GLAST LAT Procedure, Guideline	Document # LAT-MD-00039-1	Date Effective 12/12/00
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	Subsystem/Office Performance & Safety Assurance	
Document Title **Performance Assurance Implementation Plan**		

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SECTION 1: OVERALL IMPLEMENTATION

1.1 DESCRIPTION OF OVERALL IMPLEMENTATION

The requirements of the GLAST LAT Project Mission Assurance Requirements (MAR) document will be implemented in accordance with this Performance Assurance Implementation Plan (PAIP). (Refer to CDRL, DID 301.) Unless specifically addressed within this plan, the scope of application of this plan to flight and ground system hardware and software is commensurate with the defined scope of application of the performance assurance requirements in the GLAST LAT MAR document.

1.1.1 Assurance Management Organization

Responsibility for the application of this PAIP rests with all GLAST LAT Project members and, ultimately, the GLAST LAT Instrument Project Manager and Principal Investigator. Responsibility for the management of performance & safety assurance activities described in the PAIP rests with the GLAST LAT Performance & Safety Assurance Manager (PSAM).

The primary responsibility of the PSAM is to ensure the products produced by the GLAST LAT Project intended for design qualification, flight and critical ground support equipment usage meet the required levels of quality and functionality for their intended purposes. The PSAM shall be delegated the authority and responsibility to accomplish the following:

a. Participate in proposal, financial forecasting and financial status activities
b. Establish and implement quality & safety assurance requirements
c. Perform internal, partner, and supplier technical risk assessment, process assessment and product evaluation
d. Assist the GLAST LAT Project in tailoring the software/hardware development processes
e. Review and/or approve technical documents related to hardware/software, including equipment specifications, software system requirement, assembly procedures, test procedures and payload integration procedures
f. Oversee and assess critical supplier operations
g. Assist in metrics definition and assure that the development team is following the defined processes
h. Assure the identification, implementation, and verification of safety-critical components are performed
i. Document and communicate quality status/problems and recommend preventative/corrective action

1.2 USE OF MULTI-MISSION OR PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

When hardware that was designed, fabricated, or flown on a previous project is considered to have demonstrated compliance with some or all of the requirements of this document such that certain tasks need not be repeated, GLAST LAT may demonstrate how the hardware complies with requirements prior to being relieved from performing any tasks. (Refer to Section 15, RD 1-1.)

1.3 SURVEILLANCE

The work activities, operations, and documentation performed by the GLAST LAT or GLAST LAT suppliers are subject to evaluation, review, audit, and inspection by government-designated representatives from the GSFC Project Office, a Government Inspection Agency (GIA), or an independent assurance contractor (IAC). The GSFC Project Office may delegate in-plant responsibilities and authority to those agencies via a letter of delegation, or a GSFC contract with an IAC.

GLAST LAT, upon request, will provide government assurance representatives with documents, records, and equipment required to perform their assurance and safety activities. GLAST LAT will also provide the government assurance representative(s) with an acceptable work area.

1.4 APPLICABLE DOCUMENTS (Section 13)

In addition to those applicable documents cited in the project MAR, Section 13 of this plan lists implementing documents which form a part of this plan.

1.5 ACRONYMS AND GLOSSARY (Section 14)

The project MAR and the definitions included in implementing documents referenced herein define acronyms and terms as applied in this plan.

1.6 CONTRACT DELIVERY REQUIREMENTS LIST (CDRL)

The Contract Delivery Requirements List (CDRL) contains Data Item Descriptions (DID's) which describe data deliverable to the GSFC Project Office. The "CDRL numbers" cited in this document refer to the "CDRL numbers" listed on the DID's contained in the CDRL. Performance assurance deliverables required from project contractors are defined in appropriate contract procurement packages and any required contractor assurance implementation plans.

Unless otherwise indicated in this plan, all required documentation generated by GLAST LAT shall be provided to the GLAST LAT Project Office by the responsible project personnel as scheduled in applicable CDRL DID. Contractor-provided assurance deliverables shall be provided upon receipt by the contract Technical Representative to the LAT project office. The PSAM shall provide review comments or approval/disapproval recommendations as appropriate to the GLAST LAT Project Manager on all assurance deliverables received for project review or approval.

1.7 RECOMMENDED DOCUMENTATION (Section 16)

Recommended Documentation (RD's) is identified in Section 16. These are items that GSFC recommends GLAST LAT prepare; however, they are not mandatory deliverables. If requested and GLAST LAT has performed that task, GLAST LAT will make the information indicated in the RD available to the GSFC Project Office. (See "Preface" for Section 16.)

1.8 ADDENDUM A: GROUND DATA SYSTEMS ASSURANCE REQUIREMENTS

The ground data systems assurance requirements will be described in this pending addendum which may be negotiated at a later date.

1.9 ADDENDUM B: S&MA DELIVERABLES NOT COVERED IN THE CDRL

The deliverable items whose first delivery is not required until after PDR are described in this addendum. These items will be added to the CDRL at a later date (GSFC 433-CDRL-0001). They are listed here for the convenience of PAIP readers.

2.0 REQUIREMENTS DOCUMENTS

All GLAST LAT prepared requirements documents such as the instrument specification, the instrument performance verification plan, and the PAIP and its associated documentation such as the Risk Management Plan and System Safety Program Plan will be delivered electronically to the GSFC Project Office for analysis. (See the CDRL, DID 323.) The documents will be analyzed using the Automated Requirement Measurement (ARM) Tool that was developed at GSFC for use as an early life cycle aid to identify areas of a requirements specification document that can be improved.

SECTION 2: SYSTEM SAFETY REQUIREMENTS

2.1 SYSTEM SAFETY REQUIREMENTS

GLAST LAT will prepare a System Safety Program Plan (SSPP) (Refer to CDRL, DID 303) which will define the safety program in effect during all stages of design, development, fabrication, and test on the GLAST LAT Instrument. The GLAST LAT Systems Safety Program is intended to ensure safety of personnel, flight hardware, support facilities, and equipment during ground and flight operations from all hazards. The SSPP describes the safety management and engineering activities that ensures identification of hazards and, where possible, elimination or control of these hazards.

The GLAST LAT Systems Safety Program will be in accordance with the following top level safety requirements documents. The activities of the safety program are intended to meet the requirements of these documents to the extent that it is applicable to the Instrument development.

a. EWR 127-1, "Eastern and Western Range Safety Requirements" which defines the Range Safety Program responsibilities and authorities and which delineates policies, processes, and approvals for all activities from the design concept through test, check-out, assembly, and the launch of launch vehicles and payloads to orbital insertion or impact from or onto the Eastern Range (ER) or the Western Range (WR). It also establishes minimum design, test, inspection, and data requirements for hazardous and safety critical launch vehicles, payloads, and ground support equipment, systems, and materials for ER/WR users.

b. KHB 1710.2C, "Kennedy Space Center Safety Practices Handbook" which specifies and establishes safety policies and requirements essential during design, operation, and maintenance activities at KSC and other areas where KSC has jurisdiction.

As appropriate, any testing performed at GSFC will comply with the safety requirements contained in 5405-048-98, the Mechanical Systems Center Safety Manual.

Satisfactory compliance with the above requirements is required to gain payload access to the launch site and the subsequent launch. The GLAST LAT Project Manager ensures compliance with the requirements and will certify to the launch range that all of the requirements have been met.

GLAST LAT will participate in Project activities associated with compliance to NPD 8710.3, NASA Policy for Limiting Orbital Debris Generation. Design and safety activities will take into account the instrument's impact on the spacecraft's ability to conform to debris generation requirements.

2.2 SYSTEM SAFETY DELIVERABLES

Refer to the CDRL, DID's 303 through 305 for the System Safety deliverables.

SECTION 3: TECHNICAL REVIEW PROGRAM REQUIREMENTS

3.1 GENERAL REQUIREMENTS

GLAST LAT will support a series of comprehensive system-level design reviews that are conducted by the GSFC Systems Review Office (SRO). The reviews will cover all aspects of flight and ground hardware, software, and operations for which GLAST LAT has responsibility. (Refer to CDRL, DID 306.)

3.2 GSFC SYSTEM REVIEW REQUIREMENTS

For each system level review, as required by the GSFC SRO and the MAR, GLAST LAT will:

a. Develop and organize material for oral presentation to the Review Team. Copies of presentation material for GSFC SRO Reviews will be available at each review.
b. Support splinter review meetings resulting from the major review.
c. Produce written responses to recommendations and action items resulting from the review.
d. Summarize, as appropriate, the results of GLAST LAT Reviews at the component and subsystem level.

3.3 GSFC SYSTEM REVIEW PROGRAM

The GSFC Office of Systems Safety and Mission Assurance (OSSMA) System Review Program (SRP) guidelines consists of individual, periodic reviews of all GSFC managed flight missions, flight instruments, flight spacecraft, ground systems which interface with flight hardware, unique flight support equipment, and their associated software including hardware supplied to GSFC-managed flight missions.

GLAST LAT will be reviewed by an independent System Review Team (SRT), chaired by the GSFC Systems Review Office. The planned reviews are:

a. System Requirements Review (SRR)--This review is keyed to the beginning of the design, assembly, and test phase to verify that the appropriate plans and requirement specifications are in place, well documented, and understood by all parties.

b. Preliminary Design Review (PDR)--This review occurs early in the design phase by prior to manufacture of engineering hardware and the detail design of associated software. Where applicable, it should include the results of test bedding, breadboard testing, and software prototyping. It should also include the status of the progress in complying with the launch range safety requirements. At PDR, hazards associated with the flight hardware should be identified and documented.

c. Critical Design Review (CDR)--This review occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software. It will emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing. GLAST LAT may also required to present the status of the controls for the safety hazards presented in the PDR and the status of all presentations to the launch range.

d. Mission Operations Review (MOR)--This mission-oriented review will normally take place prior to significant integration and test of the flight system and ground system. Its purpose is to review the status of the system components, including the ground system and its operational interface with the flight system. Discussions will include mission integration, test planning and the status of preparations for flight operations.

e. Pre-Environmental Review (PER)--This review occurs prior to the start of environmental testing of the protoflight or flight system. The primary purpose of this review is to establish the readiness of the system for test and evaluate the environmental test plans.

f. Pre-Shipment Review (PSR)--This review will take place prior to shipment of the instrument for integration with the spacecraft and for shipment of the spacecraft to the launch range. The PSR will concentrate on system performance during qualification or acceptance testing. GLAST LAT is also required to present the status of the tracking of the safety items listed in the validation tracking log, the status of deliverable documents to the launch range and the status of presentations and any subsequent launch range issues or approvals prior to sending flight hardware to the range.

g. Flight Operations Review (FOR)--While all of the previous reviews involve operations, this review will emphasize the final orbital operation plans as well as the compatibility of the flight components with ground support equipment and ground network, including summary results of the network compatibility tests.

h. Launch Readiness Review (LRR)--This review is to assess the overall readiness of the total system to support the flight objectives of the mission. The LRR is usually held at the launch site 2 to 3 days prior to launch.

The time, place and agenda for each of the reviews will be coordinated between the GLAST LAT Project Manager and the Review Team Chairman.

3.4 SYSTEM SAFETY

The safety aspects of the systems being reviewed are a normal consideration in the system evaluations conducted by the SRP. At each appropriate review, GLAST LAT will demonstrate understanding of and compliance with the applicable launch range requirements, list any known noncompliance's and provide justification for any expected waiver conditions. In addition, GLAST LAT will present the results of any safety reviews held with the Eastern Test Range.

3.5 REVIEW REQUIREMENTS

GLAST LAT will implement a program of peer reviews at the component and subsystem levels. The program will, as a minimum, consist of a Preliminary Design Review and a Critical Design Review. In addition, packaging reviews will be conducted on all electrical and electromechanical components in the flight system.

The PDR and CDR will evaluate the ability of the component or subsystem to successfully perform its function under operating and environmental conditions during both resting and flight. The results of parts stress analyses and component packaging reviews, including the results of associated tests and analyses, will be discussed at the component PDRs and CDRs.

The packaging reviews will specifically address the following:

a. Placement, mounting, and interconnection of EEE parts on circuit boards or substrates.
b. Structural support and thermal accommodation of the boards and substrates and their interconnections in the component design.
c. Provisions for protection of the parts and ease of inspection.

GLAST LAT reviews will be conducted by personnel who are not directly responsible for design of the hardware under review. The GSFC Project Office will be invited to attend the peer reviews and will be provided 10 working days notification. The results of the reviews will be documented and the documents will be made available for review.

SECTION 4: DESIGN VERIFICATION REQUIREMENTS

4.1 GENERAL REQUIREMENTS

A system performance verification program documenting the overall verification plan, implementation, and results will be developed by GLAST LAT to ensure that the payload meets the specified mission requirements, and to provide traceability from mission specification requirements to launch and on-orbit capability. The program will consist of a series of functional demonstrations, analytical investigations, physical property measurements, and tests that simulate the environments encountered during handling and transportation, pre-launch, launch, in-orbit. All prototype or protoflight hardware will undergo qualification to demonstrate compliance with the verification requirements of this section. In addition, all other hardware (flight, follow-on, spare and re-flight as defined in Section 14, "Hardware") will undergo acceptance in accordance with the verification requirements of this section.

The Verification Program begins with functional testing of sub-assemblies; it continues through functional and environmental testing supported by appropriate analysis, at the subsystem and LAT levels of assembly; the program concludes with end-to-end testing of the entire operational system including the LAT and IOC.

The General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components (GEVS-SE) (Refer to Section 13), will be used as a baseline guide for developing the verification program. Alternative methods may be utilized provided that the net result demonstrates compliance with the intent of the requirements.

4.2 DOCUMENTATION REQUIREMENTS

The following documentation requirements will be delivered and approved in accordance with the Contract Deliverables Requirements List (CDRL).

4.2.1 Performance Verification Plan

An instrument performance verification plan (Refer to CDRL, DID 307.) will be prepared defining the tasks and methods required to determine the ability of the instrument to meet each project-level performance requirement (structural, thermal, optical, electrical, guidance/control, RF/telemetry, science, mission operational, etc.) and to measure specification compliance. Limitations in the ability to verify any performance requirement will be addressed, including the addition of supplemental tests and/or analyses that will be performed and a risk assessment of the inability to verify the requirement.

The plan will address how compliance with each specification requirement will be verified. If verification relies on the results of measurements and/or analyses performed at lower (or other) levels of assembly, this dependence will be described.

For each analysis activity, the plan will 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. Analysis results will take into account tolerance build-ups in the parameters being used.

The following documents may be included as part of the Instrument Performance Verification Plan or as separate documents to meet GLAST LAT needs.

4.2.1.1 Environmental Verification Plan

An environmental verification plan will be prepared, as part of the System Verification Plan or as a separate document, that prescribes the tests and analyses that will collectively demonstrate that the hardware and software comply with the environmental verification requirements.

The environmental verification plan will provide the overall philosophy and approach to accomplishing the environmental verification program. For each test, it will include the level of assembly, the configuration of the item, objectives, test phases, and necessary functional operations. It will also define a rationale for retest determination that does not invalidate previous verification activities. When appropriate, the interaction of the test and analysis activity will be described.

Limitations in the environmental verification program which preclude the verification by test of any system requirement will be documented. Alternative tests and analyses will be evaluated and implemented as appropriate, and an assessment of project risk will be included in the Instrument Performance Verification Plan.

4.2.1.2 System Performance Verification Matrix

A System Performance Verification Matrix will be prepared and maintained, to show each specification requirement, the reference source (to the specific paragraph or line item), the method of compliance, applicable procedure references, results, report reference numbers, etc. This matrix will be included in the system review data packages showing the current verification status as applicable. (Refer to Section 3 of this document).

4.2.1.3 Environmental Test Matrix (ETM)

As an adjunct to the system/environmental verification plan, an environmental test matrix will be prepared that summarizes all tests that will be performed on each component, each subsystem or instrument, and the payload. The purpose is to provide a ready reference to the contents of the test program in order to prevent the deletion of a portion thereof without an alternative means of accomplishing the objectives; All flight hardware, spares and prototypes (when appropriate) will be included in the matrix. The matrix will be prepared in conjunction with the initial environmental verification plan and will be updated as changes occur.

A complementary matrix will be kept showing the tests that have been performed on each component, subsystem, instrument, or payload (or other applicable level of assembly). This will include tests performed on prototypes or engineering units used in the qualification program, and should indicate test results (pass/fail or malfunctions).

4.2.1.4 Environmental Verification Specification

As part of the Instrument Performance Verification Plan, or as a separate document, an environmental verification specification will be prepared that defines the specific environmental parameters that each hardware element is subjected to either by test or analysis in order to demonstrate its ability to meet the mission performance requirements. Such things as payload peculiarities and interaction with the launch vehicle will be taken into account.

4.2.2 Performance Verification Procedures

For each verification test activity conducted at the component, subsystem, and payload levels (or other appropriate levels) of assembly, a verification procedure will be prepared that describes the configuration of the test article, how each test activity contained in the verification plan and specification will be implemented.

Test procedures will contain details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, pass/fail criteria, quality control checkpoints, data collection and reporting requirements. The procedures also will address safety and contamination control provisions. (Refer to Section 15, DID 4-2.)

4.2.3 Instrument Performance Verification Reports

After each component, subsystem, etc. verification activity has been completed, a report will be submitted. (Refer to Section 15, DID 4-3.) For each analysis activity, the report will describe the degree to which the objectives were accomplished, how well the mathematical model was validated by related test data, and other such significant results. In addition, as-run verification procedures and all test and analysis data will be retained for review.

The Instrument Performance Verification Report will be developed and maintained "real-time" throughout the program summarizing the successful completion of verification activities, and showing that the applicable system performance specifications have been acceptably complied with prior to integration of hardware/software into the next higher level of assembly.

At the conclusion of the verification program, a final Instrument Performance Verification Report will be delivered comparing the hardware/software specifications with the final verified values (whether measured or computed).

4.3 ELECTRICAL FUNCTIONAL TEST REQUIREMENTS

The required electrical functional and performance tests specified in Chapter 4.3 of the GLAST LAT MAR (along with all other calibrations, functional/performance tests, measurements, demonstrations, alignments [and alignment verifications], end-to-end tests, simulations, etc. that are part of the overall verification program) will be described in the GLAST LAT ETM.

4.4 STRUCTURAL AND MECHANICAL REQUIREMENTS

GLAST LAT will demonstrate compliance with the structural and mechanical requirements specified in Chapter 4.4 of the GLAST LAT MAR through a series of interdependent test and analysis activities. These demonstrations will verify design and specified factors of safety as well as ensure spacecraft interface compatibility, acceptable workmanship, and material integrity. GLAST LAT will ensure through discussions/reviews with the GLAST LAT Safety Engineer that, when it is appropriate, activities needed to satisfy the safety requirements are accomplished in conjunction with these demonstrations.

When planning the tests and analyses, GLAST LAT will consider all expected environments including those of structural loads, vibroacoustics, mechanical shock, and pressure profiles. Mass properties and mechanical functioning shall also be verified.

4.5 ELECTROMAGNETIC COMPATIBILITY (EMC) REQUIREMENTS

The electromagnetic characteristics of hardware will be designed in accordance with the requirements of SI-SC IRD so that:

a. The instrument and its elements do not generate electromagnetic interference that could adversely affect its own subsystems and components, other instruments, the spacecraft, or the safety and operation of the launch vehicle or the launch site
b. The instrument and its subsystems and components are not susceptible to emissions that could adversely affect their safety and performance. This applies whether the emissions are self-generated or derived from other sources or whether they are intentional or unintentional.

4.6 VACUUM, THERMAL, AND HUMIDITY REQUIREMENTS

Using equipment and/or areas with controlled environments, GLAST LAT will conduct a set of tests and analyses that collectively demonstrate the instrument hardware’s compliance with the vacuum, thermal, and humidity requirements defined in the SI-SC IRD and Sections 4.6 of the GLAST LAT MAR. The GLAST LAT program will demonstrate that:

a. The instrument will perform satisfactorily in the vacuum and thermal environment of space
b. The instrument’s thermal design and the thermal control system will maintain the affected hardware within the established mission thermal limits
c. The instrument hardware will withstand, as necessary, the temperature and humidity conditions of transportation, storage, and ELV launch

4.7 SPACECRAFT/PAYLOAD VERIFICATION DOCUMENTATION

The documentation requirements of Section 4.2 also apply to the spacecraft/payload. Following integration of the instruments onto the spacecraft, the spacecraft System Verification Report will include the instrument information.

SECTION 5: ELECTRONIC PACKAGING and PROCESSES REQUIREMENTS

5.1 GENERAL

GLAST LAT will plan and implement an Electronic Packaging and Processes Program to assure that all electronic packaging technologies, processes, and workmanship activities selected and applied meet mission objectives for quality and reliability.

5.2 WORKMANSHIP

GLAST LAT will use the following NASA and commercial workmanship standards:

a. NASA-STD-8739.3 - Soldered Electrical Connections
b. NASA-STD-8739.4 - Crimping, Interconnecting Cables, Harnesses, and Wiring
c. NASA-STD-8739.5 - Fiber Optic Terminations, Cable Assemblies, and Installation
d. NASA-STD-8739.7 - Electrostatic Discharge Control
e. NASA-STD-8739.1 - Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Assemblies
f. NASA-STD-8739.2 - Workmanship Standard for Surface Mount Technology
g. IPC-2221 - Generic Standard On Printed Board Design
h. IPC-2222 - Sectional Standard on Rigid PWB Design
i. IPC-6011 - Generic Performance Specification for Printed Boards
j. IPC-6012 - Qualification and Performance Specification for Rigid Printed Boards

Alternate workmanship standards may be used when approved by the project. GLAST LAT will submit, for review and acceptance, the alternate standard and the differences between the alternate standard and the required standard prior to project approval.

GLAST LAT will provide printed wiring board coupons and associated test reports in accordance with the applicable CDRL DID. Coupons and test reports are not required for delivery to the GSFC Project Office if GLAST LAT has coupons evaluated by a laboratory which has been approved by the GSFC Project Office, in writing before the coupons are released for evaluation. (Refer to Section 15, DID 5-1)

5.3 NEW/ADVANCED PACKAGING TECHNOLOGIES

New and/or advanced packaging technologies (e.g.,. MCMs, stacked memories, chip on board) that have not previously been used in space flight applications may be reviewed and approved through the Parts and Materials Control Board (PMCB) as defined in Section 6.2. When appropriate, a detailed Technology Validation Assessment Plan (TVAP) may be developed for each new technology. A TVAP identifies the evaluations and data necessary for acceptance of the new/advanced technology for reliable use and conformance to project requirements. (Refer to Section 15, RD 5-1.)

New/advanced technologies may be part of the Parts Identification List (PIL) and Project Approved Parts List (PAPL) defined in Section 6.3 of this document.

SECTION 6: PARTS REQUIREMENTS

6.1 GENERAL

GLAST LAT will plan and implement an Electrical, Electronic, and Electromechanical (EEE) Parts Control Program to assure that all parts selected for use in flight hardware meet mission objectives for quality and reliability.

GLAST LAT will prepare a Parts Control Plan (PCP) (Refer to CDRL, DID 308.) describing the approach and methodology for implementing the Parts Control Program. The PCP will also define the GLAST LAT's criteria for parts selection and approval based on the guidelines of this section.

6.2 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS

All part commodities identified in the NASA Parts Selection List are considered EEE parts and will be subjected to the requirements set forth in this section. Custom or advanced technology devices such as custom hybrid microcircuits, detectors, Application Specific Integrated Circuits (ASIC), Multi-Chip Modules (MCM), and magnetics will also be subject to parts control appropriate for the individual technology. (See Section 6.2.2.1 of this document.)

6.2.1 Parts Control Board

GLAST LAT will establish a Parts and Materials Control Board (PMCB) to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the project. The PMCB will be responsible for the review and approval of all parts for conformance to established criteria, and for developing and maintaining a Project Approved Parts List (PAPL). In addition, the PMCB will be responsible for all parts activities such as failure investigations, disposition of non-conformances, and problem resolutions. PMCB operating procedures will be included as part of the PCP.

6.2.1.1 PMCB Meetings

PMCB meetings will be convened as necessary to evaluate acceptance of EEE parts and/or materials in a timely manner to support the GLAST LAT Project schedule. Meetings will be held prior to the procurement of parts and/or materials. At a minimum, the PMCB meetings will be convened prior to the PDR to determine the acceptability of EEE parts including those proposed for use by both the developer and/or subcontractors, vendors, or collaborators. Emergency PMCB meetings will be convened at the discretion of the PMCB chair via telecon or e-mail to meet Project needs and schedules. The chair will be responsible for the scheduling of PMCB meetings and will notify all members, including the GSFC Project Office, at least 10 working days prior to each (non-emergency) meeting via telephone or e-mail.

The GSFC Project Office may participate in PMCB meetings and will be notified in advance of all upcoming meetings. Meeting minutes or records will be maintained by GLAST LAT to document all decisions made and a copy provided to the GSFC Project Office within three days of convening the meeting. (Refer to the CDRL, DID 309.) The GSFC Project Office may elect to overturn decisions involving non-conformances within ten days after receipt of meeting minutes. PMCB activities may be audited by the GSFC Project Office on a periodic basis to assess conformance to the GLAST LAT's PCP.

6.2.2 Parts Selection and Processing

All parts will be selected and processed in accordance with the GSFC 311-INST-001 Instructions for EEE Parts Selection, Screening and Qualification. All application notes in 311-INST-001 will apply. The appropriate parts quality level defined in 311-INST-001 will be based on system redundancy or criticality. The requirements of 311-INST-001 may be further tailored as appropriate. GLAST LAT's internal selection and processing documentation may be used to define these requirements. The requirements will then become the established criteria for parts selection, testing, and approval for the duration of the project, and will be documented in the PCP. Parts selected from the NASA Parts Selection List, MIL-STD-975, and the GSFC Preferred Parts List (PPL) are considered to have met all criteria of 311-INST-001 for the appropriate parts quality level and may be approved by the PMCB provided all mission application requirements (performance, derating, radiation, etc.) are met.

6.2.2.1 Custom Devices

In addition to applicable requirements of 311-INST-001, custom microcircuits, hybrid microcircuits, MCM, ASIC, magnetics, etc. planned for use by GLAST LAT will be subjected to a design review. The review may be conducted as part of the PMCB activity. The design review will address, at a minimum, derating of elements, method used to assure each element reliability, assembly process and materials, and method for assuring adequate thermal matching of materials.

6.2.3 Derating

All EEE parts will be used in accordance with the derating guidelines of the NASA Parts Selection List. GLAST LAT will maintain documentation on parts derating analysis and will make it available for GSFC Project Office review.

6.2.4 Radiation Hardness

All parts will be selected to meet their intended application in the predicted mission radiation environment. The radiation environment consists of two separate effects, those of total ionizing dose and single-event effects. GLAST LAT will document the analysis for each part with respect to both effects.

6.2.5 Verification Testing

Verification of screening or qualification tests by re-testing is not required unless deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. If required, testing will be in accordance with 311-INST-001 as determined by the PMCB. GLAST LAT, however, will be responsible for the performance of supplier audits, surveys, source inspections, witnessing of tests, and/or data review to verify conformance to established requirements.

6.2.6 Destructive Physical Analysis

A sample of each lot date code of microcircuits, hybrid microcircuits, and semiconductor devices will be subjected to a Destructive Physical Analysis (DPA). All other parts may require a sample DPA if it is deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. DPA tests, procedures, sample size and criteria will be as specified in GSFC specification S-311-M-70, Destructive Physical Analysis. GLAST LAT's procedures for DPA may be used in place of S-311-M-70 and will be submitted with the PCP. Variation to the DPA sample size requirements, due to part complexity, availability or cost, will be determined and approved by the PMCB on a case-by-case basis. In lieu of performing the required DPA's, GLAST LAT may provide the required number of DPA samples to the GSFC Project Office for DPA. This will be accomplished on a case by case basis through mutual agreement by GLAST LAT and the GSFC Project Office.

6.2.7 Failure Analysis

Failure analyses, performed by experienced personnel, will be required to support the non conformance reporting system. The (in-house or out-of-house) failure analysis laboratory shall be equipped to analyze parts to the extent necessary to ensure an understanding of the failure mode and cause. The failure analyses shall be available to the GSFC Project Office for review upon request.

6.2.8 Parts Age Control

Parts drawn from controlled storage after 5 years from the date of the last full screen will be subjected to a full 100 percent re-screen and sample DPA. Alternative test plans may be used as determined and approved by the PMCB on a case-by case basis. Parts over 10 years from the date of the last full screen or stored in other than controlled conditions where they are exposed to the elements or sources of contamination will not be used.

6.3 PARTS LISTS

GLAST LAT will create and maintain a Project Approved Parts List (PAPL) and a Parts Identification List (PIL) for the duration of the project. GLAST LAT may choose to incorporate the PAPL and PIL into one list, which will be submitted to GSFC as a PIL, provided clear distinctions are made as to parts approval status and whether parts are planned for use in flight hardware. (Refer to the CDRL, DID 310.)

6.3.1 Project Approved Parts List

The Project Approved Parts List (PAPL) will be the only source of approved parts for project flight hardware, and as such may contain parts not actually in flight design. Only parts that have been evaluated and approved by the PMCB will be listed in the PAPL. Parts must be approved for listing on the PAPL before initiation of procurement activity. The criteria for PAPL listing will be based on 311-INST-001 and as specified herein. (See Section 6.2.2.) The PMCB will assure standardization and the maximum use of parts listed in the PAPL. The PAPL and all subsequent revisions will be available for GSFC review upon request.

6.3.1.1 Parts Approved on Prior Projects

Parts previously approved by GSFC via the Nonstandard Parts Approval Request (NSPAR) on a previous project for a system similar to the one being procured will be evaluated by the PMCB for continued compliance to current project requirements prior to listing in the PAPL. This will be accomplished by determining that:

a. No changes have been made to the previously approved NSPAR, Source Control Drawing (SCD) or vendor list.
b. All stipulations cited in the previous NSPAR approval have been implemented on the current flight lot including performance of any additional testing.
c. The previous project's parts quality level is identical to the current project.

6.3.2 Parts Identification List

As opposed to the PAPL, the Parts Identification List (PIL) will list all parts planned for use in flight hardware regardless of their approval status. The initial PIL and subsequent updates will be submitted to GSFC Project Office in accordance CDRL DID 310. An As-Built Parts List (ABPL) will also be prepared and submitted to the GSFC Project Office in accordance with the CDRL. The ABPL is generally the final PIL with additional as-built information, such as parts manufacturers and lot date code.

6.4 ALERTS

GLAST LAT PMCB will be responsible for the review and disposition of Government Industry Data Exchange Program (GIDEP) Alerts for applicability to the parts proposed for use or incorporated into the design. In addition, any NASA Alerts and Advisories provided to GLAST LAT by GSFC will be reviewed and dispositioned. Alert applicability, impact, and corrective actions will be documented and reported, upon request, to the GSFC Project Office. Additionally, when appropriate, GLAST LAT will prepare, or assist GSFC personnel in preparing Alerts. (Refer to CDRL, DID 311.)

SECTION 7: MATERIALS, PROCESSES, AND LUBRICATION REQUIREMENTS

7.1 GENERAL REQUIREMENTS

GLAST LAT will implement a comprehensive Materials and Processes Plan (Refer to the CDRL, DID 312.) beginning at the design stage of the hardware. The Materials and Processes Plan (M&PP) will help ensure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials and lubricants employed to meet the operational requirements for the instrument. Materials and lubrication assurance approval is required for each usage or application in space-flight hardware.

7.2 MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, GLAST LAT will, when selecting materials and lubricants, consider potential problem areas such as radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, toxic offgassing, flammability and fracture toughness as well as the properties required by each material usage or application.

7.2.1 Compliant Materials

GLAST LAT will use compliant materials in the fabrication of flight hardware to the extent practicable.

In order to be compliant, a material must be used in a conventional application and meet the applicable selection criteria identified in Table 7.1. A compliant material does not require a Materials Usage Agreement (MUA). (Refer to the CDRL, DID 313.)

TABLE 7-1
MATERIAL SELECTION CRITERIA

Type Launch	Payload Location	Flammability and Toxic Offgassing	Vacuum Outgassing	Stress Corrosion Cracking (SCC)
ELV	All	Note 1	Note 2	Note 3

NOTES:

1. Hazardous materials requirements, including flammability, toxicity and compatibility as specified in Eastern and Western Range 127-1 Range Safety Requirements, Sections 2.10 and 2.12.

2. Vacuum Outgassing requirements as defined in Section 7.2.5.2.

3. Stress corrosion cracking requirements as defined in MSFC-SPEC-522.

7.2.2 Non-compliant Materials

A material that does not meet the requirements of the applicable selection criteria of Table 7.1 or meet the requirements of Table 7.1, but is used in an unconventional application, will be considered to be a non-compliant material. The proposed use of a non-compliant material requires that a Materials Usage Agreement (MUA) and/or a Stress Corrosion Evaluation Form or GLAST LAT's equivalent forms (Refer to the CDRL, DID 313 and Section 15, RD 7-1.) (Figures 7-1 and Figure 7-2), be submitted to the GSFC Project Office for approval.

7.2.2.1 Materials Used in "Off-the-Shelf-Hardware"

"Off-the-shelf hardware" for which a detailed materials list is not available and where the included materials cannot be easily identified and/or changed will be treated as non-compliant. GLAST LAT will define on a MUA (CDRL, DID 313), what measures will be used to ensure that all materials in the hardware are acceptable for use. Such measures might include any one or a combination of the following: hermetic sealing, vacuum bake-out, material changes for known non-compliant materials, etc. When a vacuum bake-out is the selected method, it must incorporate a quartz crystal microbalance (QCM) and cold finger to enable a determination of the duration and effectiveness of the bake-out as well as compliance with the satellite contamination plan and error budget.

7.2.3 Conventional Applications

Conventional applications or usage of materials is the use of compliant materials in a manner for which there is extensive satisfactory aerospace heritage.

7.2.4 Non-conventional Applications

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage will be considered a non-conventional application. Under these circumstances, the GSFC Project Office and GLAST LAT may agree for GLAST LAT to provide any/all the information required in a Non-conventional Material and Lubrication Report so that the GSFC Project Office may fully understand the application. (Refer to Section 15, RD 7-2.) In that case, the material usage will be verified for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those methods.

7.2.5 Polymeric Materials

GLAST LAT will prepare and submit a polymeric materials and composites usage list or GLAST LAT's equivalent. (Refer to the CDRL, DID 314.) Refer to Figure 7-3. The list will be submitted to the GSFC Project Office for review/approval. Material acceptability will be determined on the basis of flammability, toxic offgassing, vacuum outgassing and all other materials properties relative to the application requirements and usage environment.

7.2.5.1 Flammability and Toxic Offgassing

Material flammability and toxic offgassing will be determined in accordance with the test methods described in NASA-STD-6001. Expendable launch vehicle (ELV) payload materials will meet the requirements of Eastern and Western Range 127-1 Range Safety Requirements, Sections 2.10 and 2.12.

7.2.5.2 Vacuum Outgassing

Material vacuum outgassing will be determined in accordance with ASTM E-595. In general, a material is qualified on a product-by-product basis. However, the GSFC Project Office may require lot testing of any material for which lot variation is suspected. In such cases, material approval is contingent upon lot testing. Only materials that have a total mass loss (TML) less than 1.00% and a collected volatile condensable mass (CVCM) less than 0.10% will be approved for use in a vacuum environment unless application considerations listed on a MUA (DID 313) dictate otherwise. (The overall mission contamination control requirements may demand more stringent outgassing criteria.)

7.2.5.3 Shelf-Life-Controlled Materials

Polymeric materials that have a limited shelf-life may be controlled by a process that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf-life, and expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings and paints will be included. The use of materials whose date code has expired requires that GLAST LAT demonstrate, by means of appropriate tests, that the properties of the materials have not been compromised for their intended use. Such materials may be approved by GSFC by means of a waiver. (Refer to Section 15, RD 7-3.) When a limited-life piece part is installed in a subassembly, its usage may be approved by GSFC. This may be accomplished by including the subassembly item in the Limited-Life Plan. (Refer to Section 15, RD 7-4.)

7.2.6 Inorganic Materials

GLAST LAT will prepare and document an inorganic materials and composites usage list (Figure 7.4) or GLAST LAT's equivalent. (Refer to the CDRL, DID 315.) The list will be submitted to the GSFC Project Office for review and approval. The criteria specified in MSFC-SPEC-522 will be used to determine that metallic materials meet the stress corrosion cracking criteria. An MUA (Refer to CDRL, DID 313.) will be submitted for each material usage that does not comply with the MSFC 522 SCC requirements.

Additionally, for the GSFC Project Office to approve usage of individual materials, a stress corrosion evaluation form (RD 7-1), as discussed in Section 7.2.2, or any/all of the information contained in the stress corrosion evaluation form may be required by GSFC from GLAST LAT.

7.2.6.1 Fasteners

GLAST LAT will comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in GSFC S-313-100, Goddard Space Flight Center Fastener Integrity Requirements. To document this process, GLAST LAT may prepare a Fastener Control Plan for submission to the GSFC Project Office. (Refer to Section 15, RD 7-6.) Additionally, it is recommended that material test reports for fastener lots be submitted to the GSFC Project Office for information. (Refer to Section 15, RD 7-5.)

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

7.2.7 Lubrication

GLAST LAT will prepare and document a lubrication usage list (Figure 7.5) or GLAST LAT's equivalent. (Refer to the CDRL, DID 316.) The list will be submitted to the GSFC Project Office for approval. GLAST LAT may be requested to submit supporting applications data.

Lubricants will be selected for use with materials on the basis of valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination effects.

Lubricated mechanisms may be qualified by life testing (RD 7-4) or heritage of an identical mechanism used in identical applications. If performed, evidence of qualification must be provided to the GSFC Project Office.

7.3 PROCESS SELECTION REQUIREMENTS

GLAST LAT will prepare and document a material process utilization list or GLAST's LAT equivalent (Figure 7.5). (Refer to the CDRL, DID 317.) The list will be submitted to GSFC for review/approval. Manufacturing processes (e.g., lubrication, heat treatment, welding, chemical or metallic coatings) will be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

7.4 PROCUREMENT REQUIREMENTS

7.4.1 Purchased Raw Materials

Raw materials purchased by GLAST LAT will be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance. This information need only be provided to the GSFC Project Office when there is a direct question concerning the material's flightworthiness. (Refer to Section 15, RD 7-7.)

7.4.2 Raw Materials Used in Purchased Products

GLAST LAT will require that their suppliers meet the requirements of Section 7.4.1 of this document and provide, upon request, the results of acceptance tests and analyses performed on raw materials (RD 7-7).

MATERIAL USAGE AGREEMENT		USAGE AGREEMENT NO.:			PAGE OF
PROJECT:	SUBSYSTEM:	ORIGINATOR:			ORGANIZATION:
DETAIL DRAWING	NOMENCLATURE		USING ASSEMBLY		NOMENCLATURE
MATERIAL & SPECIFICATION			MANUFACTURER & TRADE NAME		

USAGE	THICKNESS	WEIGHT	EXPOSED AREA	ENVIRONMENT		
				PRESSURE	TEMPERATURE	MEDIA

APPLICATION:
RATIONALE:

ORIGINATOR:	PROJECT MANAGER:	DATE:

FIGURE 7-1 MUA

POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT______________________ SYSTEM/EXPERIMENT______________________ GSFC T/O ______________

DEVELOPER/CONTRACTOR ______________________ ADDRESS______________________

PREPARED BY______________________ PHONE ______________________ DATE PREPARED______________

GSFC MATERIALS EVALUATOR ______________________ PHONE ____________ DATE RECEIVED ____________ DATE EVALUATED______________

Area, cm^2	Vol., cc	Wt., gm
1 0-1	A 0-1	a 0-1
2 2-100	B 2-50	b 2-50
3 101-1000	C 51-500	c 51-500
4 >1000	D >500	d >500

ITEM NO.	MATERIAL IDENTIFICATION(2)	MIX FORMULA(3)	CURE(4)	AMOUNT CODE	EXPECTED ENVIRONMENT(5)	REASON FOR SELECTION(6)	OUTGASSING VALUES	
							TML	CVCM

NOTES

1. List all polymeric materials and composites applications utilized in the system except lubricants which should be listed on polymeric and composite materials usage list.

2. Give the name of the material, identifying number and manufacturer. Example: Epoxy, Epon 828, E. V. Roberts and Associates

3. Provide proportions and name of resin, hardener (catalyst), filler, etc. Example: 828/V140/Silflake 135 as 5/5/38 by weight

4. Provide cure cycle details. Example: 8 hrs. at room temperature + 2 hrs. at 150C

5. Provide the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. List all materials with the same environment in a group. Example: T/V : -20C/+60C, 2 weeks, 10E-5 torr, ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 mile altitude, UV, electron, proton, atomic oxygen

6. Provide any special reason why the materials was selected. If for a particular property, please give the property.
   Example: Cost, availability, room temperature curing or low thermal expansion.

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FIGURE 7-3 POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

INORGANIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT________________ SYSTEM/EXPERIMENT________________ GSFC T/O ________

DEVELOPER/CONTRACTOR ________________ ADDRESS________________

PREPARED BY________________ PHONE ________________ DATE PREPARED ________

GSFC MATERIALS EVALUATOR ________________ PHONE ________ DATE RECEIVED________ DATE EVALUATED ________

ITEM NO.	MATERIAL IDENTIFICATION(2)	CONDITION(3)	APPLICATION(4) OR OTHER SPEC. NO.	EXPECTED ENVIRONMENT(5)	S.C.C. TABLE NO.	MUA NO.	NDE METHOD

NOTES:

1. List all inorganic materials (metals, ceramics, glasses, liquids and metal/ceramic composites) except bearing and lubrication materials which should be listed on Form 18-59C.
2. Give materials name, identifying number manufacturer.
   Example: a. Aluminum 6061-T6
   b. Electroless nickel plate, Enplate Ni 410, Enthone, Inc
   c. Fused silica, Corning 7940, Corning Class Works
3. Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.
   Example: a. Heat treated to Rockwell C 60 hardness, gold electroplated, brazed.
   b. Surface coated with vapor deposited aluminum and magnesium fluoride
   c. Cold worked to full hare condition, TIG welded and electroless nickel plated.
4. Give details of where on the spacecraft the material will be used (component) and its function.
   Example: Electronics box structure in attitude control system, not hermetically sealed.
5. Give the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
   Example: T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxygen

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FIGURE 7-4 INORGANIC MATERIALS AND COMPOSITES USAGE LIST

LUBRICATION USAGE LIST

SPACECRAFT______________________ SYSTEM/EXPERIMENT______________________ GSFC T/O ____________

DEVELOPED/CONTRACTOR ______________________ ADDRESS______________________

PREPARED BY______________________ PHONE ______________________ DATE PREPARED ____________

GSFC MATERIALS EVALUATOR ______________________ PHONE ____________ DATE RECEIVED ____________ DATE EVALUATED ____________

ITEM NO.	COMPONENT TYPE, SIZE MATERIAL[1]	COMPONENT MANUFACTURER & MFR. IDENTIFICATION	PROPOSED LUBRICATION SYSTEM & AMT. OF LUBRICANT	TYPE & NO. OF WEAR CYCLES[2]	SPEED, TEMP., ATM. OF OPERATION[3]	TYPE OF LOADS & AMT.	OTHER DETAILS[5]

NOTES

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

(2) CUR = continuous unidirectional rotation, CO = continuous oscillation, IR = intermittent rotation, IO = intermittent oscillation, SO = small oscillation, (<30°), LO = large oscillation (>30°), CS = continuous sliding, IS = intermittent sliding.
No. of wear cycles: A($1\text{-}10^2$), B($10^2\text{-}10^4$), C($10^4\text{-}10^6$), D($>10^6$)

(3) Speed: RPM = revs./min., OPM = oscillations/min., VS = variable speed
CPM = cm/min. (sliding applications)
Temp. of operation, max. & min., °C
Atmosphere: vacuum, air, gas, sealed or unsealed & pressure

(4) Type of loads: A = axial, R = radial, T = tangential (gear load). Give amount of load.

(5) If BB, give type and material of ball cage and number of shields and specified ball groove and ball finishes. If G, give surface treatment and hardness. If SB, give dia. of bore and width. If torque available is limited, give approx. value.

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FIGURE 7-5 LUBRICATION USAGE LIST

MATERIALS PROCESS UTILIZATION LIST

SPACECRAFT____________ SYSTEM/EXPERIMENT____________ GSFC T/O ____________

DEVELOPER/CONTRACTOR ____________ ADDRESS____________

PREPARED BY____________ PHONE ____________ DATE PREPARED____________

GSFC MATERIALS EVALUATOR ____________ PHONE ____________ DATE RECEIVED ____________ DATE EVALUATED ____________

ITEM NO.	PROCESS TYPE(1)	CONTRACTOR SPEC. NO.(2)	MIL., ASTM., FED. OR OTHER SPEC. NO.	DESCRIPTION OF MAT'L PROCESSED(3)	SPACECRAFT/EXP. APPLICATION(4)

NOTES

(1) Give generic name of process, e.g., anodizing (sulfuric acid).

(2) If process if proprietary, please state so.

(3) Identify the type and condition of the material subjected to the process.
E.g., 6061-T6

(4) Identify the component or structure of which the materials are being processed.
E.g., Antenna dish

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FIGURE 7-6 MATERIALS PROCESS UTILIZATION LIST

SECTION 8: RELIABILITY REQUIREMENTS

8.1 GENERAL REQUIREMENTS

GLAST LAT will plan and implement a reliability program that interacts effectively with other project disciplines, including systems engineering, hardware design, and product assurance. The program will be tailored according to the risk level to:

a. Demonstrate that redundant functions, including alternative paths and work-arounds, are independent to the extent practicable.

b. Demonstrate that the stress applied to parts is not excessive.

c. Identify single failure items/points, their effect on the attainment of mission objectives, and possible safety degradation.

d. Show that the reliability design aligns with mission design life and is consistent among the systems, subsystems, and components.

e. Identify limited-life items and ensure that special precautions are taken to conserve their useful life for on-orbit operations.

f. Select significant engineering parameters for the performance of trend analysis to identify performance trends during pre-launch activities.

g. Ensure that the design permits easy replacement of parts and components and that redundant paths are easily monitored.

8.2 RELIABILITY ANALYSES

Reliability analyses will be performed concurrently with the instrument's design so that identified problem areas can be addressed and correction action taken (if required) in a timely manner.

8.2.1 Failure Modes and Effects Analysis and Critical Items List

A Failure Modes and Effects Analysis (FMEA) will be performed early in the design phase to identify system design problems. As additional design information becomes available the FMEA will be refined.

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

Severity categories will be determined in accordance with Table 8-1:

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 Severity Category 1 consequences.
2	Critical Failure modes that could result in loss of one or more mission objectives as defined by the GSFC 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 8-1

SEVERITY CATEGORIES

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

Results of the FMEA will be used to evaluate the design relative to requirements (e.g., no single instrument failure will prevent removal of power from the instrument). Identified discrepancies will be evaluated by management and design groups for assessment of the need for corrective action.

The FMEA will 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.

All failure modes that are assigned to Severity Categories 1, 1R, 1S and 2, will be itemized on a Critical Items List (CIL) and maintained with the FMEA report. (Refer to the CDRL, DID 318.) Rationale for retaining the items will be included on the CIL. The FMEA and CIL will made available for GSFC Project Office review and/or audit. Results of the FMEA as well as the CIL will be presented at all design reviews starting with the PDR. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

8.2.2 Parts Stress Analyses

Each application of electrical, electronic, and electromechanical (EEE) parts, will be subjected to stress analyses for conformance with the applicable derating guidelines. (Refer to MAR Section 6.2.3.) The analyses will be performed at the most stressful values that result from specified performance and environmental requirements (e.g., temperature and voltage) on the assembly or component. The analyses will be performed in close coordination with the packaging reviews (See MAR Section 3.5.) and thermal analyses and they will be required input data for component-level design reviews. (Refer to MAR Section 3.5.) The analyses with summary sheets and updates will be maintained by GLAST LAT participates for the GSFC Project Office to review/audit. (Refer to Addendum B, Item 8.) The results of the analyses will be presented at all design reviews starting with the PDR. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

8.2.3 Worst Case Analyses

Worst Case Analyses may be performed on circuits where failure results in a severity category of 2 or higher question the flightworthiness of the design. If performed, the most sensitive design parameters, including those that are subject to variations that could degrade performance, will be subjected to the analysis. The adequacy of design margins in the electronic circuits, optics, electromechanical, and mechanical items will be demonstrated by analyses or test or both to ensure flighworthiness. This analysis (when performed) will be made available by GLAST LAT for GSFC Project Office review. (Refer to Section 15, RD 8-1.) The results of any analyses will be presented at all design reviews starting with the PDR. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

The analyses will consider all parameters set at worst case limits and worst case environmental stresses for the parameter or operation being evaluated. Depending on mission parameters and parts selection methods, part parameter values for the analysis will typically include: manufacturing variability, variability due to temperature, aging effects of environment, and variability due to cumulative radiation. If performed, the analyses and updates will be made available to GSFC Project Office for information upon request.

8.2.4 Reliability Assessments

When necessary/prudent or when agreed-upon with the GSFC Project Office, GLAST LAT will perform comparative numerical reliability assessments 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 those potential mission limiting elements and components that will require special attention in part 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

If performed, reliability assessments will be integrated with the design process and other assurance practices to maximize the probability of meeting mission success criteria. GLAST LAT will consider how the reliability assessments will incorporate definitions of failure as well as alternate and degraded operating modes that describe plausible acceptable and unacceptable levels of performance. Degraded operating modes will include failure conditions that could be alleviated or reduced significantly through the implementation of work-arounds via telemetry.

The assessments and updates, if performed, will be submitted to the GSFC Project Office for information. (Refer to Section 15, RD 8-2.) The results of any reliability assessment will be reported at PDR and CDR. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

8.3 ANALYSIS OF TEST DATA

GLAST LAT will fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas.

8.3.1 Trend Analyses

As part of the routine system assessment, GLAST LAT may assess subsystems and components to determine measurable parameters that relate to performance stability. Selected parameters may be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring will be accomplished within the normal test framework; i.e., during functional tests, environmental tests, etc. GLAST LAT may 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 may be reviewed with the operational personnel prior to launch, and the operational personnel may continue recording trends throughout mission life. If performed, a list of subsystem and components to be assessed and the parameters to be monitored and the trend analysis reports will be maintained. (Refer to Section 15, RD 8-3.)

8.3.2 Analysis of Test Results

GLAST LAT will analyze test information, trend data, and failure investigations to evaluate reliability implications. Identified problem areas may be documented and directed to the attention of GLAST LAT Project Management for action. The results of the analyses may be presented at design reviews. The presentations will include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions. (Refer to Section 15, RD 8-3.)

8.4 LIMITED-LIFE ITEMS

Limited-life items will be identified and managed by means of a Limited-Life List, which will be submitted for approval. (Refer to the CDRL, DID 319.) The list will present definitions, the impact on mission parameters, responsibilities, and a list of limited-life items, including data elements: expected life, required life, duty cycle, and rationale for selection. The useful life period starts with fabrication and ends with the completion of the final orbital mission.

The list of limited-life items should include selected structures, thermal control surfaces, solar arrays and electromechanical mechanisms. Atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue should be used to identify limited-life thermal control surfaces and structure items. Mechanisms such as batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators, and scan devices should be included when aging, wear, fatigue and lubricant degradation limit their life. Records will be maintained that allow evaluation of the cumulative stress (time and/or cycles) for limited-life items starting when useful life is initiated and indicating the project activity that will stress the items. (Refer to Sections 4.3.6 and 4.4.5.2 of this document.) The use of an item whose expected life is less than its mission design life must be approved by the GSFC Project Office by means of a program waiver.

SECTION 9: QUALITY ASSURANCE REQUIREMENTS

9.1 GENERAL REQUIREMENTS

GLAST LAT shall define and implement a Quality Management System (QMS) that is based on ANSI/ASQC Q9001-l994, *Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation, and Servicing*, that properly encompasses GLAST LAT flight hardware and software.

The ISO 9001 Quality Standard specifies requirements which determine what elements quality systems have to encompass, but it allows significant flexibility in determining which requirements actually apply and how they are implemented. It is intended that the use of the ISO 9001 Quality Standard will also allow GLAST LAT to concentrate on value-added quality activities. GLAST LAT's Quality Manual will be provided in accordance with CDRL, DID 320.

GLAST LAT intends to allow project team institutions to use their own ANSI/ASQC Q9001 compliant system and procedures to the fullest extent possible, provided the requirements of this PAIP and the associated CDRL DID's are satisfied.

9.1 QA MANAGEMENT SYSTEM REQUIREMENTS AUGMENTATION

The following requirements augment the identified portions of ANSI/ASQC Q9001-1994.

Section 4.4.4:

New on-orbit design of software and ground stations hardware shall be in accordance with original system design specifications and validation processes.

Section 4.6.3:

The supplier's QA program should ensure flow-down to all major and critical suppliers of technical requirements and a process to verify compliance.

Section 4.13.2:

The reporting of failures will begin with the first power application at the lowest level of assembly or the first operation of a mechanical item. It will continue through formal acceptance by the GSFC Project Office.

Failures will be reported to the GSFC Project Office. (Refer to the CDRL, DID 321.) The documentation provided to GSFC will include Material Review Board (MRB)/Failure Review Board (FRB) minutes and reports.

GLAST LAT review/disposition/approval of failure reports will be described in the applicable procedure(s).

SECTION 10: CONTAMINATION CONTROL REQUIREMENTS

10.1 GENERAL

GLAST LAT will plan and implement a contamination control program applicable to the hardware. The program will establish the specific cleanliness requirements and delineate the approaches in a Contamination Control Plan (CCP). (Refer to the CDRL, DID 322.)

10.2 CONTAMINATION CONTROL PLAN

GLAST LAT will prepare a CCP that describes the procedures that will be followed to control contamination. The CCP will define a contamination allowance for performance degradation of contamination sensitive hardware such that, even in the degraded state, the hardware will meet its mission objectives. The CCP will establish the implementation and describe the methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the hardware's lifetime. In general, all mission hardware should be compatible with the most contamination-sensitive components.

Performance Assurance Personnel will monitor the fabrication, assembly and testing activities for compliance with the CCP. Out of tolerance conditions will result in a request for corrective action to responsible personnel and be processed per Section 9.8 of this PAIP.

10.3 MATERIAL OUTGASSING

All materials will be screened in accordance with NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data will be established based on hardware’s operating conditions and reviewed by GSFC.

10.4 THERMAL VACUUM BAKEOUT

GLAST LAT will determine the need to perform thermal vacuum bakeouts of flight hardware. If performed, the parameters of such bakeouts (e.g., temperature, duration, and pressure) must be individualized depending on materials used, the fabrication environment, and the established contamination allowance.

10.5 HARDWARE HANDLING

GLAST LAT will practice cleanroom standards in handling hardware. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging will be addressed.

SECTION 11: SOFTWARE ASSURANCE REQUIREMENTS

11.1 GENERAL

GLAST LAT shall employ a structured program (Software Quality Management System) for the development of software**.** The program shall recognize the phases of the development life cycle (requirements analysis, design, code and unit test, integration and build test, performance verification, and maintenance) and utilize appropriate mechanisms to facilitate the development effort and ensure the quality of the product. These mechanisms include documentation, reviews, verification activities, and configuration management. The program shall encompass instrument flight software and firmware, ground test equipment software, and any software related to mission operations. Science and data analysis software are excluded from these requirements.

11.2 SOFTWARE QUALITY MANAGEMENT SYSTEM

GLAST LAT's Software Quality Management System (SQMS) will be based on the ANSI/ASQC Q9001 Quality Standard. The following activities augment the identified portions of ANSI/ISO/ASQ Q9000-3-1997 which provides guidance on the development of a SQMS that is based on ANSI/ASQC Q9001.

11.2.1 Reviews (Augmentation to Section 4.1.3, ANSI/ASQC Q9000-3)

There will be a series of GLAST LAT-presented formal reviews conducted by a GSFC-chaired review panel that will include independent experts in the type of software under review. The formal reviews will consist of, as a minimum, a Software Requirements Review (SRR), a Preliminary Design Review (PDR), a Critical Design Review (CDR), a Test Readiness Review (TRR), and an Acceptance Review (AR). These reviews will be coordinated with the reviews defined in Section 3. GLAST LAT will record minutes and action items during each review.

11.2.2 Corrective Action (Augmentation to Section 4.1, ANSI/ASQC Q9000-3)

The corrective action process will start at the establishment of a configuration management baseline that includes the product. (Refer to Section 11.2.3.) The use of the formal software corrective action process will become mandatory with the first instance of the software's delivery to testing for the verification software requirements.

GSFC personnel will be allowed access to problem reports and corrective action information as they are prepared.

11.2.3 Configuration Management (Augmentation to Section 4.8, ANSI/ASQC Q9000-3)

GLAST LAT will establish a Software Configuration Management (SCM) baseline after each formal software review. (Refer to Section 11.2.1.) Software products will be placed under configuration management immediately after the successful conclusion of each review. Informal control will be used for preliminary versions of all products before it is placed under the formal SCM system.

GLAST LAT's SCM system will have a change classification and impact assessment process that results in Class 1 changes being forwarded to the GSFC Project Office for disposition. Class 1 changes are defined as those which affect system requirements, software requirements, system safety, reliability, cost, schedule, and external interfaces.

11.2.4 Inspection and Testing (Augmentation to Section 4.10.4, ANSI/ASQC Q9000-3)

As part of GLAST LAT's effort to verify to the Government that their software is flightworthy, GLAST LAT may prepare and maintain a software performance verification matrix. If this document is prepared, an up-to date version will be provided to the GSFC Project Office upon request. (Refer to Section 15, RD 11-1.) If a matrix is prepared, as a minimum, it will include:

a. How each specification requirement will be verified
b. The reference source (to the specific paragraph or line item)
c. The method of compliance
d. The applicable procedure references
e Verification results
f. Report reference numbers

11.2.5 Final Inspection and Testing (Augmentation to Section 4.10.4, ANSI/ASOC Q9000-3)

As part of GLAST LAT's effort to verify to the GSFC Project Office that their software is flightworthy, GLAST LAT and the GSFC Project Office may conduct a Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA) on the final delivered product and on major upgrades (defined as the change of 20% or more of the lines of code) to that product upon their mutual agreement. GLAST LAT will provide the results of any audit(s) to the GSFC Project Office. (Refer to Section 15, RD 11-2.)

11.2.6 Statistical Techniques (Augmentation to Section 4.20, ANSI/ASOC Q9000-3)

GLAST LAT will provide a copy of their source code, using a format and media that will be negotiated between GLAST LAT and the GSFC Project Office. This source code will be analyzed by GSFC's Software Assurance Technology Center, using statistical techniques, to provide software metrics and an associated report for Project and GLAST LAT usage. This information will provide insight into the quality of the GLAST LAT's software development processes and software products. (Refer to Addendum B, Item 9.)

11.3 GFE, Existing and Purchased Software

If software will be provided to GLAST LAT as government-furnished equipment (GFE) or if GLAST LAT will use existing or purchased software; GLAST LAT is responsible for the software meeting the functional, performance, and interface requirements placed upon it. GLAST LAT is also responsible for ensuring that the software meets all applicable standards, including those for design, code, and documentation; or for securing a project waiver to those standards. Any significant modification to any piece of the existing software will be subject to all of the provisions of the GLAST LAT's SQMS and the provisions of this document. A significant modification is defined as the change of twenty percent of the lines of code in the software.

11.4 SOFTWARE SAFETY

If any software component is identified as safety critical, GLAST LAT will conduct a software safety program on that component that complies with NSS 1740.13 "Software Safety Standard".

11.5 STATUS REPORTING

GLAST LAT may provide status reports to the GSFC Project Office to provide management insight into software development progress, issues, problems, actions taken, and schedules. This information may be included in GLAST LAT's Progress Reports to the Project or it may be presented at the quarterly status reviews. (Refer to Section 15, RD 11-3.)

SECTION 12: RISK MANAGEMENT REQUIREMENTS

12.1 GENERAL REQUIREMENTS

GLAST LAT will develop and implement a project-specific Risk Management Plan as a means to anticipate, mitigate and control risks and to focus project resources where they are needed to ensure success of the project. The NPG 7120.5A, NASA Program and Project Management Processes and Requirements, is the controlling requirements/guideline used in the preparation of this plan. (Refer to CDRL, DID 323.)

The primary activities of the GLAST LAT Continuous Risk Management process are:

a. Search for, locate, identify, and document reliability and quality risks before they become problems
b. Evaluate, classify, and prioritize all identified reliability and quality risks
c. Develop and implement risk mitigation strategies, actions, and tasks and assign appropriate resources.
d. Track risk being mitigated; capture risk attributes and mitigation information by collecting data; establish performance metrics; and examine trends, deviations, and anomalies
e. Control risks by performing: risk close-out, re-planning, contingency planning, or continued tracking and execution of the current plan
f. Communicate and document (via the risk recording, reporting, and monitoring system) risk information to ensure it is conveyed between all levels of the project
g. Report on outstanding risk items at all management and design reviews. The GSFC Project Office, the GSFC Systems Review Office (for design reviews only), and GLAST LAT will agree on what level of detail is appropriate for each review.

All identified reliability and quality risks will be documented and reported on in accordance with the GLAST LAT Risk Management Plan. Although not all risks will be fully mitigated, all risks shall be addressed with mitigation and acceptance strategies agreed upon at appropriate mission reviews.

12.2 PROBABILISTIC RISK ASSESSMENT (PRA)

GLAST LAT will provide all requested/required information to GSFC so that the Government can perform a Probabilistic Risk Assessment (PRA) for their hardware and software. (Refer to the CDRL, DID 324.) It will take into account a Fault Tree Analysis which the Government will also prepare with information provided by the GLAST LAT. (Refer to the CDRL, DID 325.) The information required will include parts lists (CDRL, DID 310) and schematics. Additionally, GLAST LAT will cooperate with the GSFC Project Office as required to prepare these documents.

12.3 RISK ASSESSMENT

GLAST LAT will provide all requested/required information to the GSFC Project Office so that the GSFC Project Office can perform an on-going risk assessment of the program including flight hardware and software. (Refer to the CDRL, DID 326.) Additionally, GLAST LAT will cooperate with the GSFC Project Office as required to prepare this assessment.

SECTION 13. APPLICABLE DOCUMENTS LIST

DOCUMENT	DOCUMENT TITLE
ANSI/ASQC Q9001-1994	Model for Quality Assurance in Design, Development, Production, Installation, and Servicing
ANSI/ASQOC Q9000-3	Quality Management and Quality Assurance Standards
ANSI/IPC-A-600	Acceptance Criteria for Printed Wiring Boards
ANSI/IPC-D-275	Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies
ANSI/IPC-HF 318	Microwave End Product Board Inspection and Test
ANSI/IPC-RB-276	Qualification and Performance Specification for Rigid Printed Boards
ASTM E-595	Total Mass Loss (TML) and Collected Volatile Condensable Materials (CVCM) from Outgassing in a Vacuum Environment
EWR 127-1	Eastern and Western Range Safety Requirements
KHB 1710.2D	Kennedy Space Center Safety Practices Handbook
NPD 8710.3	NASA Policy for Limiting Orbital Debris Generation
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components, rev A, dated June 1996
5405-048-98	Mechanical Systems Center Safety Manual
GSFC 311-INST-001	Instructions for EEE Parts Selection, Screening, and Qualification
GSFC 731-0005-83	General Fracture Control Plan for Payloads Using the Space Transportation System (STS)
GSFC PPL	Goddard Space Flight Center Preferred Parts List
GSFC S-312-P003	Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
GSFC S-313-100	Goddard Space Flight Center Fastener Integrity Requirements
MIL-STD 1629A	Procedures for Performing a Failure Mode Effects and Criticality Analysis
MIL-STD-756B	Reliability Modeling and Prediction
MSFC CR 5320.9	Payload and Experiment Failure Mode Effects Analysis and Critical Items List Ground Rules
MSFC-HDBK-527	Material Selection List for Space Hardware Systems
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking

NASA Reference Publication (RP) 1124	Outgassing Data for Selecting Spacecraft Materials
NASA RP-1161	Evaluation of Multi-layer Printed Wiring Boards by Metallographic Techniques
NHB 1700.7	Safety Policy and Requirements for Payloads using the Space Transportation System
NHB 8060.1	Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion
NSS 1740.13	Software Safety Standard
NSTS 1700.7B	Safety Policy and Requirements for Payloads using the International Space Station
NSTS 22648	Flammability Configuration Analysis for Spacecraft Applications
S-302-89-01	Procedures for Performing a Failure Mode and Effects Analysis (FMEA)
S-311-M-70	Specification for Destructive Physical Analysis

SECTION 14. ACRONYMS and GLOSSARY

14.1 ACRONYMS

ABPL	As-Built Parts List
ANSI	American National Standards Institute
AR	Acceptance Review
ASQC	American Society for Quality Control
ASIC	Application Specific Integrated Circuits
BOL	Beginning of Life
CCP	Contamination Control Plan
CDR	Critical Design Review
CDRL	Contract Delivery Requirements List
CIL	Critical Items List
CPT	Comprehensive Performance Test
CVCM	Collected Volatile Condensable Mass
DID	Data Item Description
DoD	Department of Defense
DPA	Destructive Physical Analysis
DRP	Design Review Program
DRT	Design Review Team
EEE	Electrical, Electronic, and Electromechanical
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EOL	End of Life
FMEA	Failure Modes and Effects Analysis
FOR	Flight Operations Review
FTA	Fault Tree Analysis
GEVS	General Environmental Verification Specification
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components
GFE	Government-Furnished Equipment
GIA	Government Inspection Agency
GIDEP	Government Industry Data Exchange Program
GMI	Goddard Management Instruction
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
IAC	Independent Assurance Contractor
ICD	Interface Control Document
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
LPT	Limited Performance Test
LRR	Launch Readiness Review
MAG	Mission Assurance Guidelines
MCM	Multi-Chip Module

MO&DSD	Mission Operations and Data Systems Directorate
MOR	Mission Operations Review
MSFC	Marshall Space Flight Center
MSR	Management Status Report
MUA	Materials Usage Agreement
NAS	NASA Assurance Standard
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications Network
NHB	NASA Handbook
NSTS	National Space Transportation System
OSSMA	GSFC Office of Systems Safety and Mission Assurance
PAPL	Project Approved Parts List
PMCB	Parts Control Board
PCP	Parts Control Plan
PDR	Preliminary Design Review
PER	Pre-Environmental Review
PFR	Problem/Failure Report
PI	Principal Investigator
PIL	Parts Identification List
POCC	Payload Operations Control Center
PPL	Preferred Parts List
PRA	Probabilistic Risk Assessment
PSR	Pre-Shipment Review
PWB	Printed Wiring Board
QCM	Quartz Crystal Microbalance
RD	Recommended Documentation
RFP	Request for Proposal
RH	Relative Humidity
S&MA	(System) Safety and Mission Assurance
SAM	Systems Assurance Manager
SCC	Stress Corrosion Cracking
SCD	Source Control Drawing
SCM	Software Configuration Management
SCR	System Concept Review
SI-SC IRD	Science Instrument - Spacecraft Interface Requirements Document
SOCC	Simulations Operations Control Center
SOW	Statement of Work
SQMS	Software Quality Management System
SRO	Systems Review Office
SRR	Software Requirements Review
STS	Space Transportation System (Shuttle)
TML	Total Mass Loss
TR	Torque Ratio
TRR	Test Readiness Review

14.2 DEFINITIONS

The following definitions apply within the context of this document:

Acceptance Tests: The validation process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract.

Assembly: See Level of Assembly.

Audit: A review of the developer's, contractor's or subcontractor's documentation or hardware to verify that it complies with project requirements.

Collected Volatile Condensable Material (CVCM): The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time.

Component: See Level of Assembly.

Configuration: The functional and physical characteristics of the payload and all its integral parts, assemblies and systems that are capable of fulfilling the fit, form and functional requirements defined by performance specifications and engineering drawings.

Configuration Control: The systematic evaluation, coordination, and formal approval/disapproval of proposed changes and implementation of all approved changes to the design and production of an item the configuration of which has been formally approved by the contractor or by the purchaser, or both.

Configuration Management: The systematic control and evaluation of all changes to baseline documentation and subsequent changes to that documentation which define the original scope of effort to be accomplished (CDRL and reference documentation) and the systematic control, identification, status accounting and verification of all configuration items.

Contamination: The presence of materials of molecular or particulate nature which degrade the performance of hardware.

Derating: The reduction of the applied load (or rating) of a device to improve reliability or to permit operation at high ambient temperatures.

Design Specification: Generic designation for a specification that describes functional and physical requirements for an article, usually at the component level or higher levels of assembly. In its initial form, the design specification is a statement of functional requirements with only general coverage of physical and test requirements. The design specification evolves through the project life cycle to reflect progressive refinements in performance, design, configuration, and test requirements. In many projects the end-item specifications serve all the purposes of design specifications for the contract end-items. Design specifications provide the basis for technical and engineering management control.

Designated Representative: An individual (such as a NASA plant representative), firm (such as assessment contractor), Department of Defense (DOD) plant representative, or other government representative designated and authorized by NASA to perform a specific function for NASA. As related to the contractor's effort, this may include evaluation, assessment, design review, participation, and review/approval of certain documents or actions.

Destructive Physical Analysis (DPA): An internal destructive examination of a finished part or device to assess design, workmanship, assembly, and any other processing associated with fabrication of the part.

Discrepancy: See Nonconformance.

Design Qualification Tests: Tests intended to demonstrate that the test item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch, and orbital operations. Their purpose is to uncover deficiencies in design and method of manufacture. They are not intended to exceed design safety margins or to introduce unrealistic modes of failure. The design qualification tests may be to either “prototype” or “protoflight” test levels.

Discrepancy: See Nonconformance

Electromagnetic Compatibility (EMC): The condition that prevails when various electronic devices are performing their functions according to design in a common electromagnetic environment.

Electromagnetic Interference (EMI): Electromagnetic energy which interrupts, obstructs, or otherwise degrades or limits the effective performance of electrical equipment.

Electromagnetic Susceptibility: Undesired response by a component, subsystem, or system to conducted or radiated electromagnetic emissions.

End-to-End Tests: Tests performed on the integrated ground and flight system, including all elements of the payload, its control, stimulation, communications, and data processing to demonstrate that the entire system is operating in a manner to fulfill all mission requirements and objectives.

Failure: A departure from specification that is discovered in the functioning or operation of the hardware or software. See nonconformance.

Failure Free Hours of Operation: The number of consecutive hours of operation without failure the hardware and/or software (as appropriate) accumulated without an operating problem or anomaly since the last major hardware/software change (as appropriate), problem, or anomaly. Hours may be accumulated over various stages of hardware integration. (Refer to Section 4.3.5.)

Failure Modes and Effects Analysis (FMEA): A procedure by which each credible failure mode of each item from a low indenture level to the highest is analyzed to determine the effects on the system and to classify each potential failure mode in accordance with the severity of its effect.

Flight Acceptance: See Acceptance Tests.

Fracture Control Program: A systematic project activity to ensure that a payload intended for flight has sufficient structural integrity as to present no critical or catastrophic hazard. Also to ensure quality of performance in the structural area for any payload (spacecraft) project. Central to the program is fracture control analysis, which includes the concepts of fail-safe and safe-life, defined as follows:

Fail-safe: Ensures that a structural element, because of structural redundancy, will not cause collapse of the remaining structure or have any detrimental effects on mission performance.

Safe-life: Ensures that the largest flaw that could remain undetected after non-destructive examination would not grow to failure during the mission.

Functional Tests: The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

Hardware: As used in this document, there are two major categories of hardware as follows:

Prototype Hardware: Hardware of a new design; it is subject to a design qualification test program; it is not intended for flight.

Flight Hardware: Hardware to be used operationally in space. It includes the following subsets:

Protoflight Hardware: Flight hardware of a new design; it is subject to a qualification test program that combines elements of prototype and flight acceptance validation; that is, the application of design qualification test levels and duration of flight acceptance tests.

Follow-On Hardware: Flight hardware built in accordance with a design that has been qualified either as prototype or as protoflight hardware; follow-on hardware is subject to a flight acceptance test program.

Spare Hardware: Hardware the design of which has been proven in a design qualification test program; it is subject to a flight acceptance test program and is used to replace flight hardware that is no longer acceptable for flight.

Re-flight Hardware: Flight hardware that has been used operationally in space and is to be reused in the same way; the validation program to which it is subject depends on its past performance, current status, and the upcoming mission.

Inspection: The process of measuring, examining, gauging, or otherwise comparing an article or service with specified requirements.

Instrument: See Level of Assembly.

Level of Assembly: The environmental test requirements of GEVS generally start at the component or unit level assembly and continue hardware/software build through the system level (referred to in GEVS as the payload or spacecraft level). The assurance program includes the part level. Validation testing may also include testing at the assembly and subassembly levels of assembly; for test record keeping these levels are combined into a "subassembly" level. The validation program continues through launch, and on-orbit performance. The following levels of assembly are used for describing test and analysis configurations:

Part: A hardware element that is not normally subject to further subdivision or disassembly without destruction of design use. Examples include resistor, integrated circuit, relay, connector, bolt, and gaskets.

Subassembly: A subdivision of an assembly. Examples are wire harness and loaded printed circuit boards.

Assembly: A functional subdivision of a component consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole. Examples are a power amplifier and gyroscope.

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

Section: A structurally integrated set of components and integrating hardware that form a subdivision of a subsystem, module, etc. A section forms a testable level of assembly, such as components/units mounted into a structural mounting tray or panel-like assembly, or components that are stacked.

Subsystem: A functional subdivision of a payload consisting of two or more components. Examples are structural, attitude control, electrical power, and communication subsystems. Also included as subsystems of the payload are the science instruments or experiments.

Instrument: A spacecraft subsystem consisting of sensors and associated hardware for making measurements or observations in space. For the purposes of this document, an instrument is considered a subsystem (of the spacecraft).

Module: A major subdivision of the payload that is viewed as a physical and functional entity for the purposes of analysis, manufacturing, testing, and record keeping. Examples include spacecraft bus, science payload, and upper stage vehicle.

Observatory: See Spacecraft.

Payload: An integrated assemblage of modules, subsystems, etc., designed to perform a specified mission in space. For the purposes of this document, "payload" and "spacecraft" are used interchangeably. Other terms used to designate this level of assembly are Laboratory, Observatory, and satellite.

Spacecraft: See Payload. Other terms used to designate this level of assembly are laboratory, observatory, and satellite.

Limit Level: The maximum expected flight.

Limited Life Items: Spaceflight hardware (1) that has an expected failure-free life that is less than the projected mission life, when considering cumulative ground operation, storage and on-orbit operation, (2) limited shelf life material used to fabricate flight hardware.

Margin: The amount by which hardware capability exceeds mission requirements

Module: See Level of Assembly.

Monitor: To keep track of the progress of a performance assurance activity; the monitor need not be present at the scene during the entire course of the activity, but he will review resulting data or other associated documentation (see Witness).

Nonconformance: A condition of any hardware, software, material, or service in which one or more characteristics do not conform to requirements. As applied in quality assurance, nonconformances fall into two categories--discrepancies and failures. A discrepancy is a departure from specification that is detected during inspection or process control testing, etc., while the hardware or software is not functioning or operating. A failure is a departure from specification that is discovered in the functioning or operation of the hardware or software.

Offgassing: The emanation of volatile matter of any kind from materials into a manned pressurized volume.

Outgassing: The emanation of volatile materials under vacuum conditions resulting in a mass loss and/or material condensation on nearby surfaces.

Part: See Level of Assembly.

Payload: See Level of Assembly.

Performance Operating Time/Hours: The number of hours or amount of time that the hardware or software (as appropriated) was operated at any level of assembly or at a particular level of assembly as defined.

Performance Validation: Determination by test, analysis, or a combination of the two that the payload element can operate as intended in a particular mission; this includes being satisfied that the design of the payload or element has been qualified and that the particular item has been accepted as true to the design and ready for flight operations.

Protoflight Testing: See Hardware.

Prototype Testing: See Hardware.

Qualification: See Design Qualification Tests.

Redundancy (of design): The use of more than one independent means of accomplishing a given function.

Repair: A corrective maintenance action performed as a result of a failure so as to restore an item to op within specified limits.

Rework: Return for completion of operations (complete to drawing). The article is to be reprocessed to conform to the original specifications or drawings.

Section: See Level of Assembly.

Similarity, Validation By: A procedure of comparing an item to a similar one that has been verified. Configuration, test data, application, and environment should be evaluated. It should be determined that design-differences are insignificant, environmental stress will not be greater in the new application, and that manufacturer and manufacturing methods are the same.

Single Point Failure: A single element of hardware the failure of which would result in loss of mission objectives, hardware, or crew, as defined for the specific application or project for which a single point failure analysis is performed.

Spacecraft: See Level of Assembly.

Subassembly: See Level of Assembly.

Subsystem: See Level of Assembly.

Temperature Cycle: A transition from some initial temperature condition to temperature stabilization at one extreme and then to temperature stabilization at the opposite extreme and returning to the initial temperature condition.

Temperature Stabilization: The condition that exists when the rate of change of temperatures has decreased to the point where the test item may be expected to remain within the specified test tolerance for the necessary duration or where further change is considered acceptable.

Thermal Balance Test: A test conducted to verify the adequacy of the thermal model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

Thermal-Vacuum Test: A test conducted to demonstrate the capability of the test item to operate satisfactorily in vacuum at temperatures based on those expected for the mission. The test, including the gradient shifts induced by cycling between temperature extremes, can also uncover latent defects in design, parts, and workmanship.

Torque Margin: Torque margin is equal to the torque ratio minus one.

Torque Ratio: Torque ratio is a measure of the degree to which the torque available to accomplish a mechanical function exceeds the torque required.

Total Mass Loss (TML): Total mass of material outgassed from a specimen that is maintained at a specified constant temperature and operating pressure for a specified time.

Unit: See Level of Assembly.

Validation: See Performance Validation.

Vibroacoustics: An environment induced by high-intensity acoustic noise associated with various segments of the flight profile; it manifests itself throughout the payload in the form of directly transmitted acoustic excitation and as structure-borne random vibration.

Workmanship Tests: Tests performed during the environmental validation program to verify adequate workmanship in the construction of a test item. It is often necessary to impose stresses beyond those predicted for the mission in order to uncover defects. Thus random vibration tests are conducted specifically to detect bad solder joints, loose or missing fasteners, improperly mounted parts, etc. Cycling between temperature extremes during thermal-vacuum testing and the presence of electromagnetic interference during EMC testing can also reveal the lack of proper construction and adequate workmanship.

Witness: A personal, on-the-scene observation of a performance assurance activity with the purpose of verifying compliance with project requirements (see Monitor).

SECTION 15. RECOMMENDED DOCUMENTATION (RD) DESCRIPTIONS

RD NO.	DESCRIPTION	REFERENCES SECTIONS
1-1	Use of Multi-Mission of Previously Designed, Fabricated, or Flown Hardware	1.2
5-1	Technology Validation Assessment Plan (TVAP)	5-3
7-1	Stress Corrosion Evaluation Form	7.2.2, 7.2.6
7-2	Non-conventional Material and Lubrication Report	7.2.4
7-3	Material Waiver	7.2.5.3
7-4	Life Test Plan for Lubricated Mechanisms	7.2.7, 7.4
7-5	Materials Test Report for Fastener Lots	7.2.6.1
7-6	Fastener Control Plan	7.2.6.1
7-7	Certificate of Raw Material Compliance	7.4.1
8-1	Worst Case Analysis	8.2.3
8-2	Reliability Assessments	8.2.4
8-3	Trend Analysis	8.3.1
11-1	Software Performance Validation Matrix	11.2.4
11-2	Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA) Results	11.2.5
11-3	Monthly Software Status Reports	11.5

Preface

The reference documentation (RD's) listed below are not contractual deliverables. (Note: The S&MA deliverables are listed in the LAT CDRL.) These RD's represent documentation that NASA requires on most flight programs. Although this information is not required (i.e., a formal deliverable) from the LAT developer, it is highly recommended that the developer prepare/utilize the listed documents to help ensure the flightworthiness of LAT hardware and software. In other words, NASA recommends, but does not require, the developer to prepare and utilize this documentation in the design and development of their hardware and/or software.

It is highly recommended that the developer discuss their need for preparing the documentation listed in this chapter internally and with NASA to determine if it is appropriate, necessary, and/or prudent to prepare (formally or informally) any of the items below to ensure the flightworthiness of their hardware and/or software.

In some case, NASA may request for that specific information listed in an item below be delivered to NASA, or available at the developer's site, for NASA's review to ensure the flightworthiness of a particular software or hardware item. For example, a "Material Wavier" or "Non-conventional Material and Lubrication Report" may be requested by NASA for a particular material on a LAT Materials List in order for that item or the list to be approved by NASA for flight. For other items listed below, if the developer elects to perform a WCA (for example) on a particular portion of the LAT design, NASA could request the option of reviewing the analysis for information. Or, if NASA sees a need for a WCA on a particular portion of the LAT design in order to ensure its flightworthiness, NASA might either request that the developer perform the WCA or that the developer provide the information for NASA to perform the WCA, as agreed upon by the developer and NASA.

Under no circumstances will NASA unilaterally redefine one of the items listed below as a mandatory formal deliverable item; however, NASA may state that the developer needs to provide all or part of the information required in one of the documents listed below in order for NASA to verify with confidence the flightworthiness of a hardware or software item. As agreed upon by the developer and NASA for each individual request, the information may:

a. Be delivered to GSFC or reviewed/surveyed/audited at the developer's (or one of their collaborator's) site
b. Be prepared as an informal or formal (i.e., unformatted or formatted) document, memo, electronic mail (e-mail), etc. or transmitted via a conversation
d. Include all of the information listed in the item below (e.g., a Material Waiver) or only those bits of information deemed essential for NASA's review

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RD Number	1-1
RD Title	Use of Multi-Mission or Previously Designed, Fabricated, or Flown Hardware
Use	Demonstrate how existing design/hardware complies with current assurance and performance requirements, thereby eliminating the need to perform identified tasks otherwise required.
References	None
Timing/Purpose	If prepared, it should be available 60 days prior to PDR for GSFC information.
Preparation	For each identified existing design or hardware configuration considered to be in some degree of compliance with current requirements as a result of demonstrated compliance with previous requirements: a. Compare each performance, design, environmental, and interface requirement (including margins) for the GLAST Project (as delineated in other related GLAST documents) with the corresponding previous requirement. For any mission requirement or environmental difference from the previous use, either describe the modifications to be made to the hardware and/or software to meet Project requirements or provide a rationale and supporting information demonstrating why use without modification is considered acceptable.

b. Compare each performance assurance requirement for GLAST with the corresponding previous requirement. Also, identify all waivers and deviations from the performance assurance requirements accepted on the previous project. For any requirement of the previous project that does not comply with the requirements of GLAST or for any previous deviation or waiver, describe what will be done to achieve compliance or provide a rationale and supporting information demonstrating why the difference is acceptable. In addition, indicate how any modifications proposed as a result of "a" above will be shown to comply with the performance assurance requirements of this Project.

c. Compare the manufacturing information for the hardware proposed for GLAST with that of the prior hardware. This will include, as a minimum, the name and location of the manufacturer, the date of manufacture, any design changes, any changes to parts or materials, any modification to packaging techniques, and any changes to fabrication or assembly controls or processes.

d. Describe all ground and flight experience with the proposed hardware and software including a description of all failures or anomalies, their cause, and any corrective action that was taken as a result.

RD Number	5-1
RD Title	Technology Validation Assessment Plan (TVAP)
Use	Assessment of new and/or advanced packaging technologies that have not been used in space flight applications.
References	MAR Section 5.3
Timing/Purpose	If prepared, provide to the developer's Parts Control Board for review and approval within 30 days after technology selection or initiation of development. If prepared, a copy should be made available to GSFC and updates for major changes should also be made available to GSFC prior to performing validation steps, screens, and tests.
Preparation	A TVAP should be prepared for each new and advanced packaging technology being used. The TVAP describes the validation process steps used to assure that the new technology meets the performance requirements of the flight environment and application. A TVAP should include the following as a minimum: a. Packaging/advanced interconnection description, generic type, and manufacturer b. Identification of TVAP validation steps, screens, and tests to be imposed to validate the technology c. Schematics of the internal and external dimensions of the technology d. Identification of the types of materials used in the manufacture of the technology e. Description of the design application for the technology and critical performance parameters Any format may be used to provide the above information; however, all submissions to GSFC should be in a computer readable form and easily printable. Updates to previously submitted TVAP's should identify changes from the previous submission. Updates should be provided whenever major changes to items 2b, 2c, 2d, or 2e occur.

RD Number	7-1
RD Title	Stress Corrosion Evaluation Form
Use	Provide detailed stress corrosion cracking engineering information required to demonstrate the successful flight of the material usage.
References	MAR Sections 7.2.2 and 7.2.6; MSFC -SPEC-522, MSFC-HDBK-527, NHB 1700.7, GMI 1700.3
Timing/Purpose	When prepared, provide to the GSFC Project Office with the Inorganic Materials Usage List 30 days before the contractor's PDR, 30 days before contractor's CDRL, and 30 days before acceptance List. Used to provide additional information to GSFC for the approval of the inorganic materials usage list.

Preparation	In order to facilitate GSFC's acceptance of the developer's Material Usage List, the developer should provide the information requested on the stress corrosion evaluation form (Figure 7-2 of this document) or an equivalent developer's form. Alternatively, the information may be provided electronically. The stress corrosion evaluation form requires, as a minimum, the following information: part number, part name next assembly number, manufacturer, material heat treatment, size and form, sustained tensile stresses, magnitude and direction, process residual stress, assembly stress, design stress, static stress, special processing, weld alloy form, temper of parent weldment metal, weld filler alloy, welding process, weld bead removal (if any), post-weld thermal treatment, post-weld stress relief, environment, protective finish, function of part, effect of failure, and evaluation of stress corrosion susceptibility.

RD Number	7-2
RD Title	Non-conventional Material and Lubrication Report
Use	Provide to the GSFC Project Office for approval 30 days prior to CDR.
References	MAR Section 7.2.4
Timing/Purpose	If a compliant material is proposed for a first time usage or application in space or an application with limited heritage, it is considered a non-conventional material application and a non-compliant material. For example, a beryllium instrument frame or a silicone carbide spacecraft structure are non-conventional applications. This report is then used to provide additional information to GSFC for the evaluation of the non-conventional material or lubricant usage.
Preparation	A non-conventional material application report or presentation should contain: a. Description of the application b. Thermal, stress and fracture analysis c. Heritage and test environment d. Rationale for not using a conventional material application with extensive heritage e. List of chemical and mechanical materials properties available and needed for design f. Extreme environments such high stresses, temperature, corrosive environments, high atomic oxygen fluxes at low earth orbit.

RD Number	7-3
RD Title	Material Waiver
Use	For usage evaluation and approval of a material that has exceeded its shelf life or expiration date.
References	MAR Section 7.2.5.3
Timing/Purpose	A waiver should be submitted for approval of uncured polymers that exceeded their expiration date or for flight approval of cured polymers and lubricated mechanism that have a limited shelf life. When prepared, provide to the GSFC Project Office for approval 30 days prior to the CDR or use.
Preparation	For uncured polymers, the mechanical and physical properties of polymer or paint samples should be measured and recorded from the same batch of material. A sample and/or test data for identical expired, uncured polymer or paint should be submitted to GSFC to demonstrate/verify that the cured paint or polymer is acceptable for flight. For lubricated mechanisms and old polymer products such as o-rings, propellant tank diaphragms, seals dampers and tapes; mechanical and physical property data, test results, and heritage performance information should be submitted to GSFC to demonstrate the flight acceptability of the hardware.

RD Number	7-4
RD Title	Life Test Plan for Lubricated Mechanisms
Use	For evaluation of all lubricated mechanisms.
References	MAR Sections 7.2.7 and 7.4
Timing/Purpose	If prepared, provide to GSFC 30 days before PDR, 30 days before CDR, and 30 days before acceptance of the lubricated mechanism for flight.
Preparation	The Life Test Plan for Lubricated Mechanisms should contain: a. Table of Contents b. Description of all lubricated mechanisms, performance functions, summary of subsystem specifications, and life requirements c. Heritage of identical mechanisms and descriptions of identical applications d. Design, drawings and lubrication system utilized by the mechanism e. Test plan including vacuum, temperature, and vibration test environmental conditions of the test f. Criteria for a successful test g. Delivery of test hardware to GSFC after a successful test h. Final Report.

RD Number	7-5
RD Title	Material Test Report for Fastener Lots
Use	For evaluation of fasteners to verify their flightworthiness.
References	MAR Section 7.2.6.1; GSFC S-313-100
Timing/Purpose	If available/prepared provide report 15 days after GSFC's request.
Preparation	As requested by GSFC, provide materials test reports for fastener applications along with information that ties the material test report to the application (e.g., parts lists and drawings).

RD Number	7-6
RD Title	Fastener Control Plan
Use	For evaluation of fasteners to verify their flightworthiness.
References	MAR Section 7.2.6.1; GSFC S-313-100, NHB 1700.7, GSFC 731-0005-83, GMI 1700.3
Timing/Purpose	If prepared, provide 30 days before the PDR.
Preparation	If prepared, the developer's fastener control plan should address the following for flight hardware threaded fasteners that are used in structural or critical applications: a. Acquisition/supplier control b. Documentation c. Traceability d. Receiving inspection e. Testing

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RD Number	7-7
RD Title	Certificate of Raw Material Compliance
Use	For information to assure acceptable flaw content, chemical composition, and physical properties of raw materials.
References	MAR Section 7.4.1
Timing/Purpose	If available, provide to the GSFC Project 15 days after request.
Preparation	Provide available information pertaining to the control of raw material including sufficient information to ensure that the supplied material meets the specified requirements. The submission should indicate the subsystem or part using the material. The generic and manufacturer's designation (if any) should be provided for the material including the type of test employed to verify material composition. The provider should indicate what tests have been performed to verify physical properties and the applicable standards controlling the testing. For example, the heat treatment condition of aluminum alloys may be verified by mechanical testing or hardness and conductivity testing. The provider should also indicate what nondestructive tests have been performed, the applicable standards controlling the testing, the type of flaw detected, and the minimum detectable flaw found as a result of the testing.

RD Number	8-1
RD Title	Worst Case Analysis (WCA)
Use	To assist the developer and NASA in making reliability/design decisions. It may be used as input for other reliability/risk analyses.
References	MAR Section 8.2.3
Timing/Purpose	When prepared, the WCA should be available to GSFC, for information, upon request including at PDR and CDR. Similarly, updates should be made available to GSFC, for information, upon request.
Preparation	A WCA is performed on circuits where failure results in a severity category of 2 or higher. The most sensitive design parameters, including those that are subject to variations that could degrade performance, should be subjected to the analysis. Adequacy of margins in the design of electronic circuits, optics, electromechanical and mechanical items should be demonstrated by analyses or test or both. The analyses should consider all parameters set at worst case limits and worst case environmental stresses for the parameter or operation being evaluated. Depending on mission parameters and parts selection methods, part parameter values for the analysis typically include the following: manufacturing variability, variability due to temperature, aging effects of environment, and variability due to cumulative radiation. The analyses should be updated to account for design changes.

RD Number	8-2
RD Title	Reliability Assessments
Use	To assist in evaluating alternative designs and to identify potential mission limiting elements that may require special attention.
References	MAR Section 8.2.4
Timing/Purpose	If performed, available upon request including at PDR and CDR for information.
Preparation	A reliability assessment report documents the methodology and results of the comparative reliability assessment guidelines delineated in Section 8.2.4 of this document including mathematical models, reliability block diagrams, failure definitions, degraded operating modes, trade-offs, assumptions, and any other pertinent information used in the assessment process. Note: The format of the report is not important but it should incorporate good engineering practices and clearly show how reliability was considered as a discriminator in the design process.

RD Number	8-3
RD Title	Trend Analysis
Use	To monitor, throughout the normal test program, parameters on components and subsystems that relate to performance stability (i.e., to any deviations from the nominal that could indicate trends). Operational personnel should continue monitoring trends throughout the mission duration.
References	MAR Section 8.3.1
Timing/Purpose	A list of the parameters that will be monitored should be delivered at CDR (and as updates become available) for information. Trend analysis reports should then be provided to GSFC at PER and FRR for information.
Preparation	A list of the parameters that will be monitored and updates to the list and trend reports should be prepared in accordance with Section 7.3.1 of this document. Additionally, a log should be kept for each subsystem (or for the instrument) of the accumulated operating time. The log should include the following minimum information: a. Identification b. Serial number c. Total operating time since assembly of unit d. Total operating time since last failure e. Total additional operating time projected for the unit prior to launch

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RD Number	11-1
RD Title	Software Performance Verification Matrix
Use	Used to aid in the verification of software requirements.
References	MAR Section 11.2.4
Timing/Purpose	If prepared, the first delivery should be at PDR. Subsequently, the matrix should be delivered to GSFC as it is updated for changes in requirements and verification.
Preparation	As a minimum, this matrix should include: a. How each specification requirement will be verified b. The references source (to the specific paragraph or line item) c. The method of compliance d. The applicable procedure references e Verification results f. Report references numbers

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RD Number	11-2
RD Title	Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA) Results
Use	Conducted to verify that the functional and performance characteristics of the software end item that were specified have been achieved. A PCA is a technical examination of the "as built" end item to verify that it conforms to existing technical documentation.
References	MAR Section 11.2.5
Timing/Purpose	If a FCA and/or PCA is performed, FCA and PCA information should be available at the Acceptance Review.
Preparation	FCA information should include a description of the tests run, number of tests run, number completed, number passed/failed/partial, listing of deviations and waivers, and identification of discrepancies outstanding from the testing, and actions to be taken to correct them. PCA information should include identification of the baseline for the “to be shipped” end item such as end item identification and listing of supporting documentation (e.g., present version and revision level). This would include such things as the software a Version Description Document.

RD Number	11-3
RD Title	Monthly Software Status Reports
Use	To report on software development progress.
References	MAR Section 11.5
Timing/Purpose	If prepared, due to GSFC on or before the 10th calendar day of each month.
Preparation	The report will address the status of the software development progress, the identification of risks with the mitigation action being taken, problems and corrective action being taken, issues, and schedules.

ADDENDUM A: GROUND DATA SYSTEMS ASSURANCE REQUIREMENTS

This addendum will be negotiated between the developer and the NASA/GSFC. It will be modeled after Chapter 12 of the GSFC MAG. Thus, it will cover:

1 Introduction
2 General
3 GFE, Existing and Purchased Software
4 Hardware
5 Validation
6 Testing
7 Corrective Action
8 Reviews
9 Configuration Management
10 Electromagnetic Compatibility Control
11 Reliability and Availability
11.1 Reliability Allocations
11.2 Reliability Prediction
11.3 Failure Mode Effects and Criticality Analysis (FMECA)

ADDENDUM B: S&MA DELIVERABLES NOT COVERED IN THE CDRL

The following items will be called out in future revised CDRL and are referenced throughout this MAR. They are listed here for clarification/information only.

ITEM NO.	DESCRIPTION	MAR REFERENCE SECTION
1	Operations and Support Hazard Analysis (O&SHA)	2.1, 2.2
2	Hazard Control Verification Log	2.2
3	Safety Assessment Report (SAR)	2.2
4	Ground Operations Plan (GOP) Inputs (to Spacecraft Contractor)	2.2
5	Performance Verification Procedure	4.2.2
~~6~~	Verification Reports	4.2.3
6	Instrument Performance Verification Report	4.2.3
7	Printed Wiring Board (PWB) Coupons	5.2
8	Parts Stress Analysis	8.2.2
9	Input for Software Metrics	11.2.6

ITEM 1: Operating and Support Hazard Analysis (O&SHA)

Title: Operating and Support Hazard Analysis (O&SHA)	CDRL No.: Not applicable at this time (n/a)
Reference: MAR Section 2.1	
Use: Evaluates activities for hazards or risks introduced into the system by operational and support procedures and evaluates the adequacy of operational and support procedures used to eliminate, control, or abate identified hazards or risks.	
Related Documents: EWR 127-1	
Place/Time/Purpose of Delivery: The first delivery is due at CDR. An updated delivery is due to support final MSPSP delivery to the Range which in turn supports the Mission Approval Safety Review (120 days before launch). GSFC will approval all deliveries/versions.	
Preparation Information: Refer to Appendix 1B of EWR 127-1 for guidance on performance of an O&SHA.	

ITEM 2: Hazard Control Verification Log

Title: Hazard Control Verification Log	CDRL No.: n/a
Reference: MAR Section 2.1	
Use: Used to document the instrument safety assessment such that it reflects how the instrument design demonstrates compliance with the safety requirements.	
Related Documents: EWR 127-1	
Place/Time/Purpose of Delivery: Initially generated to document results of hazard analyses and updated as analysis results warrant. It will be made available to Range Safety upon request. Delivery shall support the spacecraft contractor's MSPSP submittal schedule. The final MSPSP will be submitted to Range Safety at least 45 calendar days prior to hardware shipment to Range. Preliminary shipment will be TBD based on negotiation between the spacecraft contractor and the Range. GSFC will approve all deliveries/versions.	
Preparation Information: Refer to Appendix 1B.1 of EWR 127-1 for preparation directions.	

ITEM 3: Safety Assessment Report (SAR)

Title: Safety Assessment Report (SAR)	CDRL No.: n/a

Reference:

MAR Section 2.1

Use:

The Safety Assessment Report (SAR) is used to document a comprehensive evaluation of the mishap risk being assumed prior to the testing or operation of a system. The SAR will be provided to the Spacecraft Contractor as an input to their preparation of the Missile System Prelaunch Safety Package (MSPSP), which is one of the media through which missile system prelaunch safety approval is obtained.

Related Documents:
EWR 127-1

Place/Time/Purpose of Delivery:

SAR delivery shall support the spacecraft contractor's MSPSP submittal schedule. The final MSPSP will be submitted to Range Safety at least 45 calendar days prior to hardware shipment to Range. Preliminary shipment will be TBD based on negotiation between the spacecraft contractor and the Range. GSFC will approve all deliveries/versions.

Preparation Information:

The Safety Assessment Report will identify all safety features of the hardware, software, and system design as well as procedural, hardware, and software related hazards that may be present in the system being acquired. This includes specific procedural controls and precautions that should be followed. The safety assessment will summarize the following information:

1. The safety criteria and methodology used to classify and rank hazards plus any assumptions upon which the criteria or methodologies were based or derived including the definition of acceptable risk as specified by Range Safety
2. The results of analyses and tests performed to identify hazards inherent in the system including:
   - Those hazards that still have a residual risk and the actions that have been taken to reduce the associated risk to a level contractually specified as acceptable
   - Results of tests conducted to validate safety criteria, requirements, and analyses
3. The results of the safety program efforts including a list of all significant hazards along with specific safety recommendations or precautions required to ensure safety of personnel, property, or the environment. **NOTE:** The list shall be categorized as to whether or not the risks may be expected under normal or abnormal operating conditions.
4. Any hazardous materials generated by or used in the system
5. The conclusion, including a signed statement, that all identified hazards have been eliminated or their associated risks controlled to levels contractually specified as acceptable and that the system is ready to test or operate or proceed to the next acquisition phase
6. Recommendations applicable to hazards at the interface of Range User systems with other systems, as required

ITEM 4: Ground Operations Plan (GOP) Inputs

Title: Ground Operations Plan (GOP) Inputs (to Spacecraft Contractor)	CDRL No.: n/a
Reference: MAR Section 2.1	
Use: Provides a detailed description of hazardous and safety critical operations for processing aerospace systems and their associated ground support equipment. Along with the MSPSP, the GOP is the medium through which missile system prelaunch safety approval is obtained.	
Related Documents: EWR 127-1	
Place/Time/Purpose of Delivery: The draft GOP is to be provided to Range Safety 45 days prior to the spacecraft PDR and CDR. The final GOP is to be submitted 45 days prior to hardware delivery to the Range. Inputs to this plan need to support this delivery date and must be approved by GSFC.	
Preparation Information: Refer to Appendix 6A of EWR 127-1 for preparation directions.	

ITEM 5: Performance Verification Procedure

Title: Performance Verification Procedure	CDRL No.: n/a
Reference: MAR Section 4.2.2	
Use: Describes how each test activity defined in the Verification Plan will be implemented	
Related Documents None	
Place/Time/Purpose of Delivery: 30 days prior to the start of the testing for GSFC approval.	
Preparation Information: Describe the configuration of the tested item and the step-by-step functional and environmental test activity conducted at the unit/component, subsystem/instrument, and payload levels. Give details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, quality control checkpoints, pass/fail criteria, data collection and reporting requirements. Address safety and contamination control provisions. A methodology will be provided for controlling, documenting and approving all activities not part of an approved procedure and establish controls for preventing accidents that could cause personal injury or damage to hardware and facilities.	

ITEM 6: Verification Reports

Title: Verification Reports	CDRL No.: n/a
Reference: MAR Section 4.2.3	
Use: Summarize compliance with system specification requirements and/or provide a summary of testing and analysis results, including conformance, nonconformance, and trend data.	
Related Documents None	
Place/Time/Purpose of Delivery: Verification Reports: Preliminary - 72 hours after testing for GSFC information Final - 30 days after verification activity for GSFC information Instrument Performance Verification Report: Preliminary - At CDR for GSFC information Final - 30 days following on-orbit check out for GSFC information	
Preparation Information: Verification Report: Provide after each unit/component, subsystem/instrument, and payload verification activity. For each analysis activity the report will describe the degree to which the objectives were accomplished, how well the mathematical model was validated by the test data, and other significant results. Instrument Performance Verification Report: Compare hardware/software specifications with the verified values (whether measured or computed). It is recommended that this report be subdivided by subsystem.	

ITEM 7: Printed Wiring Board (PWB) Coupons

Title: Printed Wiring Board (PWB) Coupons	CDRL No.: n/a
Reference: MAR Section 5.2	
Use: For independent evaluation of the quality of PWB's used in the hardware	
Related Documents: IPC-D-275, GSFC S-312-P003, ANSI/IPC-HF 318, ANSI/IPC-A-600, NASA RP 1161	
Place/Time/Purpose of Delivery: Provide to the GSFC Project Office for approval as a precondition to board population.	

Preparation Information:

Provide a test coupon for each PWB used in the flight hardware and note the following:

a. The coupon will be per the design requirements of GSFC S-312-P-003 and will only be removed from the flight PWB panel after the panel has been through all manufacturing processes.

b. The coupon will be “as produced” by the vendor; that is, it will not have seen any processes not experienced by the PWB panel (including metallographic preparation techniques or thermal excursions).

c. The coupon will be clearly identified with the part number, serial number, vendor identification and date code or production lot number.

d. The paperwork accompanying the coupon will include the part number, serial number, vendor identification and date code or production lot number as well as the flight experiment to which the coupon pertains and the shipper identification and tracking number.

e. A fax will precede the coupon receipt by one day. This fax will be sent to the evaluation lab, and will include the part number, serial number, vendor identification and date code or production lot number as well as the flight experiment to which the coupon pertains and the shipper identification and tracking number.

Two weeks prior to shipping the coupons, the hardware provider will notify the Flight Assurance support contractor or the independent evaluation laboratory of the coupons that they plan to ship for evaluation.

Flight PWB will not be assembled prior to notification that the representative coupon has passed laboratory evaluation by the GSFC-approved laboratory.

The System Assurance Manager for the project will be provided with a preliminary fax of the coupon test results and the final report.

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

ITEM 8: Parts Stress Analysis

Title: Parts Stress Analyses	CDRL No.: n/a
Reference: MAR Section 8.2.2	
Use: Provides EEE parts stress analyses for evaluating circuit design and conformance to derating guidelines.	
Related Documents NASA Parts Selection List	
Place/Time/Purpose of Delivery: The analysis is due 30 work days before CDR for GSFC review at the developer's facility. Updates as required, with any changes clearly indicated, are to be available at the developer's site for GSFC review.	
Preparation Information: The stress analysis report will contain the ground rules for the analysis, references to documents and data used, a statement of the results and conclusions, and the analysis worksheets. The worksheets, at a minimum, will include part identification (traceable to circuit diagrams), environmental conditions assumed, rated stress, applied stress, and ratio of applied-to-rated stress.	

ITEM 9: Input For Software Metrics

Title: Input for Software Metrics	CDRL No.: n/a
Reference: MAR Sections 11.2.6	
Use: The resulting metrics will provide insight into the quality of the developer's software development processes and software products.	
Related Documents: None	
Place/Time/Purpose of Delivery: The developer will provide a copy of their source code, using a format and media that will be negotiated between the developer and the GSFC Project Office. This source code is provided for information and will be analyzed by GSFC's Software Assurance Technology Center, using statistical techniques, to provide software metrics and an associated report for Project and developer usage. A copy of the source code is due to GSFC 10 workdays before each LAT Quarterly Review or as otherwise agreed upon with the GLAST Project.	
Preparation Information: The source code will be provided to the GSFC Project Office using a format and media that will be negotiated between the GSFC and the developer.	

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes