" and "unit" are used interchangeably.

TABLE 5-2: STRUCTURAL AND MECHANICAL VERIFICATION REQUIREMENTS

### *5.4.2 Structural and Mechanical Requirements*

The contractor shall demonstrate compliance with structural and mechanical requirements through a series of interdependent test and analysis activities. The baseline requirements are stated in the ELV payload requirements of GEVS-SE. The demonstrations shall verify/ensure design and specified factors of safety, interface compatibility among the elements of the observatory and with the launch vehicle, acceptable workmanship, and compliance with associated systems safety requirements.

Table 5-2 specifies the required structural and mechanical verification activities. When planning the tests and analyses, the contractor shall consider all expected environments including those of structural loads, vibroacoustics, mechanical shock, and pressure profiles. Mass properties and mechanical functioning shall also be verified.

The structural loads, vibroacoustics, sine vibration, mechanical shock, and mechanical function tests shall verify the design's qualification.

#### *5.4.2.1 Structural Loads*

Verification of the structural loads environment shall be accomplished by a combination of test and analysis. A modal survey shall be performed to verify that the analytic model of the spacecraft bus and observatory adequately represents their dynamic characteristics. All significant modes up to 50 Hz shall be determined both in terms of frequency and mode shape. Cross-orthogonality checks of the test and analytical mode shapes, with respect to the analytical mass matrix, shall be performed with the goal of obtaining at least 0.9 on the diagonal and no greater than 0.1 off the diagonal. The test-verified model shall then be used to predict the maximum expected load for each potentially critical loading condition including handling and transportation as well as vibroacoustics effects during lift-off. The maximum loads resulting from the analysis shall define the limit loads.

#### *5.4.2.3 Sine Vibration*

The observatory shall be subjected to sweep sine vibration testing from 5 to 50 Hz to qualify the hardware for the low-frequency sine transient or sustained sine environments present in flight. The sweep sine vibration test will also provide a workmanship test for all observatory hardware that normally does not respond significantly to the acoustic environment; e.g., wiring harnesses and stowed appendages. CH-04

The observatory, in its launch configuration, shall be attached to a vibration fixture through the use of a flight-type launch vehicle attach fitting and separation system. Sine sweep vibration shall be applied at the base of the launch vehicle adapter in each of three orthogonal axes including one that is parallel to the thrust axis. The test shall represent the qualification level (i.e., the flight limit level times 1.25). The test sweep rate shall be 4 octaves per minute except in the frequency range of 25 to 35 Hz where the sweep rate shall be 1.5 octaves per minute. This test shall be performed by sweeping the applied vibration once through the 5 to 50 Hz frequency range in each test axis. CH-04

Additionally, low level sinusoidal excitation shall be used to identify all modes up to 150 Hz. Instrumentation for this low level testing shall be based on pre-test analyses. Identification of all modes up to 150 Hz will be required for simulation of a recently discovered Delta II CH-01

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launch event (i.e., a transient main engine cutoff or MECO) in the range of 115 to 125 Hz.

Before and after each vibration test, the payload shall be examined and functionally tested. Additionally, its performance shall be monitored during the test.

*5.4.2.4 Mechanical Shock*

Both self-induced and externally-induced shocks shall be considered in defining the mechanical shock environment. All observatory subsystems shall be exposed to all self-induced shocks through the actuation of the shock-producing devices. Each device shall be actuated twice to account for the scatter associated with different actuations of the same device. Additionally, when the most severe shock is externally induced, a suitable simulation of that shock shall be applied at the subsystem interface. When it is feasible to apply this shock with a controllable shock-generating device, the verification level shall be 1.4 times the maximum expected value at the subsystem interface and it shall be applied once in each of the three axes. If it is not feasible to apply the shock with a controllable shock-generating device (e.g., the subsystem is too large for the device), this test may be conducted at the spacecraft bus or observatory level through the actuation of shock-producing devices in the elements of the observatory that produce the shocks external to the subsystem to be tested. Separation shock shall also be verified through the actuation of shock-producing devices during the observatory level test. The shock-producing device(s) shall be actuated a minimum of two times for this test. CH-04 CH-02

*5.4.2.5 Mechanical Function*

A kinematic analysis of all observatory mechanical operations is required to ensure that:

a. Each mechanism can perform satisfactorily and has adequate margins under worst-case conditions
b. Satisfactory clearances exist for both the stowed and operational configurations as well as during any mechanical operation
c. All mechanical elements are capable of withstanding the worst-case loads that may be encountered

Additionally, verification tests shall be performed to demonstrate that the installation of each mechanical device is correct and that no problems exist that could prevent proper operation of the mechanism during mission life.

Verification tests shall be performed for each mechanical operation at nominal, low, and high energy levels. To establish that mechanical function is proper for normal operations, the nominal test shall be conducted at the most probable conditions predicted during normal flight. A high-energy test and a low-energy test shall also be conducted to prove positive margins of strength and function. The levels of these tests shall demonstrate margins beyond the nominal conditions by considering adverse interaction of potential extremes of parameters such as temperature, friction, spring forces, stiffness of electrical cabling or thermal insulation, and (when applicable) spin rate. Parameters to be varied during these high-energy and low-energy tests shall include, to the maximum extent practicable, all those that could substantively affect the operation of the mechanism as determined by the results of analytic predictions or development tests. As a minimum, successful operation at temperature extremes 10°C beyond the range of expected flight temperatures shall be demonstrated.

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Mechanical functions that have been adequately tested at the subsystem level (and do not have the potential for interference with other subsystems or structure) need not be re-verified at the observatory level.

*5.4.2.5.1 Minimum Clearance*

The contractor shall verify adequate dynamic clearances between the observatory and launch vehicle and between members within the observatory for all significant ground test and flight conditions. The contractor shall also verify the adequacy of dynamic clearances between members within the observatory during ground testing for vibration and acoustics as well as during flight. Additionally, a deployment analysis shall be used to verify the adequacy of clearances during observatory appendage deployment.

*5.4.2.6 Pressure Profile*

The need for a pressure profile test shall be assessed for all hardware on the observatory. If a test is required, the limit pressure profile shall be determined using the predicted pressure-time profile for the nominal trajectory of the GLAST mission.

*5.4.2.7 Mass Properties*

The contractor shall ensure that the spacecraft bus and observatory mass properties comply with derived mission requirements.

*5.4.2.8 Optical Bench Performance*

The contractor shall verify the on-orbit performance of the optical bench assembly through the use of a test correlated finite element model. The same model shall be correlated for each of the three independently applied test conditions:

CH-03

a. Mechanically induce loads into the optical bench/skirt assembly
b. Mechanically induce loads into the optical bench flexures
c. Thermally induce loads into the optical bench/skirt assembly

All performance testing shall be complete prior to the delivery of the flight structure to bus I&T.

### *5.4.3 Electromagnetic Compatibility (EMC) Requirements*

The observatory and its elements shall not generate electromagnetic interference that could adversely affect its own elements (including the instruments) or the safety and operation of the launch vehicle and launch site.

The observatory, its subsystems, components, and instruments shall not be susceptible to emissions that could adversely affect safety or performance. This applies whether the emissions are self-generated or derived from other sources or whether they are intentional or unintentional. The requirements in this document include an assurance that the observatory can operate satisfactorily within the environments usually encountered during integration and ground testing. However, some subsystems or instruments may have particularly sensitive sensors and electrical devices that are inherently susceptible to the EMI that may be expected in those

ground environments. In such cases, special work-around procedures shall be developed to meet these unique instrument needs.

Specific GLAST EMI/EMC requirements can be found in the GSFC 433-RQMT-0005, "GLAST Observatory EMI Requirements Document."

*5.4.3.1 Electromagtic Interference Control Plan (EMICP)*

The contractor shall develop an EMICP that demonstrates how the requirements of GSFC 433-RQMT-0005 will be satisfied. This Plan shall reflect the constraints placed on the observatory by the launch vehicle and launch site organizations including the launch site radiation environment. The EMICP shall be prepared and delivered to the Government in accordance with **DID J**.

To establish spacecraft/observatory design qualification, the contractor shall demonstrate compliance with this document (Section 5.4.3) by conducting an EMC test program in accordance with GSFC 433-RQMT-0005.

*5.4.3.2 Electromagnetic Interference/Compatibility Test Plan (EMICTP)*

The contractor shall develop an EMICP based on the tests and the test procedures described in GEVS-SE and MIL-STD-461E, "Electromagnetic Interference Characteristics Requirements for Equipment." The specific limits/levels shall be as defined in GSFC 433-RQMT-0005; however, stringent requirements may be necessary; e.g., for a subsystem or instrument with very sensitive electric field or magnetic field measurements. The sequence of the EMI/EMC tests relative to other environmental tests is optional with the caveat that magnetic tests shall not be performed until all vibration testing has been completed. The EMICTP shall be prepared and delivered to the Government in accordance with **DID K**.

### *5.4.4 Thermal Vacuum Verification Testing*

The spacecraft bus contractor shall conduct a set of tests, analyses, and correlations that demonstrates that all deliverable flight hardware components comply with requirements. All thermal verification testing shall be performed in a vacuum. The contractor's test verification program shall demonstrate that the observatory thermal design maintains all hardware components within the required margined hot and cold temperature limits in a simulated space vacuum environment under steady state conditions while design hot and cold environmental heat fluxes are applied to the hardware. Steady state conditions shall be defined to exist when, on a component-by-component basis, the energy-in equals the energy-out within tolerances specified by the thermal balance temperature rate of the change criteria.

The observatory flight thermal math model (TMM) shall be validated through correlation with thermal balance test results.

The observatory shall perform within specification in a simulated space vacuum environment while its components are exposed to margined minimum and maximum temperature extremes. Observatory performance within specification shall be demonstrated during both hot and cold temperature transitions (i.e., thermal cycling).

Required qualification temperature margins, applied on a component-by-component basis, shall be 10°C above and below design hot and cold operational flight limits. (Note: Thermal vacuum and thermal vacuum balance testing are only required at the observatory level and not at the spacecraft bus level.)

In accordance with **DID H**, an instrumentation plan shall be written by the spacecraft bus contractor and approved by the Government prior to MCDR. It shall specify both the location of flight/test temperature sensors and component-by-component dissipated power knowledge that shall be achieved during observatory level thermal vacuum tests. These analyses shall assure that sufficient instrumentation is installed to fully evaluate spacecraft bus and instrument thermal performance during thermal vacuum tests. Flight temperature sensor locations shall be identified that will provide adequate observatory thermal performance knowledge during flight. Hardware accessibility prior to observatory level thermal vacuum tests shall be evaluated and a dedicated set of test temperature sensors shall be identified and built into the hardware for hardware components deemed non-accessible for the application of test thermocouples at the time of thermal vacuum testing. Spacecraft electrical subsystem telemetry shall be evaluated to ensure that sufficient instrumentation is utilized to measure component-by-component power dissipation knowledge so that a meaningful spacecraft bus thermal model correlation effort can be performed.

The recommended thermal vacuum test sequence for the observatory level is:

a. Bakeout
b. Hot Operational Thermal Balance
c. Cold Survival Thermal Balance
d. Cold Operational Thermal Balance
e. Chamber Break/Reconfigure
f. Hot Non-Operational Survival Soak
g. 1st Cold Cycle, 1st Hot Cycle
h. 2nd Cold Cycle, 2nd Hot Cycle
i. 3rd Cold Cycle, 3rd Hot Cycle
j. 4th Cold Cycle, 4th Hot Cycle
k. Return to Ambient

Deviations to this sequence may be proposed with supporting rationale (e.g., contamination considerations) for Government approval.

*5.4.4.1 Thermal Vacuum Balance Testing*

Thermal vacuum balance testing shall verify thermal control system performance of the integrated flight hardware, verify expected thermal design margins, and provide a database to correlate to the flight TMM.

Operational hot, operational cold, and safe-hold cold thermal balance tests shall be performed at the observatory level. Thermal control system performance shall be verified by applying design hot and cold environmental fluxes to the hardware, while the hardware functions as it would on-orbit, to verify that the minimum and maximum temperature requirements are satisfied with margin. A 30% design control margin shall be demonstrated for all heater circuits and active two-phase heat transfer devices that are included in the thermal subsystem design., (Note: Variable conductance heat pipes, loop heat pipes, and capillary pumped looped systems are

considered to be active, two-phase, heat transfer devices. Constant conductance heat pipes are considered to be passive devices.)

In accordance with **DID H**, ninety (90) days prior to the commencement of thermal vacuum testing at the observatory level, a thermal vacuum test plan shall be delivered to the Government for approval. Prior to the observatory thermal vacuum test, the flight TMM shall be configured in the test configuration to aid in the definition of test conditions. Design hot and cold environmental fluxes shall be independently verified by GSFC thermal engineers. The thermal vacuum test math model results for each planned thermal balance, along with a comparison of the predicted test heat balance for key components to the heat balance predicted for flight, shall be included in the thermal vacuum test plan to ensure that test conditions adequately simulate the flight condition. Transient test thermal analyses that provide the basis for the steady state rate of temperature change criteria used to establish when steady state conditions have been achieved for each thermal balance point shall also be included in the test plan. The criteria shall be selected to permit no more than a 5% energy imbalance for any component compared to the theoretical steady state condition. Steady state analyses shall also be included to determine whether component thermal cycle test goals are satisfied by the thermal vacuum cycle test condition and configuration. For components whose thermal cycle test goals are not satisfied, the subsystem thermal vacuum test history (e.g., the number of cycles and temperatures) shall be included. Transient thermal analyses shall also be provided to estimate the expected thermal test durations.

In accordance with **DID H**, within 21 days of the completion of observatory level thermal balance vacuum testing, a test correlation report shall be prepared and delivered to the Government for information. This report shall:

a. Document differences between pre-test predictions and test results
b. Identify all changes made to the thermal model to achieve thermal correlation
c. Report correlation temperature results
d. Specify how these changes were incorporated into the flight thermal model
e. Provide updated flight temperature and heater power predictions

In assessing correlation adequacy, as a goal, all key instrument component model predictions shall be within ±3°C of measured temperatures; however, a tolerance of ±5°C shall be deemed acceptable. Temperature sensitive components with tolerances greater than ±5°C shall require written technical explanation that includes a component energy balance heat flow analyses, a technical assessment of why temperatures did not correlate, and a design margin analyses to assess the mission risks and margin issues associated with the non-correlation.

*5.4.4.2 Thermal Vacuum Cycle Testing*

Thermal vacuum cycling tests shall be utilized to demonstrate the ability of the spacecraft bus and instruments to perform within specification for all functional modes at temperatures 10°C above and below the design envelope of predicted on-orbit mission extremes. Although the integrated flight hardware shall be used for these tests, MLI blankets may be removed from the flight hardware to expedite the timing of thermal vacuum cycling temperature transitions. The required 10°C cold side temperature margin may be reduced to 5°C for components under active heater control assuming that design cold case thermal analyses has previously shown that the heaters, under thermostatic control, have been sized with a minimum 30% design

margin assuming minimum bus voltage. The thermal vacuum tests shall also demonstrate the ability of the spacecraft bus and instruments to perform within specification after being exposed to the predicted nonfunctional hot and cold margined temperature extremes. Cold and hot turn-on from non-functional temperature extremes shall be demonstrated for components not designed with dedicated heaters to elevate the components' temperatures from nonfunctional to operational temperature limits.

All temperature sensitive spacecraft bus components shall be subjected to a minimum of eight (8) thermal-vacuum temperature cycles prior to the observatory level thermal vacuum test. The final four (4) thermal cycles shall be performed during this test. Note: See Section 6.7 on solar array qualification, thermal vacuum testing, and thermal cycling.

Each thermal vacuum cycle shall include a cold and hot temperature soak. Test durations for thermal vacuum cycling at the required temperature levels (after appropriate target/goal temperatures are reached within tolerances specified in the thermal vacuum test plan) shall be sufficient for all performance tests to be completed. At a minimum, test temperature soak durations at the specified temperatures at the subsystem/component level shall be four (4) hours and at the observatory level shall be twelve (12) hours. A CPT shall be performed at each soak to verify that instrument and spacecraft bus performance specifications are satisfied. During temperature transitions, abbreviated performance tests shall be performed to verify observatory functional performance.

# 6.0 PARTS, MATERIALS, LUBRICATION, AND PROCESSES PROGRAM

In addition to the requirements listed in the GLAST Spacecraft SOW and the Rapid II Contract, the GLAST Spacecraft Parts, Materials, Lubrication, and Processes Program shall adhere to the requirements delineated in this section.

## 6.1 OVERVIEW OF PARTS, MATERIALS, LUBRICATION, AND PROCESSES PROGRAM

The following deliverables are associated with the GLAST Spacecraft Parts, Materials, Lubrication, and Processes Program:

| DID LTR. | DESCRIPTION | Due Date, Maturity | A/I |
|---|---|---|---|
| L | Parts, Materials, Lubrication, and Processes Control Plan (PMLPCP) | 60 Days After Contract Award, Final<br>As Generated, Updates | A |
| M | As-Designed/As-Built Parts, Materials, Lubrication, and Processes Lists | Lists - 30 Days Prior to MPDR, Initial<br>Lists - 30 Days Prior to MCDR, Update<br>Lists - As Generated, Updates<br>Lists - 60 Days Prior to Hardware Shipment, Final (As Built List)<br>Manufacturing/Fabrication Procedures/Information – Upon Request, Current | I |
| N | Alert/Advisory Disposition and Preparation | Responses - 25 Calendar Days After Receipt of Alert/Advisory from GSFC, Final | I |
| O | Printed Wiring Board (PWB) Coupons or Reports | As Received From Contractor or Evaluation Laboratory By Contractor, Final | A |

TABLE 6-1: PARTS, MATERIALS, LUBRICATION, AND PROCESSES DELIVERABLES

## 6.2 PARTS, MATERIALS, LUBRICATION, AND PROCESSES CONTROL PLAN (PMLPCP)

The contractor shall prepare and implement a Parts, Materials, Lubrication, and Processes (PMLP) Control Plan (PMLPCP), including a Parts, Materials, Lubrication, and Processes Control Board (PMLPCB) or equivalent activity to ensure that all parts, materials, lubricants, and processes selected for use in flight hardware meet mission objectives for quality and reliability. The contractor shall prepare a PMLPCP, for GSFC approval, describing the approach and methodology for implementing a PMLPCP in accordance with **DID L**. The PMLPCP shall fully describe a parts program consistent with the requirements of GSFC 311-INST-001, Level 2, including requirements for utilizing lot destructive physical analyses (DPA's) to qualify microcircuits and semiconductors.

Existing contractor in-house documentation equivalent to **DID L** may be used and referenced in the plan as applicable to address how these requirements are to be met. Referenced documentation shall be submitted to GSFC for approval. All appropriate subcontractors shall

also participate in the PMLP control program to the extent required by the prime contractor and GSFC to meet these requirements. The plan shall address how the contractor will ensure the flow down of the applicable PMLP control program requirements to subcontractors.

## 6.3 PARTS, MATERIALS, LUBRICATION, AND PROCESSES LISTS

The As-Designed Parts, Materials, Lubrication, and Processes Lists shall include the planned configuration of delivered articles. The As-Built Parts, Materials, Lubrication, and Processes Lists shall detail the actual configuration of the delivered articles. Inspection, qualification, screening, testing, evaluation, and/or failure analysis documentation shall be made available to the Government upon request. Additionally, upon request, manufacturing and/or fabrication process information/ procedures shall be made available for the Government's information. These lists and the related documentation shall be prepared and delivered to, or made available to, the Government in accordance with **DID M**.

## 6.4 GIDEP RESPONSES

The contractor shall be responsible for the review and disposition of Government Industry Data Exchange Program (GIDEP) Alerts and Advisories for their applicability to all parts proposed for use on the program. In addition, any NASA Alerts and Advisories provided to the contractor by GSFC shall be reviewed and dispositioned. Alert applicability, impact, and proposed corrective actions shall be documented and provided to the Government in accordance with **DID N**.

## 6.5 PRINTED WIRING BOARD (PWB) COUPONS

GLAST spacecraft PWB's shall be manufactured in accordance with the Class 3 requirements in the IPC PWB manufacturing standards referenced in GSFC S-312-P-003, "Process Specification for Rigid Printed Wiring Boards for Space Applications and Other High Reliability Uses." Contractor and/or supplier "equivalent" PWB manufacturing standards/ processes may be used with Government approval prior to their first use on the GLAST Program. If an equivalent contractor or supplier standard/process is approved for use, any and all subsequent revisions shall also be approved by the Government prior to their use on the GLAST Program.

As a precondition to PWB population, the contractor shall provide a test coupon for each PWB or multilayer PWB panel used in flight hardware to GSFC or a GSFC-approved laboratory for test, analysis, and review. The contractor shall provide test reports for coupons not analyzed by GSFC to the GLAST SAM. Coupons and/or test reports shall be provided to the Government in accordance with **DID O**.

## 6.6 FASTENERS

The contractor shall comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in GSFC 541-PG-8072.1.2, "Goddard Space Flight Center Fastener Integrity Requirements." The contractor and/or suppliers may use "equivalent" fastener procurement documentation and test requirements with Government approval prior to their first use on the GLAST Program. If an equivalent contractor or supplier procedure/process is approved for use, any and all subsequent revisions to the

procedure/process shall also be approved by the Government prior to their use on the GLAST Program.

To best document this process, GSFC recommends that the contractor prepare a Fastener Control Plan for submission to GSFC. Additionally, it is recommended that material test reports for fastener lots be submitted to GSFC for information. Due to safety implications, GSFC retains the right to review all contractor and supplier fastener information/data/documentation.

Fasteners made of plain carbon or low alloy steel shall be protected from corrosion. When plating is specified, it shall be compatible with the space environment. Plating shall be applied by a process that is not embrittling to steels harder than RC 33.

## 6.7 SOLAR ARRAY

The solar array shall only use parts, materials, and processes that have been qualified by test or flight to thermal cycling temperature extremes equal to or in excess of those predicted for the GLAST solar array. These parts, materials, and processes shall have been qualified in the same test or flight. If other than such proven parts, materials, and processes are used; the contractor shall fabricate and test a qualification panel to temperature extremes in excess of the predicted temperature extremes for the GLAST array over a five year life. This test shall include a minimum of eight thermal vacuum cycles and 27,500 thermal cycles. The contractor shall obtain I-V curves from the test article measured at the highest predicted flight temperature.

# 7.0 CONTAMINATION CONTROL PROGRAM

In addition to the requirements listed in the GLAST Spacecraft SOW and the Rapid II Contract, the Spacecraft Contamination Control Program shall adhere to the requirements delineated in this section.

## 7.1 OVERVIEW OF CONTAMINATION CONTROL PROGRAM

The contractor shall ensure appropriate contamination control is maintained throughout all phases of integration and test by utilizing a contamination control program consistent with the requirements of the GLAST Spacecraft SOW and the GLAST Program Contamination Control Plan. The contamination control program shall ensure that the requirements of the instruments and specific observatory elements are fulfilled. This program shall govern activities starting with the final cleaning and protection of the spacecraft bus hardware elements and continue during the assembly of the spacecraft bus; the receipt and storage of the instruments; and the integration, test, and ground operations of the GLAST Observatory. The following deliverable is associated with the GLAST Spacecraft Contamination Control Program:

| DID LTR. | DESCRIPTION | Due Date, Maturity | A/I |
|---|---|---|---|
| P | Observatory Contamination Control Plan (CCP) | 30 Days Prior to MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates | A |

TABLE 7-1: CONTAMINATION CONTROL DELIVERABLES

## 7.2 CONTAMINATION CONTROL PLAN (CCP)

The contractor shall prepare and implement an Observatory CCP to govern the comprehensive cleanliness and contamination control effort. Copies of all referenced analyses, procedures, standards, and specifications shall be made available to the Government for information upon request. The CCP shall be submitted to the Government in accordance with **DID P**.

# 8.0 RELIABILITY AND RISK MANAGEMENT PROGRAM

In addition to the requirements listed in the GLAST Spacecraft SOW and the Rapid II Contract, the Spacecraft Reliability and Risk Management Program shall adhere to the requirements delineated in this section.

## 8.1 OVERVIEW OF RELIABILITY AND RISK MANAGEMENT PROGRAM

The contractor shall plan and implement a Reliability and Risk Management Program that interacts effectively with other project disciplines including systems engineering, hardware design, safety, and the other mission assurance disciplines. The following deliverables are associated with the GLAST Spacecraft Reliability and Risk Management Program:

| DID LTR. | DESCRIPTION | Due Date, Maturity | A/I |
|---|---|---|---|
| Q | Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL) | 30 Days Prior to MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates | I |
| R | Probabilistic Risk Assessment (PRA) | PRA Plan: 30 Days Prior to MPDR, Final<br>PRA: 30 Days Prior to MCDR, Initial<br>PRA: 30 Days Prior to MOR, Final<br>PRA Plan and PRA: As Generated, Updates | I |
| S | Reliability Assessment and Prediction | 30 Days Prior to MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates | I |
| T | Fault Tree Analysis (FTA) | 30 Days Prior to MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates | I |

TABLE 8-1: RELIABILITY AND RISK MANAGEMENT DELIVERABLES

## 8.2 RELIABILITY ANALYSES

Reliability analyses shall be performed concurrently with the spacecraft/observatory design to identify problem areas so they may be addressed and correction action taken, if required, in a timely manner.

### *8.2.1 Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)*

A FMEA shall be performed early in the design phase to identify system design problems. As additional design information becomes available, the FMEA shall be updated/refined.

Failure modes shall be assessed at the component interface level for their effect at that level of analysis, the next higher level, and upward. The failure mode shall be assigned a severity category, determined in accordance with Table 8-2, based on the most severe effect caused by a failure. Mission phases (e.g., launch, deployment, on-orbit operation, and retrieval) shall be addressed in the analysis.

FMEA analysis procedures and documentation shall be performed in accordance with documented contractor procedures. Failure modes resulting in Severity Categories 1, 1R, 1S or 2 shall be analyzed at a greater depth, to the single parts if necessary, to identify failure cause.

All failure modes that are assigned to Severity Categories 1, 1R, 1S, and 2, shall be itemized on a CIL and maintained with the FMEA report. Rationale for retaining these items in the GLAST design will be included on the CIL.

The FMEA shall analyze redundancies to ensure that redundant paths are isolated or protected such that any single 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. The contractor shall use the results of the FMEA to evaluate the design relative to requirements (e.g., no single failure will prevent removal of power from the instrument). Contractor management and design groups shall evaluate all identified discrepancies and corrective action shall be implemented as required.

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

TABLE 8-2: FAILURE MODE SEVERITY CATEGORIES

The FMEA and CIL shall be prepared and submitted to the Government in accordance with **DID Q**. With the Government's prior concurrence, the contractor may submit a previously developed FMEA that utilizes a different format, including different severity codes, provided that it fully meets the intentions of the MAR. (For example, the FMEA shall distinguish between safety critical and mission critical failures and it shall identify single point failures that may result in the loss of one or more mission objectives.) Additionally, the contractor shall update the FMEA to reflect GLAST specific items that were added/modified after the original/baseline FMEA was prepared.

### *8.2.2 Probabilistic Risk Assessment (PRA)*

The contractor shall prepare a PRA plan and perform a PRA as part of the reliability and risk management program. The PRA shall provide a comprehensive, systematic, and integrated approach of identifying and categorizing the risks associated with undesirable events and developing corresponding mitigation plans. The PRA shall use results from the FMEA, FTA (Refer to Section 8.2.4.), and Reliability Assessment and Prediction Analyses (Refer to Section 8.2.3.). The assessment shall also consider all relevant critical factors including:

a. Mission success criteria
b. All phases of the mission life profile including the mission operations sequence
c. Post mission de-orbit success criteria
d. Alternative design concepts, redundancy and cross-strapping approaches, and part substitutions
e. System and personnel safety considerations
f. Design elements that are the greatest detractors of system reliability
g. All hardware, software, and ground system elements that are needed during any part of the mission operations sequence
h. Identification of software critical safety models
i. Relevant trend analysis (Refer to Section 8.2.5.)
j. Potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations

The PRA Plan and the PRA shall be performed and delivered to the Government in accordance with **DID R**.

### *8.2.3 Reliability Assessments and Predictions*

The contractor shall perform comparative numerical reliability assessments and reliability predictions in accordance with **DID S** to:

a. Evaluate alternative design concepts, redundancy and cross-strapping approaches, and part substitutions
b. Identify the elements of the design which are the greatest detractors of system reliability
c. Identify potential mission limiting elements and components that will require special attention in selection, testing, environmental isolation, and/or special operations
d. Assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable
e. Evaluate the impact of proposed engineering change and waiver requests on reliability

The contractor shall describe the level of detail of a model suitable for performing the intended functions enumerated above. The assessments and updates shall be submitted to GSFC for information in accordance with the SOW. The results of any reliability assessment shall be reported at MPDR and MCDR. Presentations shall include comments on how the analysis was used to perform design trade-offs and how the results were taken in consideration when making design or risk management decisions.

### *8.2.4 Fault Tree Analysis (FTA)*

A FTA that addresses both spacecraft/observatory mission failures and degraded modes of operation shall be performed and delivered in accordance with **DID T**. Beginning with each undesired state (spacecraft/observatory failure or degraded spacecraft/observatory mission), the fault tree shall be expanded to include all credible combinations of events/faults and environments that could lead to the undesired state. Component hardware/software failures, external hardware/ software failures, and human factors shall be considered in the analysis.

### *8.2.5 Trend Analyses*

As part of the routine system assessment, the contractor shall assess all subsystems and components to determine measurable parameters that relate to performance stability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring shall be accomplished within the normal test framework; i.e., during functional tests, environmental tests, etc. The contractor shall establish a system for recording and analyzing the parameters as well as any changes from the nominal even if the levels are within specified limits. Trend analysis data shall be collected throughout development. A list of subsystem and components to be assessed and the parameters to be monitored and the trend analysis reports shall be maintained.

The contractor shall analyze test information, trend data, and failure investigations to evaluate reliability implications. Identified problem areas shall be documented and directed to the attention of contractor management for action.

## 9.0 APPLICABLE DOCUMENTS

| | |
|---|---|
| ANSI/ISO/ASQ Q9001: 2000 | American National Standard Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation and Servicing |
| ANSI/ESD S20.20-1999 | Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) |
| EWR 127-1 | Eastern and Western Range Safety Requirements |
| GSFC 311-INST-001 | Instructions for EEE Parts Selection, Screening, and Qualification |
| GSFC 433-RQMT-00005 | GLAST Observatory Electromagnetic Interference (EMI) Requirements Document |
| GSFC Supplement S-312-P003 | Process Specification for Rigid Printed Wiring Boards for Space Applications and Other High Reliability Uses |
| GSFC GEVS-SE | General Environmental Verification Specification for Space Transportation System (STS) and ELV Payloads, Subsystems and Components |
| IPC/EIA J-STD-001C | Requirements for Soldered Electrical and Electronic Assemblies |
| IPC-2221 | Generic Standard on Printed Board Design |
| IPC-2222 | Sectional Design Standard for Rigid Organic Printed Boards |
| IPC-6011 | Generic Performance Specifications for Rigid Printed Wiring Boards |
| IPC-6012 | Qualification and Performance Specification for Rigid Printed Wiring Boards |
| MIL-STD-461 | Electromagnetic Interference Characteristics Requirements for Equipment |
| NASA-STD-8739.1 | Requirements for Conformal Coating and Staking of Printed Wiring Boards |
| NASA-STD-8739.2 | Requirements for Surface Mount |
| NASA-STD-8739.3 | Requirements for Soldered Electrical Connections |
| NASA-STD-8739.4 | Requirements for Cabling and Crimping |

## 10.0 ACRONYMS

| | |
|---|---|
| A | For Approval |
| A/I | For Approval/For Information |
| ANSI | American National Standards Institute |
| ARB | Anomaly Review Board |
| ASQ | American Society for Quality |
| CCP | Contamination Control Plan |
| CDRL | Contract Delivery Requirement List |
| CIL | Critical Items List |
| COTR | (GSFC GLAST) Contracting Officer's Technical Representative |
| CPT | Comprehensive Performance Tests |
| DID | Data Item Description |
| DPA | Destructive Physical Analysis |
| DR | Discrepancy Report |
| EEE | Electrical, Electronic, and Electromechanical |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| EMICP | Electromagnetic Interference Control Plan |
| EMISM | Electromagnetic Interface Safety Margins |
| EMICTP | Electromagnetic Interference/Compatibility Test Plan |
| ESD | Electrostatic Discharge |
| EV | Expendable Vehicle |
| EWR | Eastern and Western Range |
| FMEA | Failure Modes and Effects Analysis |
| FTA | Fault Tree Analysis |
| GBM | GLAST Burst Monitor |
| GFE | Government Furnished Equipment |
| GIA | Government Inspection Agency |
| GIDEP | Government/Industry Data Exchange Program |
| GLAST | Gamma-ray Large Area Space Telescope |
| GOP | Ground Operations Plan |
| GSFC | Goddard Space Flight Center |
| I | For Information |
| IAC | Independent Assurance Contractor |
| I&T | Integration and Test |
| I-V | Current versus Voltage |
| LPT | Limited Performance Test |
| MAR | Mission Assurance Requirements (Document) |
| MCM | Multi-Chip Modules |
| MCDR | Mission Critical Design Review |

| | |
|---|---|
| MLI | Multi-layer Insulation |
| MOR | Mission Operations Review |
| MPDR | Mission Preliminary Design Review |
| MSPSP | Missile System Prelaunch Safety Package |
| MRB | Material Review Board |
| NCR | Non-conformance Report |
| PHA | Preliminary Hazard Analysis |
| PMLP | Parts, Materials, Lubrication, and Processes |
| PMLPCB | Parts, Materials, Lubrication, And Processes Control Board |
| PMLPCP | Parts, Materials, Lubrication, and Processes Control Plan |
| PRA | Probabilistic Risk Assessment |
| PWB | Printed Wiring Board |
| QMS | Quality Management System |
| RSDO | (GSFC) Rapid Spacecraft Delivery Office |
| SAM | (GSFC GLAST) Systems Assurance Manager |
| S&MA | System Safety and Mission Assurance |
| SOW | Statement of Work |
| STS | Space Transportation System |
| TMM | Thermal Mass Model |

CH-04

# APPENDIX A

# SAFETY AND MISSION ASSURANCE RELATED SPACECRAFT AND OBSERVATORY DELIVERABLES

CHECK THE GLAST PROJECT WEBSITE AT
http://glast.gsfc.nasa.gov/project/cm/mcdl TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

TABLE A-1: SUMMARY OF SAFETY AND MISSION ASSURANCE RELATED DELIVERABLES

| DID Ltr. | Description | Due Date, Maturity | A/I |
|---|---|---|---|
| A | Discrepancy Reports (DR's) and Material Review Board (MRB) Reports | DR - Within 16 Work Hours of Preparation, Preliminary<br>DR - At Completion of Analysis & Assignment of Corrective Action, Current<br>Class 2 DR – After MRB Closure, Final<br>Class 1 DR - After MRB Closure, Final<br>Notice Within 5 Work Days of DR On Similar Hardware, Current<br>MRB Report - 5 Work Days After Each MRB Meeting, Final | I<br>I<br>I<br>A<br>I<br>I |
| B | Non-Conformance Reports (NCR's) and Anomaly Review Board (ARB) Reports | NCR - Within 16 Work Hours of Occurrence, Preliminary<br>NCR - At Completion of Analysis & Assignment of Corrective Action, Current<br>"Non-Significant" NCR – After ARB Closure, Final<br>"Significant" NCR - After ARB Closure, Final<br>Notice Within 5 Work Days of NCR on Similar Hardware, Current<br>ARB Report - 5 Work Days After Each ARB Meeting, Final | I<br>I<br>I<br>A<br>I<br>I |
| C | As-Built Hardware and Software Configured Items Lists | 60 Days Prior to Hardware Shipment, Final<br>As Generated, Updates | I |
| D | System Safety Program Plan | 45 Days After Contract Award, Initial<br>45 Days Prior to MCDR, Final | A |
| | Preliminary Hazard Analysis (PHA) | 30 Days Prior to MPDR, Preliminary<br>30 Days Prior to MCDR, Final | A |
| | Safety Noncompliance Reports | As Generated, Final | A |
| | Hazards Control Verification Log | When Requested, Current | I |
| | Ground Operations Plan (GOP) including Hazardous and Safety Critical Procedures | GOP -45 Days Prior to MCDR, Initial<br>GOP - 45 Days Prior to the Observatory's Delivery to Range, Final<br>Procedures - 15 Days Prior to First Run of Procedure, Final | A |
| E | Missile System Prelaunch Safety Package (MSPSP) | 13.5 Months Prior to Observatory Shipment to Range, Initial<br>75 Days Prior to Observatory Shipment to Range, Final | A |
| F | Debris Generation Analysis Report | 30 Days Prior to MPDR, Initial<br>65 Days Prior to MCDR, Final<br>As Generated, Updates | I |

CH-03

| DID Ltr. | Description | Due Date, Maturity | A/I |
|---|---|---|---|
| G | Technical Reviews | GSFC Chaired/Co-Chaired Review Technical Material -<br>7 Work Days Prior to Review, Final<br>Minutes and Action Items for Peer Reviews – 10 Work Days After Review, Final<br>Responses to Government Requests for Action - Per Schedule Established at/for Review, Final<br>Responses to Peer Review Action Items– After Closure, Final | I<br>I<br>A<br>I |
| H | Spacecraft and Observatory Integration and Test (I&T) Plan | 60 Days Prior to the MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates<br>Verification Procedures, Test Results, and Test Reports – Upon Request | A<br>A<br>A<br>I |
| | Observatory Level Thermal Vacuum Test Plan | 90 Days Prior to the Commencement of Observatory Level Thermal Vacuum Testing, Current<br>As Generated, Updates | A |
| | Observatory Level Thermal Vacuum Test Correlation Report | 21 Days After the Completion of Observatory Level Thermal Balance Vacuum Testing, Current<br>As Generated, Updates | I |
| I | Observatory Performance Verification Plan | Plan - 60 Days Prior to the MPDR, Initial<br>Plan - 30 Days Prior to MCDR, Final<br>Plan - As Generated, Updates<br>Test Results/Reports - Within 60 days of Test Completion, Current | A<br>A<br>A<br>I |
| J | Electromagnetic Interference Control Plan (EMICP) | 30 Prior to the MPDR, Preliminary<br>90 Days After MPDR, Final<br>As Generated, Updates | I<br>A<br>A |
| K | Electromagnetic Interference/ Compatibility Test Plan (EMICTP) | 90 Days After MPDR, Preliminary<br>90 Days Prior to the MCDR, Final<br>As Generated, Updates | I<br>A<br>A |
| L | Parts, Materials, Lubrication, and Processes Control Plan (PMLPCP) | 60 Days After Contract Award, Final<br>As Generated, Updates | A |

| DID Ltr. | Description | Due Date, Maturity | A/I |
|---|---|---|---|
| M | As-Designed/As-Built Parts, Materials, Lubrication, and Processes Lists | Lists - 30 Days Prior to MPDR, Initial<br>Lists - 30 Days Prior to MCDR, Update<br>Lists - As Generated, Updates<br>Lists - 60 Days Prior to Hardware Shipment, Final (As Built List)<br>Manufacturing/Fabrication Procedures/Information – Upon Request, Current | I |
| N | Alert/Advisory Disposition and Preparation | Responses - 25 Calendar Days After Receipt of Alert/Advisory from GSFC, Final | I |
| O | Printed Wiring Board (PWB) Coupons or Reports | As Received From Manufacturer/Evaluation Laboratory By Contractor, Final | A |
| P | Observatory Contamination Control Plan (CCP) | 30 Days Prior to MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates | A |
| Q | Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL) | 30 Days Prior to MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates | I |
| R | Probabilistic Risk Assessment (PRA) | PRA Plan: 30 Days Prior to MPDR, Final<br>PRA: 30 Days Prior to MCDR, Initial<br>PRA: 30 Days Prior to MOR, Final<br>PRA Plan and PRA: As Generated, Updates | I |
| S | Reliability Assessment and Prediction | 30 Days Prior to MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates | I |
| T | Fault Tree Analysis (FTA) | 30 Days Prior to MPDR, Initial<br>30 Days Prior to MCDR, Final<br>As Generated, Updates | I |

| **Title:** Discrepancy Reports (DR's) and Material Review Board (MRB) Reports | **DID Letter:** A |
|---|---|
| **Reference:** Spacecraft MAR, Sections 2.1 and 2.2 | |
| **Purpose:** To provide reporting, monitoring, and closure of all non-conformances and material discrepancies and their corrective actions | |
| **Related Documents:** | |

**Preparation Information**

The GLAST SAM and/or their representative (designated as the GSFC Quality member of the Materials Review Board [MRB]) shall receive 8 work hours notice prior to a MRB meeting. Within 16 work hours of the initial opening of a DR, a draft shall be delivered to the SAM or their designated representative for information. A follow-up informational copy shall be delivered to the SAM or their representative when the analysis and assignment of correction actions have been completed. As a non-voting member of the MRB, the SAM or their representative shall approve all Class 1 DR's after their closure by the MRB. All DR and MRB reports shall be provided to the SAM or their representative within 5 workdays after each MRB meeting. Closed Class 2 DR's shall be delivered for information only. Additionally, if a discrepancy is found on another contractor program that could affect GLAST hardware, the SAM or their designated representative shall be notified within 5 workdays.

Prepare discrepancy reports and MRB reports in the contractor's format in accordance with contractor guidelines. Provide sufficient detail and supporting material to back-up the MRB decisions.

Decisions resulting in recommendations for "repair" or "use as-is" shall require additional documentation to enable GSFC reviewers to understand the rationale for these decisions.

Note: If a GLAST Government Assurance Representative is located in the contractor's facility, he/she shall be placed on the distribution list (hard copy, website, or electronic) of all DR's and their updated/amended versions.

| **Title:** Non-Conformance Reports (NCR's) and Anomaly Review Board (ARB) Reports | **DID Letter:** B |
|---|---|

**Reference:**
Spacecraft MAR, Sections 2.1 and 2.3

**Purpose:**
To provide reporting, monitoring, and closure of all non-conformances and failures and their corrective actions

**Related Documents:**

**Preparation Information**

The GLAST SAM and/or their representative (designated as the GSFC Quality member of the Anomaly Review Board [ARB]) as well as the Observatory COTR shall be notified within 16 work hours of an anomaly/failure/malfunction occurrence. At the completion of the analysis and the assignment of correction actions, an updated report shall be delivered to the SAM and/or their representative as generated. As a non-voting member of the ARB, the SAM or their representative shall approve all "significant" NCR's after their closure by the ARB. Reports may be provided electronically or via a website or fax. All NCR and ABR reports shall be delivered to the SAM or their representative within 5 days after each ARB meeting. Closed "non-significant" NCR's shall be delivered for information only. Additionally, the SAM and/or their representative shall be notified within 5 workdays of nonconformances affecting similar busses.

The GSFC Quality member of the ARB (i.e., the SAM or their representative) shall receive 8 work hours notice prior to an ARB meeting. Additionally, they shall receive updated NRC information prior to each ARB meeting and an ARB report within 5 workdays after each ARB meeting.

The spacecraft bus contractor shall report non-conformances relative to the spacecraft bus to the Government beginning with the first power application at the start of end item acceptance testing of a major spacecraft bus component or subsystem. For mechanical items, non-conformance reporting shall commence with the first operation of a mechanical item (as applicable to the hardware level for which the GLAST spacecraft bus contractor is responsible). Nonconformance reporting shall continue through formal acceptance by the GLAST Project, including post-launch operations, commensurate with the GLAST spacecraft bus delivery order. Additionally, the spacecraft contractor shall document all anomalies occurring at the observatory level including anomalies relating to Government Furnished Equipment (GFE). The spacecraft contractor shall conduct failure investigations for anomalies relative to the spacecraft bus and interface and shall support the investigation of anomalies relative to GFE.

DID C - AS-BUILT HARDWARE AND SOFTWARE CONFIGURED ITEMS LISTS

| **Title:** As-Built Hardware and Software Configured Items Lists | **DID Letter:** C |
|---|---|
| **Reference:** Spacecraft MAR, Sections 2.1 and 2.5 | |
| **Purpose:** To list/document the "box level" component items that make up the delivered spacecraft bus and the modules which comprise the spacecraft bus software | |
| **Related Documents:** | |

**Preparation Information**

The as-built lists shall be delivered electronically (in a format mutually acceptable to the Government and the contractor) to GSFC for information 60 days prior to hardware/software shipment. Any updated lists shall be delivered to GSFC as generated for information.

As a minimum, the configuration lists (not to be confused with the as-built parts, materials, lubrication, and processes lists) for delivered items shall include the following information:

a. For each major hardware subassembly:

- Name/nomenclature
- Item number
- Serial number
- As built drawing number including latest revision letter and chance notice
- Location on the bus
- Any approved deviations or waivers affecting the installed configuration item
- Applicable supporting remarks

b. For each software module:

- Software module title
- Code identification or serial number
- Software inventory numbering system
- Module revision number

DID D - SYSTEM SAFETY DOCUMENTATION

| **Title:** System Safety Documentation | **DID Letter:** D |
|---|---|

**Reference:**
Spacecraft MAR, Sections 3.1 and 3.2

**Purpose:**
To provide information to verify that the GLAST spacecraft bus and associate flight and ground hardware, software, and procedures are safe

**Related Documents:**
EWR 127-1 and KHB 1710.2D
NASA GB 1740.13.96, "NASA Guidebook for Safety Critical Software"
Observatory Launch Site Operations and Test Plan
29CFR 1910, "Delta II Payload Planner's Guide"

**Preparation Information**

As part of the GLAST Safety Program, related safety documentation shall be provided in accordance with EWR 127-1 per the delivery schedule noted below. GSFC and Launch Range approval of all safety-related documentation is required prior to launch. All documentation shall meet the requirements of EWR-127-1 and other pertinent NASA/KSC/GSFC safety specifications/standards.

- System Safety Program Plan (EWR 127-1, Appendix 1B)
  - Due to GSFC for approval 45 days after contract award (Initial) and 45 days prior to MCDR (Final).
- Preliminary Hazard Analysis (PHA) (EWR 127-1, Appendix 1B)
  - Due to GSFC for approval 30 days prior to MPDR (Preliminary) and 30 days prior to MCDR (Final).
- Safety Non-Compliance Reports (EWR 127-1, Appendix 1C)
  - Due to GSFC for approval as generated (Final).
- Hazards Control Verification Log (EWR 127-1, Appendix 1B.1)
  - To be maintained and made available to GSFC upon request.
- Ground Operations Plan (GOP) including Hazardous and Safety Critical Procedures (EWR 127-1, Appendix 6A and 6B)
  - The GOP is due to GSFC for approval 45 days prior to MCDR (Initial) and 45 days prior to observatory's delivery to the Range (Final).
  - Hazardous and Safety Critical Procedures are due to GSFC for approval 15 days prior to the first run of each procedure.

A single closed-loop tracking system shall be implemented to track hazards and their controls, providing an audit trail of hazard resolution. The close-out of each hazard control shall be ensured/verified prior to launch.

DID E - MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE (MSPSP)

| **Title:** Missile System Prelaunch Safety Package (MSPSP) | **DID Letter:** E |
|---|---|

**Reference:**
Spacecraft MAR, Sections 3.1 and 3.2

**Purpose:**
To document observatory and GSE design and test information in order to evaluate the safety measures that will be employed during observatory operations at the launch complex and to obtain approval to use the launch site facilities and resources when coupled with the launch site operations and test plan. Sections of this document will provide the information that is necessary to obtain approval for each safety issue identified in the launch site process.

**Related Documents:**
EWR 127-1, Appendix 3A
Observatory Launch Site Operations and Test Plan
29CFR 1910, "Delta II Payload Planner's Guide"

**Preparation Information**

The preliminary plan is due to GSFC 13.5 months prior to the observatory's shipment to the Range. The final plan is due 75 days prior to shipment to the Range. Both versions are for GSFC's approval.

The MSPSP shall describe all observatory systems, support hardware, and operations beginning with the arrival of the observatory and GSE at the Range through lift-off. A flow plan and a time line shall be provided. The package shall identify all hazards associated with the process at the launch site and show operations that require coordination either with the launch vehicle operations or other range activities. The closure of each hazard shall be ensured/documented.

a. Observatory test and build-up facility requirements, including floor space, electrical power, and cleanliness
b. Use of large scale GSE; e.g., test consoles and handling fixtures at each facility that is planned for use
c. Large Area Telescope or spacecraft bus unique testing of high power RF lasers
d. Integrated vehicle or range activities for coordination and reviews
e. Personnel facilities
f. Staffing and training plans
g. Observatory transportation and servicing
h. Fueling process, location, safeguards, GSE, tankage, and storage

For each safety issue identified by the MSPSP, a payload hazard report (or equivalent) shall be generated. Each payload hazard report shall document the causes, controls, and precaution verification methods for each hazard.

Payload hazard reports and the MSPSP shall be updated (as the hardware progresses through the stages of design, fabrication, test, and flight readiness) to support each safety milestone review for inclusion in the current SAR. The updates shall reflect the current status of measures to eliminate or to minimize the effects of each hazard identified. Every SAR iteration shall be accompanied by copies of all deviation/waiver requests against safety requirements that cannot be met. The close-out of each hazard control shall be ensured/verified prior to launch.

DID F - DEBRIS GENERATION ANALYSIS REPORT

| **Title:** Debris Generation Analysis Report | **DID Letter:** F |
|---|---|

**Reference:**
Spacecraft MAR, Sections 3.1 and 3.3

**Purpose:**
To limit the generation of orbital debris. This analysis is required to demonstrate compliance with the requirements of NPD 8710.3 and NSS 1740.14

**Related Documents:**
NASA Directive NP, "NASA Policy for Limiting Orbital Debris Generation" (http://nodis.hq.nasa.gov/Library/Directives/NASA-WIDE/Policies/Program_Management/N_PD_8710_3.html)
NSS 1740.14, "Guidelines and Assessment Procedures for Limiting Orbital Debris"

**Preparation Information**

A preliminary analysis shall be due 30 days prior to the MPDR with the final analysis due 65 days prior to the MCDR. Updates shall be submitted to GSFC as generated. All analyses shall be submitted to GSFC for information.

An analysis shall be conducted and documented to assess orbital debris generation potential and debris mitigation options. The analysis shall include:

a. The potential for orbital debris generation in both nominal operation and malfunction conditions including malfunctions during launch
b. The potential for orbital debris generation due to on-orbit impact with existing space debris (natural or human generated) or other orbiting space systems
c. The debris casualty area generated by the observatory, without a propulsion system, during an uncontrolled re-entry*
d. The debris field generated by the observatory, with a propulsion system, during a controlled re-entry
e. Survival of re-entering space system components after post-mission disposal

Orbital Debris Assessment Services shall be available from Johnson Space Center using ORSAT.

* If the observatory debris casualty area exceeds 6.8 meters squared, include recommendations for alternative materials and design that may reduce the debris casualty area.

DID G - TECHNICAL REVIEWS

| **Title:** Technical Reviews | **DID Letter:** G |
|---|---|
| **Reference:** Spacecraft MAR, Section 4.1 | |
| **Purpose:** To provide technical review material and handouts that review team members will need to read prior to the review. Provide review minutes and action items after technical reviews. | |
| **Related Documents:** None | |

**Preparation Information**

Provide review materials/hand-outs 7 workdays prior to each GSFC-chaired/co-chaired technical review for information. This shall include the reviews listed in Spacecraft SOW. Provide an electronic or hard copy of technical review material including vu-graphs. Documentation may be made available via a website. Material shall include risk and safety status as of the date of the particular technical review.

For each GSFC-chaired/co-chaired technical review, provide responses to Government requests for action (per the schedule established at/for the review) for GSFC approval. Responses may be electronic, hard copy, or web-based as agreed upon at each review.

Provide minutes and action items from each technical review peer within 10 workdays following each review for GSFC information. Provide copies of the responses to peer review action items to GSFC for information after the actions/requests are closed.

| **Title:** Spacecraft and Observatory Integration and Test (I&T) Plan | **DID Letter:** H |
|---|---|
| **Reference:** Spacecraft MAR, Sections 5.1, 5.2, 5.4.4, and 5.4.4.1 | |
| **Purpose:** To demonstrate the contractor's plans and approach to I&T for the observatory (i.e., integrated spacecraft bus and instruments). It shall include final bus comprehensive performance testing. | |
| **Related Documents:** | |

Preparation Information

A preliminary plan is due 60 days prior to the MPDR. The final draft is due to GSFC 30 days before the MCDR with all subsequent changes due as generated. All versions are for approval. Verification Procedures, test results, and test reports shall be made available for the Government's information upon request. In association with this plan, the contractor shall provide to the Government the observatory level thermal vacuum test plan for approval 90 days prior to the commencement of the covered testing. Within 21 days of the completion of the observatory level thermal balance vacuum test, an observatory level thermal vacuum test correlation report shall be delivered to the Government for information. If this plan or report is revised, the revisions shall also be submitted to Government for the same level of approval/review.

The contractor shall provide definitive test plans for the spacecraft bus and observatory I&T that identify the scope, purpose, sequence (test flow), and success criteria for the activities below. The contractor shall identify where in the test flow repeat activities occur to re-baseline system performance (e.g., observatory full functional test). The minimum I&T activities that the contractor shall address in the plan at the spacecraft bus and observatory levels are listed below. The contractor shall provide complete written justification for each analysis the contractor chooses to perform in lieu of test. The contractor shall provide complete written justification for each analysis that he proposes to perform in lieu of testing. Additionally, the contractor shall provide complete written justification for each environmental test that he proposes not to perform.

1. Spacecraft level

    a. Integration and Test
    b. Final spacecraft bus comprehensive performance tests

2. Observatory level (Refer to Spacecraft SOW, Section 4.3.4.2, "Observatory Integration and Test")

    a. Large Area Telescope (LAT) and GLAST Burst Monitor (GBM) integration*
        i. Mechanical integration
        ii. Electrical integration
        iii. Instrument calibration test
        iv. Instrument comprehensive performance test
    b. EMI/EMC/ESD test
    c. Optical and mechanical alignments

d. Magnetic survey
e. Attitude control subsystem phasing
f. Solar array integration (required only if integrated at the observatory level)
g. Flight payload attach fitting integration
h. Mass properties measurements
i. Vibration test including sine vibration
j. Acoustics test
k. Shock test
l. Solar array deployment
m. Thermal vacuum test
   - Instrumentation Plan (Refer to Spacecraft MAR, Section 5.4.4.)
n. Thermal balance test
o. RF compatibility test
p. Cleanliness, control, and monitoring
q. End-to-end functional test

* - Elements “i" through “iv” shall be included for each instrument. Additionally, the contractor shall coordinate plans and procedures for LAT and GBM integration with the Government.

DID I - OBSERVATORY PERFORMANCE VERIFICATION PLAN

| **Title:** Observatory Performance Verification Plan | **DID Letter:** I |
|---|---|

**Reference:**
Spacecraft MAR, Sections 5.1 and 5.3
DID H, "Observatory and Spacecraft I&T Plan"

**Purpose:**
To demonstrate the contractor's plans and approach for the performance verification of the observatory (i.e., the integrated spacecraft bus and instruments). It shall include final bus comprehensive performance testing.

**Related Documents:**

**Preparation Information**

A preliminary draft is due 60 days prior to the MPDR. The final draft is due to GSFC 30 days before the MCDR with all subsequent changes due as generated. All versions are for approval. Additionally, prior to the Government taking possession of the observatory, on-orbit test results and test reports shall be delivered to the Government within 60 days of test completion.

This plan shall clearly identify where, how, and when each observatory performance requirement is verified in the I&T program before launch and how these requirements will be verified again on-orbit. Additionally, this plan shall include end-to-end testing of the observatory with the appropriate ground system elements prior to launch. Each observatory performance requirement shall be verified either by analysis or by test before and after launch. In summary, this plan shall provide:

1. I&T: A matrix or outline narrative of where each performance requirement of the bus will be verified in the I&T flow. Identify the test procedure or analysis that will accomplish that item's requirement verification.

2. On-Orbit: A matrix or outline narrative of where/how each performance requirement of the observatory will be verified after launch. Identify the test procedure or analysis that will accomplish that item's requirement verification.

The contractor shall update the test matrix as the contractor/subcontractor tests are actually accomplished throughout the program and present it at pertinent GSFC reviews.

DID J - ELECTROMAGNETIC INTERFERENCE CONTROL PLAN (EMICP)

| **Title:** Electromagnetic Interference Control Plan (EMICP) | **DID Letter:** J |
|---|---|

**Reference:**
Spacecraft MAR, Sections 5.1 and 5.4.3.1

**Purpose:**
To establish methodologies for achieving electromagnetic compatibility and meeting the EMI requirements

**Related Documents:**
GSFC 433-RQMT-0005, "GLAST Observatory Electromagnetic Interference (EMI) Requirements Document"
MIL-STD-461E, "Electromagnetic Interference Characteristics Requirements for Equipment"

**Preparation Information**

A preliminary draft is due to GSFC 30 days prior to the MPDR for information. The final draft is due to GSFC 90 days after MPDR for approval. Additionally, updates shall be provided as generated for approval.

As a minimum, the EMI Control Plan (EMICP) shall contain:

1.0 Introduction
- Purpose
- Scope
- System description

2.0 EM Schedule and Milestones

3.0 Applicable Documents
- GEVS
- MIL standards
- MIL specifications

4.0 Prediction and Analysis
- Prediction and analysis techniques
- Identification of potential EMI problems
- Degradation criteria and safety margins
- Tailoring of applicable EMC/EMI documents
- System EM environment
- Determining anticipated EM environment during the project
- Procedure for resolving potential EMI problems

5.0 Specification Requirements
- Frequency management
- Applicability of EMC/EMI standards and specifications
- Bonding and grounding
- Installation criteria
- Government furnished material/equipment
- Safety
- Corrosion control

6.0 EMI Mechanical Design
- General
- Shielding
- Electrical harness conduit
- Corrosion control procedures

| | |
|---|---|
| | - Box closure; i.e., gaskets, interlocking flanges, etc. |
| | - Thermal blankets |
| 7.0 | Electrical/Electronic Wiring Design |
| | - General |
| | - Cable separation and routing |
| | - Grounding |
| | - Bonding |
| | - Connectors |
| | - Interconnecting cabling |
| 8.0 | Electrical/Electronic Circuit Design |
| | - General |
| | - Filter selection |
| | - Subsystem location and separation |
| | - Power considerations |
| | - Power switching |
| 9.0 | Documentation |
| | - EMC Program Plan |
| | - EMC Control Plan |
| | - EMC Test Plan |
| | - EMC Test Report |
| | - EMC Analysis Report |
| 10.0 | EMC Testing |
| 11.0 | EMC Control Plan Revisions |

| **Title:** Electromagnetic Interference/Compatibility Test Plan (EMICTP) | **DID Letter:** K |
|---|---|

**Reference:**
Spacecraft MAR, Sections 5.1 and 5.4.3.2

**Purpose:**
To establish test concepts and outline electromagnetic compatibility tests required for components, major assemblies, instruments, the spacecraft bus, and the observatory in accordance with GSFC 433-RQMT-0005

**Related Documents:**
GSFC 433-RQMT-0005, "GLAST Observatory Electromagnetic Interference (EMI) Requirements Document"
MIL-STD-461E, "Electromagnetic Interference Characteristics Requirements for Equipment"

**Preparation Information**

A preliminary draft is due to GSFC 90 days after the MPDR for information. The final draft is due 90 days prior to the MCDR for approval. Updates are required as generated for approval.

The EMI/EMC Test Plan (EMICTP) shall contain the following as a minimum:

1.0 Introduction
- Purpose
- Scope
- Objective

2.0 Applicable Documents
- EMI requirements document
- Reference documents
- GEVS
- Military standards and specifications

3.0 EMI Test Program
- Test application
  - Operating modes
  - Acceptance criteria
  - Quality assurance provisions
- Measurements
- Calibration
- EMISM
- Test discrepancies and failures
- Test documentation

4.0 Test Facility
- Description of shielded enclosure
- Ground plane
- Bonding and grounding
  - Ambient measurement
  - Radiated ambient
  - Conducted ambient
- Test conditions

5.0 Test Equipment
- EMC test equipment accuracy and calibration

- Test equipment list
- Current probe correction factors
- Antenna correction factors
- EMC test support equipment

6.0 EMI/EMC Test Methods

Component EMI/EMC Tests

- Conducted emissions
- Conducted susceptibility
- Radiated emissions
- Radiated susceptibility
- DC magnetic properties/susceptibility
- Major subassembly EMI/EMC tests
  - Instrument EMI/EMC tests
  - Spacecraft EMI/EMC tests
  - Grounding and bonding
- Observatory EMC verification
  - Grounding and bonding
  - Power self-compatibility tests
  - RF compatibility tests

7.0 Data Acquisition

- Data Sheets

DID L - PARTS, MATERIALS, LUBRICATION, AND PROCESSES CONTROL PLAN (PMLPCP)

| **Title:** Parts, Materials, Lubrication, and Processes Control Plan (PMLPCP) | **DID Letter:** L |
|---|---|
| **Reference:** Spacecraft MAR, Sections 6.1 and 6.2 | |
| **Purpose:** To describe the contractor's approach and methodology for implementation of his PMLP control program | |
| **Related Documents:** | |

**Preparation Information**

This PMLPCP is due 60 days after contract award for GSFC approval. Any revision is due upon its release for GSFC approval. The contractor may utilize existing documentation as section(s) of this plan.

The PMLPCP shall address all PMLP program requirements. As a minimum, the PMLPCP shall include:

a. The contractor's plan or approach for conforming to parts, materials, lubrication, and processes (PMLP) requirements
b. Selection criteria (including the order of precedence for preferred parts lists, etc.) for standard PMLP
c. The criteria for selection of custom PMLP
d. The contractor's parts control organization, identifying key individuals and specific responsibilities.
e. Detailed PMLP Control Board (PMLPCB) procedures including PMLPCB membership, designation of chairperson, responsibilities, review and approval procedures, meeting schedules and method of notification, and meeting minutes
f. PMLP tracking methods and approach, including tools to be used such as databases, reports, NASA Parts Selection List (NPSL), etc.
    - A description of system for identifying and tracking PMP approval status.
g. The details of the internal operating procedures (which may be attached to the PMLPCP) that will be used for PMPL procurement, processing, and testing methodology and strategies to perform the following functions:
    - Incoming inspections
    - Screening
    - Qualification testing
    - Derating
    - Testing of PMLP pulled from stores
    - Destructive Physical Analysis
    - Radiation assessments
    - PMLP age control and tracebility
h. PMLP vendor surveillance and audit plan
i. Electrostatic Control Plan
j. Flow down of PMLPCB requirements to sub-contractors

| **Title:** As-Designed/As-Built Parts, Materials, Lubrication, and Processes Lists | **DID Letter:** M |
|---|---|

**Reference:**
Spacecraft MAR, Sections 2.4, 6.1 and 6.3

**Purpose:**
To document the parts, materials, processes, and lubrications (PMPL) used to fabricate the designed/delivered spacecraft bus. The lists will be used to determine the safety, reliability, and risk associated with the spacecraft design. The PMPL lists will also be used to determine if a latent problem, that has been previously discovered by NASA/industry, has been designed/built into the spacecraft. Additionally, the lists will help in the evaluation of any on-orbit performance problems/issues.

**Related Documents:**

**Preparation Information**

The preliminary as-designed lists are due to GSFC 30 days prior to MPDR. The final as-designed lists are due 30 days prior to MCDR. As-designed list updates are due to GSFC as generated. Changes from previous lists shall be clearly denoted. The as-built lists are due to GSFC 60 days prior to hardware shipment. All data/lists shall be delivered electronically to GSFC on the appropriate GSFC forms, equivalent vendor forms, or GSFC-approved Excel spreadsheets. All lists are for information. Part inspection, qualification, screening, testing, evaluation, and/or failure analysis information shall be made available to the Government upon request. Additionally, upon request, manufacturing and/or fabrication process information/procedures shall be made available for the Government's information.

The As-Designed PMPL Lists shall include the planned configuration of delivered articles. The As-Built Parts, PMPL Lists shall detail the actual configuration of the delivered articles. The contractor shall provide information on inorganic, polymeric, and composite materials, lubrication usage, and materials processes as well as EEE parts. Changes since prior submissions shall be clearly identified.

a. Parts Lists

The Parts Identification List (PIL) or Program Parts List (PPL) shall be prepared and maintained throughout the life of the project. The PIL/PPL and As-Built Parts List (ABPL) shall be compiled by subsystem or component and shall, as a minimum, include:

- Part name
- Part number
- Manufacturer
- Manufacturer's generic part number
- Procurement specification

Note: The ABPL shall include the following information in addition that listed above:

- Lot date code
- Quantities

- Parts location to the sub-assembly level

c. Materials Lists

As a minimum, the polymeric materials and composites usage list form shall include:

- Spacecraft bus
- Subsystem or instrument name
- GSFC technical officer
- Contractor and address
- Prepared by and phone number
- Date of preparation
- GSFC materials evaluator and evaluator's phone number
- Date received by GSFC
- Date evaluated by GSFC
- Item number (See Note 1.)
- Material identification (See Note 2.)
- Mix formula (See Note 3.)
- Cure (See Note 4.)
- Amount code
- Outgassing values

Notes:

1. List all polymeric materials and composites applications utilized in the system except lubricants which should be listed on the lubricants usage list.
2. List the name of the material, identifying number and manufacturer; e.g., Epoxy, Epon 828, E. V. Roberts and Associates
3. Provide proportions and name of resin, hardener (catalyst), filler, etc.; e.g., 828/V140/Silflake 135 as 5/5/38 by weight
4. Provide cure cycle details; e.g., 8 hours. at room temperature plus 2 hours at 150$^{o}$C

As a minimum, the inorganic materials and composite usage list form shall include:

- Spacecraft bus
- Subsystem or instrument name
- GSFC technical officer
- Contractor and address
- Prepared by and phone number
- Date of preparation
- GSFC materials evaluator and evaluator's phone number
- Date received by GSFC
- Date evaluated by GSFC
- Item number (See Note 1.)
- Materials identification (See Note 2.)
- Condition (See Note 3.)
- Application or usage (See Note 4.)
- Expected environment
- Stress corrosion cracking table number

- MUA number
- NDE method

Notes:

1. List all inorganic materials (metals, ceramics, glasses, liquids and metal/ceramic composites) except bearing and lubrication materials that should be listed on GSFC Form 18-59C.
2. Give materials name and identifying number manufacturere; e.g., Aluminum 6061-T6; Electroless nickel plate, Enplate Ni 410, Enthone, Inc.; Fused silica, Corning 7940, Corning Class Works
3. Give details of the finished condition of the material, heat treatment designation (e.g., hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.; e.g., heat treated to Rockwell C 60 hardness, gold electroplated, brazed; surface coated with vapor deposited aluminum and magnesium fluoride; cold worked to full hard condition, TIG welded and electroless nickel plated.
4. Give details of the locations on the spacecraft bus where the material will be used (component) and its function; e.g., electronics box structure in attitude control system, not hermetically sealed.

As a minimum, the lubricant usage list shall include:

- Spacecraft bus
- Subsystem or instrument name
- GSFC technical officer
- Contractor and address
- Prepared by and phone number
- Date of preparation
- GSFC materials evaluator and evaluator's phone number
- Date received by GSFC
- Date evaluated by GSFC
- Item number
- Component type
- Size
- Material (See Note 1.)
- Component manufacturer
- Manufacturer identification
- Proposed lubrication system
- Amount of lubrication
- Type and number of wear cycles (See Note 2.)
- Speed, temperature and atmosphere of operation (See Note 3.)
- Type and magnitude of loads (See Note 4.)
- Other appropriate/relevant details (See Note 5.)

Notes:

1. List ball bearing (BB), sleeve bearing (SB), gear (G), sliding surfaces (SS), or sliding electrical contacts (SEC), etc. Give generic identification of materials used for the component; e.g., 440C steel, PTFE.

2. List continuous unidirectional rotation (CUR), continuous oscillation (CO), intermittent rotation (IR), intermittent oscillation (IO), small angle (less than $30^o$) oscillation (SAM), large angle (greater than 30o) oscillation (LAM), continuous sliding (CS), or intermittent sliding (IS), etc. State the number of wear cycles; e.g., 1 to 1E2 ("A"), 1E2 to 1E4 ("B"), 1E4 to 1E6 ("C"), or greater than 1E6 ("D").
3. State the speed as revolution per min. (RPM), oscillations per min. (OPM), variable speed (VS), or sliding speed in cm. per minute (CPM). State operational temperature range atmosphere as: vacuum, air, gas sealed or unsealed and pressure.
4. List the type of loads; e.g., axial, radial, tangential (gear load). State the magnitude of load.
5. For ball bearings, state the type and material of ball cage, number of shields, and the type of ball groove surface finishes. For gears, state the surface treatment and hardness. For sleeve bearings, state the bore diameter and width. Provide torque and torque margins.

As a minimum, the material process utilization list shall include:

- Spacecraft bus
- Subsystem or instrument name
- GSFC technical officer
- Contractor and address
- Prepared by and phone number
- Date of preparation
- GSFC materials evaluator and evaluator's phone number
- Date received by GSFC
- Date evaluated by GSFC
- Item number
- Process type (See Note 1.)
- Contractor specification number (See Note 2.)
- Military, ASTM, Federal or other specification number
- Description of material processed (See Note 3.)
- Spacecraft bus/instrument application (See Note 4.)

Notes:

1. Give the generic name of the process; e.g., anodizing (sulfuric acid)
2. State if the process is proprietary.
3. Identify the material type and condition subjected to the process; e.g., 6061-T6.
4. Identify the component or structure for which the materials are being processed; e.g., antenna dish.

All welding and brazing of flight hardware, including repairs, shall be performed by certified operators in accordance with the requirements of the appropriate industry or government standards. A copy of the procedure qualification record (PQR) and a current copy of the operator qualification test record shall be provided along with the Materials Process Utilization List.

| **Title:** Government Industry Data Exchange Program (GIDEP) Alert Responses | **DID Letter:** N |
|---|---|
| **Reference:** Spacecraft MAR, Sections 6.1 and 6.4 | |
| **Purpose:** To review and disposition GIDEP/NASA Alerts and Advisories that are provided by GSFC or sources | |
| **Related Documents:** | |

**Preparation Information**

Responses are due to GSFC within 25 calendar days of the receipt of an Alert/Advisory. Alert responses shall cover all program hardware from any source including the contractor, their subcontractors, and all suppliers/vendors. Alert/advisory impacts, if any, shall be discussed at technical reviews and Parts Control Board (PCB) meetings. This information shall be provided for GSFC information; however, GSFC must concur with the contractor that all flight hardware is flightworthy.

The contractor shall provide an impact statement to GSFC for each Alert or Advisory reviewed. When a negative impact exists, the contractor shall provide a narrative plan of action and an implementation date within the 25 calendar days listed above.

A monthly status report shall be submitted to the GLAST SAM and/or their designated representative indicating:

1. The Alerts/Advisories reviewed for applicability
2. The status of the associated hardware or documentation (e.g., parts lists) reviewed
3. Impact to the program
4. Proposed corrective action

DID O - PRINTED WIRING BOARD (PWB) COUPONS OR REPORTS

| **Title:** Printed Wiring Board (PWB) Coupons or Reports | **DID Letter:** O |
|---|---|
| **Reference:** Spacecraft MAR, Sections 6.1 and 6.5 | |
| **Purpose:** To provide an independent evaluation of the quality of PWB's used in flight hardware | |
| **Related Documents:** IPC-D-275, GSFC S-312-P003, ANSI/IPC-HF 318, ANSI/IPC-A-600, NASA RP 1161 | |

**Preparation Information**

Provide PWB coupons or their analysis reports to GSFC for approval as a precondition to PWB population. Coupons or reports shall be submitted to GSFC as soon as they are received from the PWB supplier or evaluation laboratory.

Provide a test coupon (for each PWB that will be used in flight hardware) to GSFC or to an evaluation laboratory. If an evaluation laboratory is used, the coupon analysis report shall be supplied to GSFC in lieu of the coupon. For both cases, the following shall be observed:

- The coupon shall be per the design requirements of GSFC S-312-P-003 and shall only be removed from the flight PWB panel after the panel has been through all manufacturing processes.
- The coupon shall be "as produced" by the vendor; i.e., it will not have seen any processes not experienced by the PWB panel (including metallographic preparation techniques or thermal excursions).
- The coupon shall be clearly identified with the part number, serial number, vendor identification, and date code or production lot number.
- The paperwork accompanying a coupon shall include the part number, serial number, vendor identification, and date code or production lot number as well as the flight equipment to which the coupon pertains, the shipper identification, and the tracking number.
- Two weeks prior to shipping coupons, the hardware provider shall notify the GLAST SAM or the independent evaluation laboratory (as appropriate) that they plan to ship the coupons for evaluation.
- A fax shall precede a coupon's receipt by 1 day. This fax shall be sent to the evaluation lab or the GSFC SAM (as appropriate) and shall include the part number, serial number, vendor identification, and date code or production lot number plus the flight equipment to which the coupon pertains, the shipper identification, and the tracking number.
- Flight PWB shall not be assembled prior to notification that the representative coupon has passed laboratory evaluation by the GSFC-approved laboratory.
- A preliminary fax of the coupon's test results and final report shall be provided to the GLAST SAM.

A list of certified laboratories, their addresses, and phone and fax numbers will be provided by the GSFC Materials Engineering Branch upon request.

DID P - OBSERVATORY CONTAMINATION CONTROL PLAN (CCP)

| **Title:** Observatory Contamination Control Plan (CCP) | **DID Letter:** P |
|---|---|

**Reference:**
Spacecraft MAR, Sections 7.1 and 7.2

**Purpose:**
To define the level of cleanliness and methods/procedures to be followed to achieve adequate cleanliness/contamination control and to define the approach required to maintain cleanliness/contamination control through spacecraft bus and observatory integration test, shipment, and flight

**Related Documents:**
LAT Contamination Plan and GBM Contamination Plan

**Preparation Information**

The preliminary draft is due 30 days before MPDR. The final draft is due to GSFC 30 days before MCDR. Updates are due as generated to GSFC. All revisions are for approval. Copies of all referenced analyses, procedures, standards, and specifications shall be made available to the Government upon request.

The contamination/cleanliness control plan shall:

1. Define the methods, procedures, schedule, measurement and reporting, and requirements for ensuring the adequacy of observatory contamination control requirements

2. Define levels of cleanliness and methods/procedures to be followed for the observatory for each phase of the program (e.g., spacecraft bus development, instrument integration and test, observatory environmental test, etc.) The plan shall detail the analyses to be performed to assess instrument sensitivity and to define requirements. Each phase shall define a cleanliness budget that is verifiable.

3. Identify critical fabrication and assembly activities that will be performed in clean rooms at the Class 10,000 level and the cleaning processes necessary to achieve the surface cleanliness levels

4. Identify the atmospheric contaminants, temperature, and humidity controls that will be used during electronic fabrication (including soldering), integration, testing, transportation, and launch. Indicate how other controls will meet the requirements including a description of all facilities that will be used. Include a thermal vacuum test contamination monitoring plan including vacuum test data, QCM and cold-finger location and temperature, pressure data, system temperature profile, and shroud temperature.

5. Identify shipping containers design features that will keep the contamination levels of flight hardware within the contamination budget during shipment and storage

6. Define the requirements and methods/procedures required to maintain cleanliness during spacecraft bus and observatory fabrication, integration, test, and launch operations

7. Demonstrate that the control contamination efforts are consistent with controls to prevent

electrostatic damage

8. Indicate the methods and frequency for monitoring cleanliness levels and accretions to ensure compliance with requirements

9. Define criteria for materials selection and acceptance relative to contamination control. The criteria shall include outgassing as a function of temperature and time; the nature of outgassing chemistry; and the areas, weight, location, and view factors of critical surfaces.

10. Specify criteria for the bake-out and outgassing certification of critical subsystems

11. Provide a contamination training program. All personnel required to work in clean areas with flight hardware shall be trained in the proper clean area procedures.

12. Define the overall vent location and orientation policy indicating how unintentional venting shall be avoided. (All applicable drawings shall show vent locations that comply with the venting analysis.)

13. Identify the cleaning, inspection, and bagging to be used for parts, flight subassemblies, and the assembled spacecraft bus. Identify the schedule for spacecraft bus and observatory cleaning. Reference the procedures used for these activities.

14. Define the design requirements and design approach for contamination control throughout the mission through launch operation

15. Perform particle and molecular modeling analyses for ascent and on-orbit operations for contamination sensitive components

CHECK THE GLAST PROJECT WEBSITE AT
http://glast.gsfc.nasa.gov/project/cm/mcdl TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

| **Title:** Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) | **DID Letter:** Q |
|---|---|

**Reference:**
Spacecraft MAR, Sections 8.1 and 8.2.1

**Purpose:**
To evaluate the spacecraft bus design relative to requirements and to identify single point failures, critical items, and/or hazards

**Related Documents:**
GSFC S-302-89-01, "Procedures for Performing an FMEA"
MSFC CR 5320.9, "Payload and Experiment Failure Mode Effects Analysis and Critical Items List Ground Rules"
MIL-STD 1629A, "Procedures for Performing an FMECA"

**Preparation Information**

The preliminary FMEA and CIL are due to GSFC for information 30 days before the MPDR. Final copies are due to GSFC for information 30 days before the MCDR. Updates are due to GSFC for information as generated.

The FMEA report shall document the approach, methodologies, results, conclusion, and recommendations. The report shall include objectives, level of analysis, ground rules, functional description, functional block diagrams, reliability block diagrams, bounds of equipment analyzed, reference to data sources used, identification of problem areas, single-point failures, recommended corrective action, and worksheets as appropriate for the specific analysis performed.

The CIL shall include item identification, cross-reference to FMEA line items, and retention rationale. Appropriate retention rationale may include design failures, historical performance, acceptance testing, manufacturing product assurance, elimination of undesirable failure modes, and failure detection methods.

FMEA reports already completed by the spacecraft bus contractor will be reviewed for content regardless of their format. Existing reports shall be revised for any GLAST-unique or revised/altered designs.

DID R - PROBABILISTIC RISK ASSESSMENT (PRA)

| **Title:** Probabilistic Risk Assessment (PRA) | **DID Letter:** R |
|---|---|
| **Reference:** Spacecraft MAR, Sections 8.1 and 8.2.2 | |
| **Purpose:** To provide a structured, disciplined approach to analyzing system risk to support management decisions to ensure mission success; improve safety in design, operation, maintenance and upgrade; improve performance; and reduce design, operation and maintenance costs | |
| **Related Documents:** | |

**Preparation Information**

The PRA Plan is due to GSFC 30 days before the MPDR. The preliminary PRA is due to GSFC 30 days before the MCDR while the final PRA is due to GSFC 30 days before the MOR. Any additional PRA Plan or PRA updates are due to GSFC as generated. All documents are due to GSFC for information.

A PRA Plan shall be generated as part of the PRA. It shall explain how the PRA will be performed and include the types of analyses that will be performed for each scenario and what modeling tools and techniques will be used; e.g., Failure Mode and Effects Analysis (FMEA), Fault Tree Analyses (FTA), and/or reliability predictions. The PRA Plan shall also explain how the PRA will tie into the overall risk management process.

The PRA shall include:

1. An objective, scope, and definition of the development of end-states-of-interest to the decision maker
2. The definition of the mission phases and success criteria
3. Failure scenario models (e.g., fault ) addressing all relevant critical factors
4. A description of the development of likelihood estimates for risk assessments

The summary of results and conclusions shall include a ranked list of high, medium, and low risks based on the likelihood and consequence of failures identified in the FTA, the FMEA, and the Integration & Test (I&T) problem reports with uncertain corrective actions.

DID S - RELIABILITY ASSESSMENTS AND PREDICTIONS

| **Title:** Reliability Assessments and Predictions | **DID Letter:** S |
|---|---|
| **Reference:** Spacecraft MAR, Sections 8.1 and 8.2.3 | |
| **Purpose:** To assist in evaluating alternative designs, to identify potential mission limiting elements that may require special attention, and to evaluate the ability of the design to successfully meet its mission reliability requirements | |
| **Related Documents:** MIL-STD-756B, "Reliability Modeling and Prediction"<br>MIL-STD-217, "Reliability Prediction of Electronic Equipment"<br>RAC-TR-85-229, "Reliability Predictions for Spacecraft" | |

**Preparation Information**

A preliminary assessments and predictions is due to GSFC 30 days prior to the MPDR. The final documentation is due to GSFC 30 days prior to the MCDR. Updates are due to GSFC as generated. All versions are for information.

The assessment/prediction report shall document the methodology and results of comparative reliability assessments and predictions including mathematical models, reliability block diagrams, failure rates, failure definitions, degraded operating modes, trade-offs, assumptions, and any other pertinent information used in the assessment process.

The format of the report is not critical but it should incorporate good engineering practices and clearly show how reliability was considered as a discriminator in the design process.

DID T - FAULT TREE ANALYSIS (FTA)

| **Title:** Fault Tree Analysis (FTA) | **DID Letter:** T |
|---|---|

**Reference:**
Spacecraft MAR, Sections 8.1 and 8.2.4

**Purpose:**
To specify and analyze an undesired system state in the context of its environment and operation to find all credible ways in which the undesired event can occur. This analysis will provide a methodical approach to understanding the system, its operation, and the environment in which it will operate so that informed decisions regarding system design and operation can be made.

**Related Documents:**

**Preparation Information**

A preliminary FTA is due to GSFC 30 days prior to the MPDR. The final FTA is due to GSFC 30 days prior to the MCDR. Updates are due to GSFC as generated. All versions are for information.

The Fault Tree Analysis Report shall contain:

1. Ground rules for the analysis including definitions of the undesirable end states analyzed
2. References to the documents and data used
3. The fault tree diagrams
4. Statement of the results and conclusions