GEOSPACE-Radiation Belt Storm Probes (G-RBSP) Program Mission Assurance Requirements (MAR)

June 2007

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CHANGE LOG

Revision Ltr/ Change No.	Description/ Pages Affected	CCR No.	Date Approved
Initial Release	All	466-1	June 2007

This document is a RBSP CM-controlled document. Changes to this document require prior approval of the applicable Configuration Control Board (CCB) Chairperson or designee. Proposed changes shall be submitted to the RBSP CM Office (CMO), along with supportive material justifying the proposed change.

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

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Chapter 1. Overall Requirements

1.0 GENERAL

The purpose of this document is to concisely state the Safety and Mission Assurance (SMA) requirements for the Geospace - Radiation Belt Storm Probes (G-RBSP) Mission.

The SMA requirements for the G-RBSP Mission are structured in accordance with the Class C risk classification and scientific requirements of the G-RBSP mission. A strong parts and materials program, robust reliability and quality programs for hardware and software, and significant reliance on the test program will be key factors in balancing requirements against program cost and complexity constraints and the increased risk that may be incurred in a predominantly non-redundant system. The developer has responsibility and control over development of the hardware, the integration and test program, and launch site operations. The G-RBSP Program Office (located at Goddard Space Flight Center (GSFC)) will monitor the developer's activities to provide insight into their compliance with these SMA requirements. Emphasis will be focused on those activities that contribute most to product reliability and integrity or are deemed high-risk efforts. The developer shall ensure these Mission Assurance Requirements are flowed down to all of their suppliers who are producing hardware, software, and critical ground support equipment.

It should be noted that "developer" as specified in this document applies to the G-RBSP project office (i.e. the spacecraft builder). In addition, the developer shall flowdown this document in its entirety to each of their instruments and their suppliers.

The developer shall model their quality program in accordance with these requirements and ANSI/ASQ Q9001-2000, "Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation, and Servicing", or equivalent.

The developer is encouraged to make maximum use of existing practices and procedures in developing and implementing the safety and mission assurance program. The developer may offer an alternate method of meeting the intent of a requirement when such a method is better aligned with the manner in which the total work is to be accomplished, subject to G-RBSP Program approval. The developer shall develop and maintain adequate internal documentation for all safety, reliability and quality assurance activities. The developer shall make available for program review all procedures, documents and quality records generated or utilized in support of the G-RBSP SMA program.

Non-United States suppliers shall provide a plan that describes the quality systems that will be used for the G-RBSP project in support of these Mission Assurance Requirements. The supplier should indicate specific plans, standards or processes that will be employed whenever possible and provide copies for Project review when requested.

1.1 DESCRIPTION OF OVERALL REQUIREMENTS

This document presents a concise statement of the G-RBSP mission SMA requirements. The developer shall plan and implement an organized SMA program for flight hardware, software and ground support equipment as defined in this MAR. The developer shall support and participate with the G-RBSP Program in validating and periodically reviewing the SMA program.

Managers of assurance activities shall have direct access to Project management, along with the functional freedom and authority to interact with all other elements of the Project. The developer's Quality Manager shall interface with the NASA G-RBSP Systems Assurance Manager (SAM) on SMA activities and issues. In the event that SMA issues require Program management attention, the developer shall direct issues to the G-RBSP Contracting Officer's Technical Representative (COTR).

1.2 SURVEILLANCE OF THE DEVELOPER

The work activities, operations, and documentation performed by the developer or their suppliers are subject to evaluation, review, audit, and inspection by government-designated representatives from the G-RBSP Program, the Defense Contract Management Agency, or an independent assurance contractor. The G-RBSP Program may delegate in-plant responsibilities and authority to these organizations via a letter of delegation, letter of assignment, or task assignment.

The developer shall grant access to hardware, software and manufacturing and test facilities as well as supporting documentation to NASA representatives as necessary to conduct an assessment or survey. The developer, upon request, shall provide government assurance representatives with documents, records, databases and equipment required for them to perform their delegated duties. The developer shall also provide the government assurance representative(s) with a work area within developer facilities appropriate for the activity to be performed.

1.3 QUALITY MANUAL

The developer shall submit a Quality Manual for G-RBSP Program review and approval in accordance with Appendix A of this Document. The developer shall include as part of the Quality Plan a reference to each section of this MAR with a description, or reference to the developer's internal procedure, that describes the developer's approach for ensuring compliance with the requirements of this MAR and the Statement of Work (SOW) for the GEOSPACE – Radiation Belt Storm Probes Project (G-RBSP).

The G-RBSP Program's Systems Assurance Manager (SAM) will periodically validate the developer's overall SMA program to validate compliance to these MAR requirements and the developer's Quality Plan.

Chapter 2. Quality Management System

2.0 QUALITY MANAGEMENT SYSTEM

The developer shall define and implement a quality management system based on ANSI/ISO/ASQ Q9001:2000 or equivalent that encompasses G-RBSP flight hardware, software, and ground support equipment.

2.1 SUPPLEMENTAL QUALITY MANAGEMENT SYSTEM REQUIREMENTS

The following requirements supplement ANSI/ISO/ASQ Q9001:2000.

2.1.1 NONCONFORMANCE REPORTING AND CORRECTIVE ACTION

The developer shall implement a system for identifying and reporting hardware and software nonconformances through a closed loop reporting system; ensuring that positive corrective action is implemented to preclude recurrence and verification of the adequacy of implemented corrective action by audit and test as appropriate. The Nonconformance Reporting and Corrective Action (NRCA) process shall include:

1. Nonconformance detection and reporting procedures;
2. Nonconformance tracking and management procedures;
3. Nonconformance impact assessment and corrective action procedures;
4. Interfaces to the Configuration Management process.

2.1.1.1 MATERIAL REVIEW BOARD

The developer shall inform the G-RBSP Program of MRB meeting schedules and agendas with sufficient advance notice (four business hours minimum) to permit G-RBSP Program participation. The developer shall provide the G-RBSP Program access to the developer's G-RBSP material discrepancy-reporting database. The G-RBSP Program COTR reserves disapproval rights on MRB decisions.

2.1.1.2 REPORTING OF ANOMALIES

The developer shall provide access to documentation relating to hardware and software anomalies to the G-RBSP Program beginning with the first "power on application" tests at the board level of flight hardware/software/critical GSE; or the first operation of a mechanical item.

The developer shall formally report anomalies to the G-RBSP Program office verbally and via email within 24 hours of occurrence starting at box-level acceptance testing. The developer shall supply Problem/Failure Reports (PFRs) documenting the anomaly and investigation to the G-RBSP Program COTR within 5 business days of the occurrence in accordance with Appendix A of this document . The developer shall provide a Monthly PFR Status Report to the G-RBSP Program which includes a list of all open PFR reports and a list of the PFR reports closed during the month.

The G-RBSP Program will review failure report dispositions prior to Observatory or Instrument Integration and Test (I&T) and maintain approval authority of all failure report dispositions starting at the first instrument I&T with the spacecraft.

The developer shall implement a process for software problem reporting and corrective action that addresses reporting, analyzing, and correcting nonconformances throughout the development life cycle. The developer's Quality Plan shall provide for a corrective action process that tracks every nonconformance to its final disposition. The NRCA process for a software product shall start no later than the establishment of a configuration management baseline that includes the product.

2.1.2 CONTROL OF MONITORING AND MEASURING DEVICES

The developer shall ensure that Testing and Calibration Laboratories used for G-RBSP fabrication, test and inspection hardware are compliant with the requirements of ISO 17025 – General Requirements for the Competence of Testing and Calibration Laboratories.

2.1.3 CONFIGURATION MANAGEMENT

The developer shall perform configuration management (CM) in support of the G-RBSP Project. The developer shall document the CM process in a Configuration Management Plan. The configuration of deliverable items shall be maintained throughout all phases of assembly and test. Configuration verification shall be performed and documented as assemblies are incorporated into higher-level assemblies and at major Project milestones (i.e. pre-environmental test, pre-ship, pre-launch, etc). The CM system shall have a change classification and impact assessment process that results in Class 1 Configuration Change Requests (CCRs) being forwarded to the G-RBSP Program for approval. Class 1 changes are defined as changes that impact mission science and performance requirements, system safety, cost, schedule, and external interfaces. All other changes are considered to be Class 2 changes.

Any flight item that is found to be non-compliant with the requirements of the contract Statement of Work (SOW) or the MAR and is not reworked to be compliant, or is not replaced with a compliant item, shall be dispositioned via a waiver. The developer shall submit Class I waivers to the G-RBSP Program office for final approval. Waivers that affect mission requirements, system safety, cost, schedule, and external interfaces are to be processed as Class I. All other waivers are processed as Class 2.

Software CM is further defined in Chapter 5 of this MAR.

2.2 GROUND SUPPORT EQUIPMENT

The developer shall assemble and maintain elements of mechanical and electrical Ground Support Equipment (GSE) and associated software that directly interfaces with flight deliverable items to the same standards as the deliverable flight items unless approval by the G-RBSP program SAM is received, including calibration control and configuration management. (See Sections 8.2.3 and 8.3.3.) Parts and materials selection and reporting requirements are excepted as long as deliverable flight item contamination requirements are not compromised. Problem reporting for GSE shall begin with the first use with deliverable flight items and shall continue for the duration of the Project.

2.3 REQUIREMENTS FLOW-DOWN

The developer shall ensure flow-down of SMA requirements to all suppliers and establish a process to verify compliance. The developer's contracts review and purchasing processes shall indicate the process for documenting, communicating, and reviewing requirements with sub-tier suppliers to ensure requirements are met. These mission assurance requirements shall be flowed down to all suppliers or institutions as applicable based on the work to be performed. The developer shall ensure that quality plans, processes and procedures submitted by the developer's sub-tier suppliers are compliant to the requirements in this MAR.

Chapter 3. System Safety Requirements

3.0 GENERAL REQUIREMENTS

The developer shall implement a system safety program in accordance with contractual and regulatory requirements. The system safety program shall be initiated in the concept phase of design and continue throughout all phases of the mission as defined by the requirements documents in this Chapter. The developer shall implement a program that provides for early identification and control of hazards during design, fabrication, test transportation, and ground activities. The system safety program shall also identify and control hazards to personnel, facilities, support equipment, and the flight system throughout the life cycle of the G-RBSP Instrument Suite. The program shall address hazards in the flight hardware, associated software, ground support equipment, and support facilities

The safety program shall satisfy the applicable guidelines, constraints, and requirements stated in Air Force Space Command Manual 91-710 (AFSPCMAN 91-710), Range Safety Requirements and KNPR 8715.3, "KSC Safety Practices Procedural Requirements";

Specific safety requirements include the following:

a) If a system failure may lead to a catastrophic hazard, the system shall have three inhibits (dual fault tolerant). A Catastrophic hazard is defined as a condition that may cause death or permanently disabling injury, major system or facility destruction on the ground, or vehicle during the mission.

b) If a system failure may lead to a critical hazard, the system shall have two inhibits (single fault tolerant). A Critical hazard is defined as a condition that may cause severe injury or occupational illness, or major property damage to facilities, systems, or flight hardware.

c) Hazards which cannot be controlled by failure tolerance (e.g., structures, pressure vessels, etc.) are called "Design for Minimum Risk" areas of design and have separate, detailed safety requirements that they must meet. Hazard controls related to these areas are extremely critical and warrant careful attention to the details of verification of compliance on the part of the developer.

3.1 SYSTEM SAFETY PROGRAM PLAN

The developer shall prepare and implement a System Safety Program Plan (SSPP). The SSPP shall describe the system safety implementation process which includes analysis, reduction, and/or elimination of hazards. The SSPP shall define the required safety documentation, applicable documents, associated schedules for completion, roles and responsibilities on the project, methodologies for the conduct of any required safety analyses, reviews, and safety assessment report. The Contractor shall deliver the SSPP in accordance with Appendix A of this document.

3.2 SAFETY REQUIREMENTS COMPLIANCE CHECKLIST

The developer shall demonstrate that the payload is in compliance with all safety requirements and any non-compliant areas have been identified. The developer shall document this in a Compliance Checklist and shall be submitted in accordance with Appendix A of this document. The checklist shall indicate for each requirement if the proposed design is compliant, non-compliant but meets intent, non-compliant (waiver required) or non-applicable. An example of a compliance checklist can be found in Appendix E of the Eastern and Western Range 127-1, Range Safety Requirements, *Range User Handbook*.

3.3 PRELIMINARY HAZARD ANALYSES

The developer shall perform and document a preliminary hazard analysis (PHA) in accordance with AFSPCMAN 91-710 to obtain an initial risk assessment of the instrument/spacecraft system and submitted in accordance with Appendix A of this document. Based on the best available data, including mishap data from similar systems and other lessons learned, hazards associated with the proposed instrument design shall be evaluated for hazard severity, hazard probability, and operational constraints.

The PHA shall consider the following for identification and evaluation of hazards as a minimum:

a) Hazardous components
b) Safety related interface considerations among various elements of the system, including

consideration of the potential contribution by software to system and subsystem mishaps.
c) Environmental constraints including the operating environments.
d) Operating, test, maintenance, built-in-tests, diagnostics, and emergency procedures.
e) Facilities.
f) Safety related equipment, safe guards, and possible alternate approaches.
g) Malfunctions to the system, subsystems, or software.

The developer shall develop analyses for identifying the hazards associated with the hardware, support equipment, software, instrument ground operations and ground support equipment, and their interfaces. The developer shall take measures to minimize each identified hazard.

The PHA shall be updated as all hardware and software progresses through the stages of design, fabrication, test, transportation, and launch. Hazard reports shall be generated for all identified system hazards. The hazard reports shall document the causes, controls, verification methods and status of verification for each hazard.

3.4 OPERATIONS HAZARD ANALYSIS

An Operations Hazard Analysis (OHA) shall be performed to identify the hazards to payload or personnel when a facility is being used or an activity is being performed. The OHA shall document all controls and methods of verifications for each hazard listed. The OHA process considers the timing and sequence of tasks with respect to the equipment/hardware/software design, human engineering provisions, assembly, test, and operating procedures, and the facility environments for each specific operation being performed. The Operations Hazard Analysis shall be delivered in accordance with Appendix A of this document.

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3.5 SOFTWARE SAFETY ANALYSIS

The developer shall identify hazards caused by software as a part of the nominal hazard analysis process, and their controls will be verified prior to acceptance.

3.6 SAFETY ASSESSMENT REPORT

The developer shall perform and document a Safety Assessment Report (SAR). The contents of the package shall also include hazard reports that address identified Instrument-Suite hazards, hazard controls, verifications, and status. The SAR shall be submitted to the G-RBSP project for inclusion in the project generated Missile System Prelaunch Safety Package (MSPSP).

3.7 MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE

The spacecraft developer shall prepare and submit a Missile System Pre-Launch Safety Package (MSPSP) to GSFC for review and approval in accordance with Appendix A of this document and the SOW. The developer shall take measures to control and/or minimize each significant identified hazard. The developer shall use, as inputs to the MSPSP, the results of the SAR(s) provided by the instrument and subsystem developers.

3.8 VERIFICATION TRACKING LOG

All verifications that are listed on the hazard reports shall reference the test, analyses, and/or inspections that were performed to verify the hazard is controlled or eliminated. The VTL shall be delivered with the instruments/subsystem final SAR and updated regularly until all items are closed. A payload VTL shall be prepared and delivered with the final MSPSP to GSFC. Individual VTL items shall be closed with appropriate documentation verifying the stated hazard control has been implemented, and individual closures shall be complete prior to first operational use/restraint.

3.9 SUPPORT FOR SAFETY WORKING GROUP MEETINGS

The developer shall provide technical support to the G-RBSP Program for safety working group meetings, Technical Interface Meetings, and technical reviews as requested.

3.10 ORBITAL DEBRIS ASSESSMENT

The developer will supply an Orbital Debris Assessment in accordance with NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris and the NASA policy NPD 8710.3, NASA Policy for Limiting Orbital Debris Generation in accordance with Appendix A of this document and the SOW. Design and safety activities shall take into account the spacecraft's ability to conform to debris generation requirements.

3.11 LAUNCH SITE SAFETY SUPPORT

The developer shall provide safety support for hazardous operations at the launch site. NOTE: Range safety is not responsible for project safety support at the launch ranges.

3.12 SAFETY NONCOMPLIANCE/WAIVER REQUESTS

When a specific safety requirement cannot be met the contractor shall submit an associated safety noncompliance/waiver request which identifies the hazard and shows rationale for approval of the waiver, as defined by AFSPCMAN 91-710.

The noncompliance request shall include the following information:

a) A statement of the specific safety requirement and its associated source document name and paragraph number for which the waiver or deviation is being requested.
b) A detailed technical justification for the exception.
c) Analyses to show that the mishap potential of the proposed alternate requirement, method or process, as compared to the specified requirement.
d) A narrative assessment of the risk involved in accepting the waiver or deviation.
e) A narrative on possible ways of reducing hazard severity and probability, and existing compliance activities.
f) Starting and expiration date for the waiver/deviation.

Safety Noncompliance/Waiver Requests shall be delivered in accordance with Appendix A of this document.

3.13 GROUND OPERATIONS PROCEDURES

The developer shall submit all ground operations procedures to be used at GSFC facilities or the launch site In accordance with Appendix A of this document. All hazardous operations, as well as the procedures to control them shall be identified. The developer shall ensure that launch site procedures comply with the launch site and NASA safety regulations.

3.14 ACCIDENT/INCIDENT (MISHAP) INVESTIGATION AND REPORTING

The developer shall report all accidents/mishaps/incidents via an Accident/Incident Mishap Report verbally and via email within 24 hours of occurrence to the G-RBSP Program Manager and GSFC Program Safety Manager (PSM). Accident/Incident investigation and reporting for these activities shall be investigated and reported in compliance with NPR 8621.1, "NASA Mishap and Close-Call Reporting, Investigating and Record keeping Policy," and NPR 8621.1, "NASA Procedures Requirements for Mishap Reporting, Investigating and Record Keeping."

Chapter 4. Reliability Requirements

4.0 GENERAL REQUIREMENTS

Early in the design process the developer shall identify potential reliability concerns and the steps being taken to mitigate them. Reliability analyses of the design shall be conducted in accordance with the following sections. These analyses shall be reviewed with the G-RBSP Program as they are developed and iterated, and reported in detail at the formal design reviews. The developer shall prepare and submit a Reliability Program Plan (RPP) that documents the planned approach for implementing the reliability tasks, describing how the reliability activities interact effectively with other engineering disciplines, and discuss the scheduling of the reliability tasks relative to the project milestones. The Reliability section of the Quality Plan corresponding to this MAR may be used as the RPP. The RPP shall be submitted to the G-RBSP Program in accordance with Appendix A of this document.

The Reliability program shall:

a. Use tools to assess, manage, and quantitatively evaluate the need to reduce project risk;
b. Demonstrate that redundant functions, including alternative paths and work arounds, are independent to the extent practicable;
c. Demonstrate that stress applied to parts is not excessive;
d. Identify single point failure items, their effect on the attainment of mission objectives, and possible safety degradation;
e. Show that the reliability design meets mission design life requirements and is consistent among the systems, subsystems, and components;
f. Identify limited-life items and ensure that special precautions are taken to conserve their useful life for on-orbit operations;
g. Select significant engineering parameters for the performance of trend analysis to identify performance trends following acceptance testing;
h. Ensure that the design permits easy replacement of parts and components and that redundant paths are easily monitored.

4.1 RELIABILITY ANALYSES

The developer shall perform reliability analyses concurrently with the design so that identified problem areas can be addressed and corrective action taken (if required) in a timely manner.

4.1.1 FAILURE MODES AND EFFECTS ANALYSIS AND CRITICAL ITEMS LIST

The developer shall perform a “bottom-up” Failure Modes and Effects Analysis (FMEA) early in the design phase to identify system design problems. As additional design information becomes available the developer shall refine the FMEA. Failure modes shall be assessed at the component interface level, at a minimum, to verify that lower level failures do not propagate to the next higher level of assembly and cause damage or degradation. The interfaces between custom support equipment and flight hardware shall be analyzed to preclude the propagation of support equipment failures to the flight hardware. Each failure mode shall be assessed for the effect at that level of analysis, the next higher level and upward. Each failure mode shall be assigned a severity category based on the most severe effect caused by a failure. All mission phases (e.g., launch, deployment, on-orbit operation, and disposal) shall be addressed in the analysis.

Severity categories shall be determined in accordance with Table 4-1:

TABLE 4-1. SEVERITY CATEGORIES

Category	Severity	Description
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 G-RBSP Mission Requirements Document.
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

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

Results of the FMEA shall be used to evaluate the design relative to requirements. Identified discrepancies shall be evaluated by management and design groups for assessment of the need for corrective action. The FMEA shall be used to 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, shall be itemized on a Critical Items List (CIL) and maintained with the FMEA report. Rationale for retaining the items shall be included on the CIL. The FMEA and CIL shall be submitted to the G-RBSP Program in accordance with Appendix A of this document. Results of the FMEA and the CIL shall be presented at all design reviews. The presentations shall 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.

4.1.2 WORST CASE ANALYSIS

The developer shall perform worst-case analyses for mission or science-critical parameters that are subject to variations that could degrade performance, or where failure results in a FMEA severity category of 2 or higher. Circuits with common cause failures (e.g. replicated circuitry) shall be considered in the worst-case analysis. Analyses or test or both shall demonstrate adequacy of margins in the design of electronic circuits, optics, electromechanical and mechanical items (mechanisms). The analyses shall consider all parameters set at worst-case limits and worst-case environmental stresses for the parameter or operation being evaluated. The analyses shall be updated in keeping with design changes. The analyses and updates shall be presented at applicable design reviews, formal reports are not required.

4.1.3 PROBABILISTIC RISK ASSESSMENT AND FAULT TREE ANALYSIS

The developer shall generate the mission-level Probabilistic Risk Assessment (PRA) per NPR 8705.4, Risk Classification for NASA Payloads, as part of their risk management and reliability programs.

The developer shall perform "top-down" Fault Tree Analyses (FTA) and present specific results in their Preliminary Design Review (PDR), Critical Design Review (CDR) and post-CDR reviews. FTAs are typically performed to a level of depth that is appropriate to identify functional dependencies and relationships among the basic events, and to a depth that is consistent with the data available and the objectives of the analysis. FTAs for G-RBSP shall be performed to the circuit card functional and component interface level, at a minimum.

The FTAs shall address both mission failures and degraded modes of operation. The FTAs shall be integrated as part of the PRA process. Beginning with each undesired state, the fault tree shall be expanded to include all credible combinations of events, faults and environments that could lead to that undesired state. Component hardware/software failures, external hardware/software failures, and human factors shall be considered in the analysis. The PRA shall be submitted to the G-RBSP Program in accordance with Appendix A of this document.

4.1.4 PARTS STRESS ANALYSES

The developer shall perform stress analyses on Electrical, Electronic, and Electromechanical (EEE) parts and devices, as applied in circuits within each component for conformance with the derating policy of EEE-INST-002. The analyses shall be performed at the most stressful part-level parameter values that can result from the specified performance and environmental requirements on the assembly or component. The analyses shall be performed in close coordination with the packaging reviews and shall require input data for component-level design reviews. The analyses shall be documented, and justification shall be included for all applications that do not meet the derating criteria. The parts stress analyses shall be submitted to the G-RBSP Program in accordance with Appendix A of this document.

4.1.5 RELIABILITY ASSESSMENTS AND PREDICTIONS

The developer shall perform comparative numerical assessments and/or reliability predictions based on historical performance of similar items on-orbit, test data, data books such as Mil-HDBK-217F, or engineering experience in the given order of preference, Expectations for the subject activity are as follows:

a. Evaluate alternative design concepts, redundancy and cross strapping approaches, and part substitutions;
b. Help identify the elements of the design which are potentially the greatest detractors of system reliability;
c. Help identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations;
d. Help evaluate the impact of proposed engineering changes and waiver requests on reliability.

It is important to note that the intent of the subject activity is as a design-assist tool during early development and not as a methodology to calculate "probability of success" estimates for the overall mission.

The results of the reliability assessments shall be presented at the PDR and CDR, and submitted to the G-RBSP Program in accordance with Appendix A of this document. The presentations shall include comments on how the analyses was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

4.2 RELIABILITY ANALYSIS OF TEST DATA

The developer shall fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas.

4.2.1 TREND ANALYSES

The values of certain parameters will directly impact a component or systems reliability. Those measurable parameters that directly affect system or component reliability are sampled over time. The parameter values are examined to see if there is a pattern of deviation over time (i.e. a trend) from acceptable parameter values, or at least estimate the long-term range of values of these influential variables. Thus, if these parameters are trending towards hazardous or unacceptable levels, the potential problem could be identified prior to the occurrence of high-risk situations. The objective is to compare extrapolated end-of-mission performance with specified functional performance requirements to assure that satisfactory performance can be reasonably expected.

The developer shall perform trend analyses to the component level to track measurable parameters that relate to performance stability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring shall be accomplished within the normal test framework (i.e., during functional tests, environmental tests, etc). The developer shall establish a system for recording and analyzing the parameters as well as any changes from the nominal even if the levels are within specified limits. The developer shall include in the monthly status report to the G-RBSP Program any areas of concern identified through the Trend Analyses. A list of parameters to be monitored shall be presented at the CDR and the trend analysis reports shall be prepared and submitted to the G-RBSP Program monthly. Trend analysis data shall be reviewed with the mission operational personnel prior to launch, and the mission operational personnel shall continue recording trends throughout mission life for early detection of possible mission failure tendencies.

4.2.2 ANALYSIS OF TEST RESULTS

The developer shall analyze test information, trend data, and failure investigations to evaluate reliability implications. Identified problem areas shall be documented and directed to the attention of developer management for action. This information shall be included in the developer's monthly status reports to the G-RBSP Program. The results of the development tests analyses shall be presented at design reviews. The presentations shall 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.

4.3 LIMITED-LIFE ITEMS

The developer shall identify and manage limited-life items. Limited-life items include all hardware that is subject to degradation because of age, operating time, or cycles such that their expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined. The developer shall maintain a list of limited-life items that shall include the following data elements: item, expected life, required life, duty cycle, rationale for selection and effect on mission parameters. An item's useful life period begins with either (1) its fabrication or (2) installation into flight hardware, as appropriate, and ends when the orbital mission is completed.

The developer shall compile a list of limited-life items, to be supplied to G-RBSP Program per Appendix A of this document that includes selected structures, thermal control surfaces, instrument sensors, and electromechanical mechanisms. Atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue shall be used to identify limited-life thermal control surfaces and structure items. Mechanisms (e.g. momentum wheels, gyros, actuators, etc.) shall be included when aging, wear, fatigue and lubricant degradation limit their life. Records shall 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 activity that stresses the items. The use of an item with an expected life that is less than its mission design life shall be approved by the G-RBSP Program by means of a waiver.

4.4 CONTROL OF SUPPLIERS

The developer shall ensure that system elements obtained from suppliers will meet the pertinent Program reliability requirements. All subcontracts shall include provisions for review and evaluation of the suppliers' reliability efforts by the developer at the developer's discretion, and by the G-RBSP Program at its discretion.

The developer shall tailor the reliability requirements of this document in hardware and software subcontracts for the Project and shall exercise necessary surveillance to ensure that suppliers' reliability efforts are consistent with overall system requirements. The developer shall, as a result of this tailoring:

1. Incorporate reliability requirements in subcontracted equipment specifications;
2. Assure that suppliers have reliability programs that are compatible with the overall program;
3. Review suppliers' assessments and analyses for accuracy and correctness of approach;
4. Review suppliers' test plans, procedures, and reports for correctness of approach and test details;
5. Attend and participate in suppliers' design reviews;
6. Ensure that suppliers comply with the applicable system reliability requirements during the Project operational phase.

Chapter 5. Software Assurance Requirements

5.0 GENERAL REQUIREMENTS

Software Assurance is the planned and systematic set of activities that ensures that software lifecycle processes and products conform to requirements, standards, and procedures. As such, software assurance comprises a set of disciplines that strive to improve the overall quality of the product/software while employing risk mitigation techniques. For NASA, these disciplines include Software Quality, Software Safety, Software Reliability, Verification and Validation (V&V), and Independent Verification and Validation (IV&V).

The developer's Software Assurance program shall address software assurance disciplines and functions for all flight and ground system software. The software assurance program shall apply to software and firmware developed under this contract, including Government off-the-shelf (GOTS) software, modified off-the-shelf (MOTS) software, and commercial off-the-shelf (COTS) software when used.

The developer shall address software assurance in the project Quality Manual. The developer shall identify personnel with roles and responsibilities for software assurance in the project Quality Manual.

The developer shall plan and document software roles and responsibilities, software development processes and procedures, software reviews, software tools, resources, schedules and deliverables throughout the development life cycle in a Software Management Plan, made available to G-RBSP program personnel in accordance with Appendix A of this document. The developer shall document and maintain under configuration control all software requirements in a Software Requirements Specification.

5.0.1 SOFTWARE QUALITY ASSURANCE

The developer shall implement a Software Quality program to assure the quality of the software products and software processes. The developer shall conduct software process and product assurance activities throughout the development life cycle. At a minimum, these activities shall include assessments of plans, procedures, requirements, design, code, test, configuration management, risk management, and verification and validation.

5.0.2 SOFTWARE SAFETY

The developer shall ensure that safety considerations are integrated with the overall software assurance and systems safety program. The developer shall ensure that their approach to the software safety program is documented in the System Safety Program Plan as appropriate.

The developer shall ensure that software safety requirements are clearly identified, documented, tracked, and controlled throughout the lifecycle. The developer shall identify potential hazards and ensure implementation of safety critical requirements. The developer shall test all software safety critical components on actual hardware to ensure that the safety requirements were sufficiently implemented and that applicable controls are in place to verify all safety conditions.

5.0.3 SOFTWARE RELIABILITY

The developer shall ensure that software reliability is incorporated into their software products. The developer shall ensure that appropriate activities are planned to support the achievement and verification of the developer's software reliability requirements.

5.0.4 VERIFICATION AND VALIDATION

The developer shall plan and implement a Verification and Validation (V&V) program to ensure that software being developed or maintained satisfies functional, performance, and other contractual requirements. To assist in the verification and validation of software requirements, the developer shall include software requirements in the project Requirements Verification Matrix (see Section 7.1).

V&V activities shall be performed during each phase of the development process and may include the following:

1. Analysis of system and software requirements allocation, verifiability, testability, completeness and consistency.
2. Design and code walkthroughs and/or inspections (i.e., engineering peer reviews).

3. Formal reviews.
4. Documented Test Plans and Procedures.
5. Test planning, execution, and reporting.

5.0.5 INDEPENDENT VERIFICATION AND VALIDATION

When the IV&V discipline is required by program request, the developer shall provide information required for the NASA Independent Verification and Validation (IV&V) effort to NASA IV&V Facility personnel. This may include access to all software reviews and reports, developer plans and procedures, software code, software design documentation, and software problem reporting data. Wherever possible, the developer shall permit electronic access to the required information or furnish soft copies of requested information to NASA IV&V personnel.

The developer shall review and assess all NASA IV&V findings and recommendations. The developer shall forward their assessment of these findings and recommendations to NASA IV&V personnel accordingly. The developer shall take necessary corrective action based upon their assessment and notify NASA IV&V personnel of this correction action. The developer shall also notify IV&V personnel of those instances where they decided not to take corrective action on specific IV&V findings and recommendations. A developer point of contact shall be assigned and available to NASA IV&V personnel, as required, for questions, clarification, and status meetings.

5.1 PEER REVIEWS

The developer shall ensure software is included in the engineering peer review program as appropriate. See Section 6.3 of this document.

5.2 SOFTWARE CONFIGURATION MANAGEMENT

The developer shall ensure that software is included in a configuration management system that provides baseline management and control of software requirements, design, source code, data, and documentation. The developer shall document their approach for software configuration management in the Configuration Management Plan.

5.3 STATUS REPORTING

The developer shall include in the monthly status reports to the government information that identifies software development schedules, issues and action items.

5.4 GOVERNMENT FURNISHED EQUIPMENT, EXISTING AND PURCHASED SOFTWARE AND FIRMWARE

If the developer is provided software as government-furnished equipment (GFE), or will use existing or purchased software and firmware, the developer shall ensure that the software and firmware meets the functional, performance, and interface requirements placed upon it. The developer shall ensure that the software and firmware meets applicable standards, including those for design, code, and documentation, or shall secure a G-RBSP Project waiver to those standards. Any significant modification to any piece of the existing software shall be subject to the provisions of the developer's quality management system 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.

Chapter 6. Technical Review Requirements

6.0 GENERAL REQUIREMENTS

The developer shall provide appropriate personnel to support a formal independent review program that is compliant with NPR 7120.5D, GPR 8700.4 and 8700.6. The program shall also meet the objectives of NPR 7123.1 and the GSFC-STD-1001 and the following overarching principles:

1. Assures that the instrument(s) and supporting designs are consistent with the requirements in this document;
2. Assures that the characteristics of the systems are carefully examined to develop the best approach consistent with existing constraints and available resources;
3. Provides a means of periodic evaluation of the hardware, software, and ground support development;
4. Assures that end-item deliverables (systems and subsystems) meet the G-RBSP requirements for performance.

The developers shall support the Life Cycle Reviews that are conducted by the Standing Review Board (SRB) and additional reviews conducted by the GSFC Systems Review Office (SRO) throughout the life cycle of the project. The developers will support the implementation of the independent review program and be responsive to the objectives of the review that will be described in a Terms of Reference (ToR) document for each CMR. The developer will also support a rigorous peer review program that is consistent with GPR 8700.6. The reviews cover all aspects of flight and ground hardware, software, and operations for which the developer has responsibility, as covered in NPR 7120.5 and GSFC-STD-1001. For each specified project and system-level review conducted by the Agency SRB or GSFC SRO. The developer shall:

a. Develop and organize material for oral presentation to the G-RBSP independent review team.
b. Support splinter review meetings resulting from the major review;
c. Produce written responses, in a timely manner, to requests for action (RFA) and action items resulting from the review. All RFA responses shall be entered into the GSFC RFA database for closure.;
d. Summarize, as appropriate, the results of the peer reviews at the component and subsystem level.

6.1 PEER REVIEWS

The developer shall also perform a series of engineering peer reviews (EPR) that is consistent with GPR 8700.6. These reviews are expected to be the most detailed of the G-RBSP reviews and have a technical focus. The peer review process shall ensure that participants are provided a detailed review of the component and subsystem design and show the ability of the design to meet system and mission level requirements.

The developer shall provide for engineering peer reviews of component and subsystem hardware/software chaired by the developer and held during all phases of the Project life cycle. The developer shall ensure that actions resulting from the peer reviews are tracked to closure and that records relating to peer reviews (e.g. agendas, minutes, etc.) are maintained for the duration of the project. The developer shall notify the G-RBSP Project of the peer review schedule. The G-RBSP Project may elect to send attendees to peer reviews and will notify the developer if participation is anticipated. The results of the peer reviews will be summarized at the next higher system level review.

6.2 REVIEW ACTION ITEM TRACKING

The developer shall implement a system for tracking the status and resolution of Action Items initiated during formal and peer reviews, and the status of these Action Items shall be reported at the formal reviews. Action Items shall be assigned unique control numbers that identify the item under review and the review type.

Chapter 7. Design Verification Requirements

7.0 GENERAL REQUIREMENTS

The developer shall conduct a system performance verification program covering the component through Instrument and Observatory levels. The developer shall document the overall verification plan, implementation, and results in a System Performance Verification and Validation Plan to ensure that the specified mission requirements are met, and to provide traceability from mission requirements through launch and on-orbit capability. The plan shall be submitted to the G-RBSP program in accordance with Appendix A of this document. The verification program shall consist of a series of functional demonstrations, analytical investigations, physical property measurements, and environmental tests that simulate the environments encountered during handling and transportation, pre-launch, launch, and on-orbit. The developer shall maintain as-run verification procedures and all test and analysis data.

All flight hardware and software shall undergo qualification to demonstrate compliance with the requirements of this section. In addition, all other hardware (flight follow-on, spare and re-flight) shall undergo acceptance in accordance with the requirements of this section.

The Verification Program shall begin with functional testing at the component level of assembly. It shall continue through functional and environmental testing at the component, subsystem, instrument, spacecraft and observatory levels of assembly, supported by appropriate analysis. The program shall conclude with end-to-end testing of the entire operational hardware/software system at the observatory level including the instruments, the ground control center, and the appropriate network elements.

The GSFC-STD-7000, General Environmental Verification Specification (GEVS) for GSFC Programs and Projects shall be used to develop the verification program. The GEVS document is available at: http://msc-docsrv.gsfc.nasa.gov/cmdata/170/STD/GEVS-STD-7000.pdf.

7.1 REQUIREMENTS VERIFICATION MATRIX

The developer shall provide adequate documentation to demonstrate compliance with all performance requirements identified in the contract Statement of Work. The developer shall maintain a Requirements Verification Matrix that shows the flow-down of all requirements (hardware and software) and the methods of verification. The Requirements Verification Matrix may be included in the System Performance Verification and Validation Plan. The Requirements Verification Matrix and supporting documentation shall provide the following information:

- Systems Performance Validation Plan flow-down;
- Basis for verification method (test, analysis, similarity, heritage, etc.);
- Dates accomplished with name and signature of person performing the action;
- Dates verified with name and signature of person verifying performance;
- Definition of specific environments for each requirement;
- Tracking of requirements verified against those planned;
- Detailed supporting documentation of compliance with each requirement.

7.2 ENVIRONMENTAL TEST PROGRAM

The developer shall conduct an environmental test program for flight hardware sufficient to demonstrate design qualification, acceptance, and to test for workmanship. Functional testing shall be performed before, during, and after environmental tests, as appropriate. The developer's environmental test plans shall define the specific parameters associated with the planned environmental tests. The developer shall establish environmental test levels to encompass predictions based on spacecraft and launch vehicle parameters for launch and operations. The developer shall consider interactions with the spacecraft and launch vehicle in defining these environmental parameters. These special interactions include subjects like resonance de-tuning, EMI/EMC effects, pyrotechnic firing disturbances, etc. as applicable.

Prototype and protoflight hardware shall undergo appropriate qualification tests to demonstrate compliance with the design requirements. Flight, flight spare, follow-on, and re-flight hardware shall undergo flight-like acceptance test levels to verify acceptable assembly workmanship.

The following environmental exposures are required as a baseline for G-RBSP Observatories and Instruments:

Components:

Sine Vibration, Random Vibration, Strength, EMI/EMC, Magnetic Properties, Thermal Vacuum/Thermal Balance, Mass Properties, and Deployment shall be performed. Comprehensive Performance Tests (CPTs) shall be part of the verification program at these levels of assembly.

Observatory and Instrument Levels:

Strength (static or quasi-static), Low level (Pogo) Sine Vibration, Random Vibration, Acoustics, Mechanical Shock, EMI/EMC, Magnetic Properties, Thermal Vacuum/Thermal Balance, Mass Properties, and Deployment shall be performed.

Repeated functional tests shall be used to demonstrate the growing maturity of the instruments or spacecraft subsystems, perform trending analysis, and to baseline performance status before each and after environmental test. CPT demonstrations shall be performed to verify full mission hardware compliance, compatibility, and operability; and to perform trending analysis.

7.3 END-TO-END TEST

Prior to the Pre-Ship Review for the G-RBSP Observatories, the developer shall participate in an end-to-end compatibility test to demonstrate the ground system capability to communicate with each observatory (up-link and down-link) via the ground to space network. Simulated normal orbital mission scenarios encompassing launch, systems turn-on, housekeeping, command/control, and stabilization/pointing shall be demonstrated, including the collecting, processing, and archiving of science data. Observatory immunity to erroneous commands, autonomous safe-hold, and simulated anomaly recovery operations shall also be demonstrated.

7.4 DEMONSTRATION OF FAILURE-FREE OPERATION

The GSFC-STD-7000, General Environmental Verification Specification (GEVS) for GSFC Programs and Projects shall be used to develop the verification program. The criteria for failure-free operation are contained within this document. The GEVS document is available at: http://msc-docsrv.gsfc.nasa.gov/cmdata/170/STD/GEVS-STD-7000.pdf.

7.5 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, the developer shall demonstrate how the hardware complies with requirements and gain approval from the G-RBSP Program office.

CHAPTER 8. Workmanship Standards and Processes

8.0 GENERAL REQUIREMENTS

The developer shall plan and implement a Workmanship Program to assure that all electronic packaging technologies, processes, and workmanship activities selected and applied meet mission objectives for quality and reliability.

8.1 APPLICABLE DOCUMENTS

Conformal Coating and Staking: NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies;

Soldering – Flight, Surface Mount Technology: NASA-STD-8739.2, Surface Mount Technology;

Soldering – Flight, Manual (hand): NASA-STD-8739.3, Soldered Electrical Connections;

Soldering – Ground Systems: IPC/EIA J-STD-001C, Requirements for Soldered Electrical and Electronic Assemblies;

Electronic Assemblies – Ground Systems: IPC-A-610C, Acceptability of Electronic Assemblies;

Crimping, Wiring, and Harnessing: NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring;

Fiber Optics: NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation;

Electrostatic Discharge Control (ESD): ANSI/ESD S20.20-1999 ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)

Printed Wiring Board (PWB) Design:

- IPC 2221 Generic Standard on Printed Wiring Board Design and
- IPC 2222, Sectional Design Standard for Rigid Organic Printed Boards;
- IPC-2223, Sectional Design Standard for Flexible Printed Boards;

Printed Wiring Board Manufacture:

- IPC A-600, Acceptability of Printed Boards
- IPC-6011, Generic Performance Specification for Printed Boards
- IPC-6012, Qualification and Performance Specification for Rigid Printed Boards
    - Flight Applications – Supplemented with: IPC 6012B Qualification and Performance Specification for Rigid Printed Boards: all flight boards shall be compliant to the Performance Specification Sheet for Space and Military Avionics (SMA Specification Sheet) class 3/A product. In the event of a conflict between the Design and Manufacture Specifications, the SMA specification shall take precedence.
- IPC-6013, Qualification and Performance Specification for Flexible Printed Boards.

The current status and/or any application notes for these standards can be obtained at URL http://standards.nasa.gov.

8.2 DESIGN

8.2.1 PRINTED WIRING BOARDS

The Printed Wiring Board (PWB) manufacturing and acceptance requirements identified in this chapter are based on using PWBs designed in accordance with the PWB design standards referenced above. The developer shall ensure that space flight PWB designs do not include features that prevent the finished boards from complying with the Class 3 Requirements of the appropriate manufacturing standard (e.g., specified plating thickness, internal annular ring dimensions, etc.).

8.2.2 ASSEMBLIES

The developer shall incorporate the design considerations listed in the NASA workmanship standards to the extent practical.

8.2.3 GROUND SYSTEMS THAT INTERFACE WITH SPACE FLIGHT HARDWARE

Ground system assemblies that interface directly with space flight hardware shall be designed and fabricated using space flight parts, materials, and processes for any portion of an assembly that mates with the flight hardware, unless approval by the G-RBSP Project SAM is received; or that will reside with the space flight hardware in environmental chambers or other test facilities that simulate a space flight environment (e.g., connectors, test cables, etc.).

8.3 WORKMANSHIP REQUIREMENTS

8.3.1 TRAINING AND CERTIFICATION

The developer shall ensure that all personnel working on deliverable hardware are certified as having completed the required training, appropriate to their involvement, as defined in the standards identified in Section 8.1.

8.3.2 FLIGHT AND HARSH ENVIRONMENT GROUND SYSTEMS WORKMANSHIP

8.3.2.1 PRINTED WIRING BOARDS

The developer shall manufacture Printed Wiring Boards (PWBs) in accordance with the Class 3 Requirements in the above referenced PWB manufacturing standards; for IPC 6012 product Class 3/A shall be used. The developer shall provide printed wiring board (PWB) coupons to the G-RBSP Project SAM, or to a GSFC-approved laboratory for evaluation in accordance with Appendix A of this document. PWB coupon approval shall be obtained prior to population of flight PWBs. The developer may have the coupons evaluated at an alternate laboratory if written approval is obtained from the G-RBSP Project SAM in advance. If an approved alternate laboratory is used, delivery of the test reports to the G-RBSP Project SAM is required.

8.3.2.2 ASSEMBLIES

The developer shall fabricate assemblies using the appropriate workmanship standards listed above (i.e., NASA-STD-8739.3 for hand soldering; NASA-STD-8739.4 for crimping/cabling; NASA-STD-8739.5 for fiber optic termination and installation; etc.).

8.3.3 GROUND SYSTEMS (NON-FLIGHT) WORKMANSHIP

8.3.3.1 PRINTED WIRING BOARDS

The developer shall ensure that PWBs which do not interface directly with flight hardware are manufactured in accordance with the Class 2 Requirements in the above referenced PWB manufacturing standards.

8.3.3.2 ASSEMBLIES

The developer shall fabricate assemblies using the Class 2 Requirements of J-STD-001C and IPC-A-610C, and ANSI/ESD S20.20-1999. If any conflicts between J-STD-001C and IPC-A-610C are encountered, the requirements in J-STD-001C shall take precedence.

8.3.4 DOCUMENTATION

The developer shall document the procedures and processes that will be used to implement the above referenced workmanship, design, and ESD control standards including any procedures or process requirements referenced-in via those standards.

The developer may propose alternate standards. Proposals for use of alternate standards must be accompanied by objective data that documents mission safety or reliability will not be compromised. The developer's use of alternate standards is limited to the G-RBSP Project and is allowed only after they have been reviewed and approved by the G-RBSP Program office.

8.4 NEW OR ADVANCED PACKAGING TECHNOLOGIES

New and/or existing advanced packaging technologies (e.g., multi-chip modules (MCMs), stacked memories, chip on board, ball grid array (BGA), etc.) shall be reviewed, approved by the Project Parts Control Board and included in the Project Approved Parts List (PAPL).

8.5 HARDWARE HANDLING

The developer shall ensure that handling of flight hardware is performed by designated personnel in accordance with approved procedures that address cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., antistatic film materials), and purging. Procedures for the control of contamination shall be implemented in all phases of assembly and test. The developer shall ensure that personnel working on flight hardware are certified as having completed the required certifications prior to handling any flight hardware. This includes, but is not limited to, the aforementioned workmanship, design and ESD awareness courses.

8.6 ELECTROSTATIC DISCHARGE CONTROL REQUIREMENTS

The developer shall document and implement an ESD Control Program in an ESD Control Plan in accordance with ANSI/ESD S20.20-1999, or equivalent, suitable to protect the most sensitive components used in the Project. At a minimum, the ESD Control Program shall address training, protected work area procedures and verification schedules, packaging, facility maintenance, storage, and shipping. The ESD Control Plan shall be made available to GSFC personnel upon request.

The developer shall ensure that all personnel who manufacture, inspect, test, otherwise process electronic hardware, or require unescorted access into ESD protected areas are certified as having completed the required training, appropriate to their involvement, as defined in GPR 8730.6 or ANSI/ESD S20.20-1999 prior to handling any electronic hardware.

The developer shall ensure that electronic hardware is manufactured, inspected, tested, or otherwise processed only at designated ESD protective work areas. The developer shall verify these work areas on a regular schedule as identified in the developer's ESD Control Program.

The developer shall properly package electronic hardware in ESD protective packaging at all times when not actively being manufactured, inspected, tested, or otherwise processed.

CHAPTER 9. Parts Requirements

9.0 GENERAL

The developer shall plan and implement an EEE Parts Control Program to assure that all parts selected for use in flight hardware meet mission objectives for quality and reliability. The program shall be in place to effectively support the design and part selection processes through the launch of the G-RBSP spacecraft.

The developer shall prepare a Parts Control Plan (PCP) describing the approach and methodology for implementing their Parts Control Program. The PCP shall be submitted to G-RBSP Project personnel and the GSFC Project Parts Engineer (PPE) for review in accordance with Appendix A of this document. The PCP shall also define the developer's criteria for parts selection and approval based on the guidelines of this section. The plan shall address how the developer ensures the flow down of the applicable parts control requirements to the suppliers.

The developer shall select and process all parts in accordance with EEE-INST-002, GSFC EEE Parts Selection, Screening, Qualification and Derating, for part quality level 2 or better. Exceptions for use of a lesser grade part with additional testing shall only be made on a case by case basis when a level 2 part is not available. Such exceptions require approval by the Parts Control Board (PCB). The developer shall control the selection, application, evaluation, and acceptance of all parts through the PCB.

9.1 DEVELOPER'S PROJECT PARTS ENGINEER

The developer shall designate one key individual to be their Project Parts Engineer (PPE). The PPE shall have the prime responsibility for management of their EEE parts control program. This individual shall have direct, independent and unimpeded access to the GSFC PPEs and PCB. The PPE shall work with design engineers, radiation engineers, reliability engineers and the GSFC PPE to perform part selection and control.

Tasks performed by the developer PPE shall include but are not limited to the following:

1. Work with GSFC PPE team to perform parts control.
2. Provide PCB agenda, prepare Parts Lists and provide supporting part information for parts evaluation and approval by the PCB.
3. Coordinate PCB meetings, maintain minutes, develop and maintain the instrument's Parts Identification List (PIL), develop the instrument portion of the Project Approved Parts List (PAPL), As-Designed Parts List (ADPL) and As-Built Parts List (ABPL).
4. Perform Customer Source Inspections (CSI) and audits at supplier facilities as required.
5. Prepare part procurement, screening, qualification, and modification specifications, as required.
6. Disposition/track part nonconformances and part failure investigations.
7. Track and report impact of Alerts and Advisories on flight hardware.

9.2 PARTS CONTROL BOARD (PCB)

The developer shall establish a Parts Control Board (PCB) to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. The PCB shall be responsible for the review and approval of all EEE parts, for conformance to established criteria of section 9.3, and for developing and maintaining the PAPL for the instrument. In addition, the PCB is responsible for providing assistance for all parts activities such as part failure investigations, disposition of part non-conformances, and part problem resolutions. PCB operating procedures shall be included as part of the PCP.

When parts require additional testing per EEE-INST-002 to bring them to Level 2 parts requirement, the PCB will work with the SAM to determine if the testing should be performed to Level 3 or Level 2 based on the criticality, redundancy and application of the part and the instrument.

9.2.1 PCB RESPONSIBILITIES

The PCB responsibility shall include but not limited to the following:

- Evaluation of EEE parts for conformance to established criteria and inclusion in the PAPL,
- Develop and maintain the PAPL PIL, ADPL and ABPLs for the instrument,
- Review and approve EEE part derating as necessary for unique applications,
- Define testing requirements,
- Review unique applications (including radiation effects),
- Track part failure investigations and non-conformances.

If there are any parts issues that cannot be resolved at the PCB level, the issues shall be elevated as appropriate.

9.2.2 PCB MEETINGS AND NOTIFICATION

PCB meetings shall be convened as needed. The GSFC Project Parts Engineer shall be a permanent voting member for PCB actions. The developer's PPE shall maintain meeting minutes or records to document all decisions made.

The developer PPE shall notify attendees at least five (5) working days in advance of upcoming meetings. Notification of PCB meetings shall include a proposed agenda and documentation necessary to conduct the review.

9.2.3 PCB MEMBERSHIP

As a minimum, the PCB membership shall consist of the developer's Product Assurance Manager, developer PPE, GSFC Project PPE and GSFC Project Radiation Engineer (PRE) when required. The participation of the developer PPE and GSFC PPE is required for all PCB meetings. The developer PPE, GSFC PPE and GSFC PRE shall be permanent working and voting members of the PCB. The developer PPE shall assure that the appropriate individuals with engineering knowledge and skills are represented as necessary at meetings, such as part commodity specialists, Radiation Engineers, SAM or the appropriate subsystem design engineer.

9.3 PART SELECTION AND PROCESSING

9.3.1 GENERAL

All part commodities identified in EEE-INST-002 are considered EEE parts and shall be subject to the requirements set forth in this chapter. EEE Parts types that do not fall in to any of the categories covered in EEE-INST-002 shall be reviewed by the PCB and evaluated using the closest NASA, DSCC or government controlled specification. In the event a suitable government baseline specification does not exist, the PCB shall identify the best available industry standard for that particular commodity, and develop appropriate procurement, screening and qualification specification.

9.3.2 PARTS SELECTION

Parts shall be selected according to the GSFC EEE Parts Selection, Screening, Qualification and Derating document (EEE-INST-002) for quality level 2 or better. Exceptions for use of a lower grade shall only be made on a case by case basis when a level 2 part is unavailable, and such exceptions require approval by the PCB. The use of a lower grade part requires additional testing to be performed in accordance with EEE-INST-002 to upgrade the part to level 2 or as agreed upon by the PCB.

Parts selected from the NASA Part Selection List (NPSL) for quality level 2 or better are preferred. All other EEE parts shall be selected, manufactured, processed, screened, and qualified, as a minimum, in the same manner as the nearest applicable quality level 2 device.

EEE-INST-002 contains value added testing for a number of parts listed in the NPSL. The NPSL is available at the following URL: http://nepp.nasa.gov/npsl. These tests include PIND testing for EEE devices with internal cavities, surge current testing for tantalum capacitors and dielectric screening for several types of ceramic capacitors. These and any other value added tests listed in EEE-INST-002 shall be performed to enhance the reliability of parts. PCB approval is required if there is any deviation from any screening or qualification tests as specified in EEE-INST-002.

9.3.3 RADIATION REQUIREMENTS FOR PART SELECTION

9.3.3.1 GENERAL

An appropriate radiation hardness assurance program shall be developed and conducted, through PCB and the GSFC Project Radiation Engineer (PRE), based on project requirements. The Parts Control Plan shall address all phases of the flight hardware development including the design, test, and production.

9.3.3.2 EVALUATION OF RADIATION EFFECTS IN PARTS

All parts shall be evaluated to perform their function in their intended application in the predicted radiation environment including the applicable Radiation Design Margin (RDM). The developer shall document the radiation analysis of each part as applicable. The radiation environment causes the following three main degradation effects that must be accounted for all active parts selection:

- **Total Ionizing Dose (TID)**, including Enhanced Low Dose Rate (ELDR) effects. Parts shall be selected to ensure their adequate performance in the application up to a dose of 2x the expected mission dose.
- **Single-Event Effects (SEE),** Parts must be assessed for the potential of Single Event Upset (SEU) or Single Event Transient (SET), which requires analysis of the circuit application on a case-by-case basis. Parts susceptible to Single Event Latch up (SEL) shall be avoided. If performance demands the use of an SEL susceptible part, measures shall be implemented to ensure that SEL induced damage (both prompt and latent) are mitigated and that the instrument performance is not compromised. These measures must be approved by the developer Radiation Engineer (RE) and PPE, along with GSFC Project Radiation Engineer (PRE) and GSFC PPE before the part can be added to the PAPL.
- **Displacement Damage,** Parts shall be able to withstand the displacement damage induced by high energy protons, to twice the fluence expected in the predicted G-RBSP environment.

These effects and others may require individual part application analyses to be performed as necessary by the PRE. The developer shall document the radiation analysis of each part as applicable.

9.3.3.3 RADIATION TRANSPORT ANALYSIS

When deemed necessary, transport calculations for the incident radiations shall be performed for shielding appropriate for the mission of interest using established codes.

9.3.4 CUSTOM OR ADVANCED TECHNOLOGY DEVICES.

Below are devices that shall be subject, but not limited, to parts control and shall include a design review and approved by the PCB appropriate for the individual technology:

a. Custom microcircuits such as Application Specific Integrated Circuits, Hybrid Microcircuits, Multi-Chip Modules, and D/C Power Converters

b. Field Programmable Gate Array (FPGA) based designs

c. Custom microwave devices and Microwave Monolithic Integrated Circuits (MMIC's)

d. High power microwave devices. All microwave device designs with a output power greater than 10 watts RF at S-band and Ku-band and 1 watt RF at Ka-band or higher shall be reviewed by NASA for multipactor margin and other critical RF reliability considerations (e.g., hermetic packaging, hydrogen poisoning, design margins, etc.).

e. Embedded passive or active component substrates or PWB's

The design review shall include element evaluation to assure each element's reliability, (review shall include such items as burn-in, voltage conditioning, sample size, element derating, etc.), device construction and assembly process, including materials evaluation (for such items as contamination concerns, metals whisker concerns, and adequate material thermal matching); Materials specialists may be consulted as necessary. The PCB chair shall chair the review and invite all required developer, subcontractor, supplier, vendor, and GSFC personnel (e.g., subject matter experts, systems engineering, Mission Assurance personnel, etc.). A Customer Source Inspection may be required.

A procurement specification may be required for parts in this category based on the recommendation of the PCB. These specifications shall fully describe the item being procured and shall include physical, mechanical, environmental, electrical test requirements, and quality assurance provisions necessary to control manufacture and acceptance. Screening requirements designated for the part can be included in the procurement specification. Test conditions, burn-in circuits, failure criteria, and lot rejection criteria shall also be included. For lot acceptance or rejection, the Percentage of Defectives Allowable (PDA) in a screened lot shall be in accordance with that prescribed in the closest military part specification and/or GSFC EEE-INST-002.

9.3.5 PLASTIC ENCAPSULATED MICROCIRCUITS (PEMS)

The use of Plastic Encapsulated Microcircuits is discouraged. However, when use of PEMs is necessary to achieve unique performance requirements that can not be achieved by using hermetic high reliability microcircuits, plastic encapsulated parts, must meet the requirements of EEE-INST-002. The PCB shall review the procurement specification, application of part, and storage processes for plastic encapsulated parts to assure that all aspects of EEE-INST-002 have been met.

9.3.6 VERIFICATION TESTING

Re-performance of screening tests, which were performed by the manufacturer or authorized test house as required by the military or procurement specification, is not required unless deemed necessary as indicated by failure history, GIDEP Alerts, age or other reliability concerns. If required, testing shall be performed in accordance with GSFC EEE-INST-002 or as determined by the PCB.

9.3.7 PARTS APPROVED ON PRIOR PROJECTS

Parts previously approved by GSFC for other projects via prior PCB activity or a Nonstandard Parts Approval Request (NSPAR) shall not be granted “Grandfather approval” on the G-RBSP project. However, existing approval packages may be brought to the PCB as an aid to present candidate parts for approval. (Preparation of NSPARs is not a requirement for G-RBSP). Such candidate parts shall be evaluated by the PCB for compliance to current Project requirements by determining that:

1. No changes have been made to the previously approved NSPAR, Source Control Drawing (SCD) or supplier list.

2. All stipulations cited in the previous NSPAR approval have been implemented on the current flight lot, including performance of any additional testing.

3. The previous project’s parts quality level is identical to the current project.

4. No new information has become available which would preclude the use of the previously approved part in a high reliability space flight application.

9.3.8 PARTS USED IN OFF-THE-SHELF ASSEMBLIES

Units or assemblies that are purchased as “off-the-shelf” hardware items shall be subjected to an evaluation of the parts used within them. The parts shall be evaluated for screening compliance to EEE-INST-002, established reliability level, and include a radiation analysis. Units may be required to undergo modification for use of higher reliability parts or Radiation hardened parts. Modifications such as additional shielding for radiation effectiveness or replacing radiation-soft parts for radiation-hardened parts may be required and shall be subject to PRE approval as part of the PCB approval activities.

9.4 PART ANALYSIS

9.4.1 DESTRUCTIVE PHYSICAL ANALYSIS

A sample of each lot date code of Field Programmable Gate Arrays (FPGAs), hybrid microcircuits, microcircuits, oscillators, and semiconductor devices shall 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 shall be as specified in GSFC specification S-311-M-70, Destructive Physical Analysis. The PCB on a case-by-case basis shall consider variation to the DPA sample size requirements, due to part complexity, availability or cost.

9.4.2 FAILED EEE PARTS

The developer shall have a plan to report all EEE component failures during EEE part screening and qualification; during qualification and acceptance testing of flight hardware - beginning with the first application of power at the subassembly level continuing through, unit, subsystem, and system levels. A Failure Review Board (FRB) shall be convened, if recommended by the PCB. The failure reporting plan shall include identification of failed parts, notification to GSFC within ten (10) business days after time of failure, retrieval of failed/overstressed parts, part failure analysis and documentation of all pertinent information related to each failure. The failure reporting plan shall be documented and presented to the PCB for review and approval.

9.4.3 FAILURE ANALYSIS

When a component part Failure Analysis (FA) is necessary to support a Failure Review Board (FRB) activity, the developer shall prepare a part Failure Analysis Report. The Developer PPE shall submit the completed report to the PCB for review and approval in order to assure proper documentation is presented for the FRB. The failure report form shall as a minimum, provide the following information:

- The failed part's identity (part name, part number, reference designator, manufacturer, manufacturing lot / date code, and part serial number if applicable), and symptoms by which the failure was identified (the conditions observed as opposed to those expected).
- The name of the unit or subsystem on which the failure occurred, date of failure, the test phase, and the environment in which the test was being conducted.
- An indication of whether the failure of the part or item in question constitutes a primary or a secondary (collateral) failure (caused by another failure in the circuit and not a failure on its own merit.)
- The results of the failure analyses conducted and the nature of the rework/retest/corrective action taken in response.

The completed failure report shall include copies of any supporting photographs, X-rays, metallurgical data, microprobe or spectrographic data, Scanning Electronic Microscope (SEM) photographs, pertinent variables (electrical and radiation) data, etc. Radiation data shall be submitted where it is deemed pertinent to the failure mechanism. The FRB shall achieve a timely resolution and closure of each failure incident and will document the findings.

9.5 ADDITIONAL REQUIREMENTS

9.5.1 PARTS AGE CONTROL

All parts procured with date codes greater than five (5) years from the date of manufacture to date of procurement shall be subjected to a re-screen and sample DPA per PCB recommendation. Alternate test plans may be used as approved by the PCB on a case-by-case basis. Parts taken from user inventory older than 5 years do not require re-screen provided they have been properly stored and use has been approved by the PCB. Proper storage is defined as maintaining the parts within their rated temperature range and protected from conditions that create electrostatic damage or contaminants that may affect their functionality (e.g., corrosive atmospheres that damage the plating on the leads or terminations). Parts over 10 years old from the date of manufacture to the date of procurement shall not be procured.

9.5.2 DERATING

All EEE parts shall be used in accordance with the derating guidelines of GSFC EEE-INST-002. The developer's derating policy may be used in place of the GSFC guidelines and shall be submitted with developer's PCP for approval by the PCB. Any component that exceeds the manufacturer's temperature limit specification or does not meet the derating guidelines of EEE-INST-002 shall be reviewed and approved by the PCB before use.

9.5.3 GIDEP ALERTS

The developer shall be responsible for the review and disposition of all GIDEP Alerts on parts proposed for flight use. In addition, any NASA Alerts and Advisories provided to the developer by GSFC shall be reviewed and dispositioned. Alert applicability, impact, and corrective actions shall be continuously documented and reported to GSFC. The review process shall continue from delivery up to launch. See Chapter 12 of this MAR.

9.5.4 PROHIBITED METALS

Pure tin (Sn), cadmium (Cd), and zinc (Zn) shall not be used as an internal or external finish on any EEE parts and associated hardware. These materials are susceptible to spontaneous whisker growth that can lead to electrical short circuits.

Procurement specifications that prohibit the use of pure Sn, Cd, or Zn plating are recommended. An independent verification of plating composition shall be carried out by the developer, if recommended by the PCB. Materials characterization methods such as EDS (Energy Dispersive Spectroscopy) or XRF (X-ray Fluorescence) should be used for verifying that prohibited materials are not present in internal or external finishes.

9.5.5 TRACEABILITY

The developer shall utilize traceability database(s) that shall provide the capability to retrieve historical records of EEE parts from initial procurement and receipt through storage, kitting, assembly, test, and final acceptance of the deliverable product. Also, the database shall permit the traceability to the procurement document and shall provide for:

- Cross-referencing and traceability of part manufacturer and date code to the assembly traveler or production plan.
- The storage of the accumulated data records.

All flight EEE parts shall be traceable to the date code or manufacturer’s inspection lot, wafer lot (where applicable) and shall be maintained throughout manufacturing for each deliverable item.

9.5.6 ESD CONTROL

The developer shall ensure that storage areas, laboratories, and work areas that receive, distribute, assemble, disassemble, handle, test or repair electrostatic discharge sensitive (ESDS) equipment are inspected and ESD-certified for proper equipment and handling procedures in accordance with section 8.6 of this MAR. The developer shall assess their ESD requirements and determine what level of precaution is necessary to ensure that their ESDS parts are protected. This information shall be contained within an ESD Control Plan and made available to GSFC personnel upon request. For parts and assemblies that have and ESD sensitivity level of 250V or less, extra precautions (such as Ionizers, controlled environment, and proper equipment/personnel grounding) are required to protect from ESD events.

9.6 PARTS LISTS

The developer shall develop and maintain a Parts Identification List (PIL), Project Approved Parts List (PAPL) and As-Designed Parts List (ADPL) for the duration of the project. Parts must be approved for listing on the PAPL before initiation of procurement activity. Long Lead items shall be identified on the PIL and have conditional approval from the PCB before procurement.

9.6.1 PARTS IDENTIFICATION LIST (PIL)

The PIL shall list all parts proposed for use in flight hardware. The PIL is prepared from design team inputs or supplier inputs, to be used for presenting and tracking candidate parts to the PCB. The PIL shall include as a minimum the following information: Part type, Manufacturer’s generic part number, part description, manufacturer, procurement specification, comments and Federal Stock Class.

9.6.2 PROJECT APPROVED PARTS LIST (PAPL)

The PAPL shall list only approved parts for flight hardware, and shall be the combined listing of all parts submitted through Parts Identification Lists that are approved by the PCB, plus approval status and disposition notes. Only parts that have been evaluated and approved by the PCB shall be listed in the PAPL. The PCB shall assure standardization of parts listed in the PAPL across various systems and subsystems.

9.6.3 AS-DESIGNED PARTS LIST (ADPL)

The developer PPE shall establish an As-Designed Parts List (ADPL) as soon as practical after the preliminary release. The GSFC PPE shall maintain a copy in the GSFC Parts Database, and will work with the design teams to keep the list(s) current.

9.6.4 AS-BUILT PARTS LIST (ABPL)

An As-Built Parts List (ABPL) shall also be prepared and submitted to the G-RBSP Program office by the Developer PPE. The ABPL is a final compilation of all parts as installed in flight equipment, with additional "as-installed" part information such as manufacturer name, CAGE code, Lot-Date Code, part serial number (if applicable). Provisions shall be in place to find quantity used and provide traceability to box or board location through build paperwork. The manufacturer's plant specific CAGE code is preferred, but if unknown, the manufacturer's general CAGE code is sufficient.

9.7 DATA REQUIREMENTS

Upon request, summary data shall be provided to the Project Parts Engineer for all testing performed as applicable. The developer shall ensure that variable data (read and record) is recorded for initial, interim and final electrical test points as applicable. The developer shall provide this data to GSFC upon request.

For flight lots with samples subjected to Radiation Lot Acceptance Testing (RLAT), the radiation report that identifies parameter degradation behavior shall be provided to the PCB, and variables data acquired during radiation testing shall be kept available to GSFC as applicable.

The developer shall have a method in place for the retention of data generated for parts tested and used in flight hardware. The data shall be kept on file in order to facilitate future risk assessment and technical evaluation, as needed.

Each developer and supplier shall perform, or be responsible for the performance of applicable incoming inspections and shall provide data to ensure that products meet the requirements of the procurement specification.

9.8 RETENTION OF DATA, PART TEST SAMPLES AND REMOVED PARTS

The developer shall have a method in place for the retention of data generated for parts tested and used in flight hardware. The data shall be kept on file in order to facilitate future risk assessment and technical evaluation, as needed. In addition, the developer shall retain all part functional failures, all destructive and non-flight non-destructive test samples, which could be used for future validation of parts for performance under certain conditions not previously accounted for. These devices shall be kept until end of mission. PIND test failures may be submitted for DPA or radiation testing. Data shall be retained for the useful life of the spacecraft, unless otherwise permitted by the PCB. All historical quality records and data required to support these records shall be retained through the end of the contract and shall be provided to GSFC upon request.

Materials, Processes and Lubrication Requirements

10.0 GENERAL REQUIREMENTS

The developer shall implement a comprehensive Materials and Processes Control program beginning at the design stage of the hardware. The program shall ensure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials, processing and lubricants employed to meet the operational requirements for the G-RBSP Project. Materials and lubrication assurance approval is required for each usage or application in space-flight hardware. Materials selection shall be in accordance with the specific Project performance requirements and as defined below. The Materials and Process Control program shall be documented in a Materials and Processes Control Plan to be provided to G-RBSP Program personnel in accordance with Appendix A of this document.

The plan shall include:

a. Materials, & Processes Control Board (MPCB) operating procedures, membership, responsibilities, authority, meeting schedules, MP review procedures, MP approval/disapproval procedures, GSFC involvement, and plans for updating the operating procedures; the definition of the role and authority of each MPCB member; and relationships with various groups within the prime, associate, and sub-developer organizations (see section 12.2 for further information). In programs where the developer deems that a MPCB is impractical, a Materials Assurance Engineering shall serve in its place.

b. Shelf life control plan (see section 10.2.8 for further information).

c. MP vendor surveillance and audit plan

d. MP qualification plan that describes how new MP should be qualified for the intended end item application

e. Incoming inspection and test plan

f. Destructive Physical Analysis (DPA) plan

g. Defective materials controls program.

h. MPCB coordination and interactions with other program control boards; i.e., CCB, failure review board (FRB), mass properties control board (MPCB) and MRB.

i. Corrosion prevention and control plan.

j. Contamination Prevention and Control Plan, as required.

k. Standardization of program MP.

l. Traceability control plan.

10.1 MATERIALS AND PROCESSES CONTOL BOARD

A MPCB shall be responsible for the planning, management, and coordination of the selection, application, and procurement requirements of all materials and processes intended for use in the deliverable end item(s). MPCB findings, decisions, and directions shall be within the contractual requirements, and shall be binding on all applicable developers and sub-developers. The GSFC Materials Assurance Engineer (MAE) shall be a permanent member of the MPCB to ensure real-time approval/disapproval of MPCB decisions and actions. If there are any materials issues, which the developer and GSFC cannot resolve at the MPCB level, then the GSFC MAE shall inform the SAM and the Project Manager of the issue and the associated risk. After this discussion, the GSFC Project Manager will decide whether to accept the risk and ask the developer to submit a waiver to document the issue, or to elevate the issue to the developer's management for resolution.

10.1.1 CHAIRMANSHIP

The MPCB Chairman shall be responsible for preparation and distribution of MPCB meeting agenda and minutes, conducting MPCB meetings and managing the MPCB.

10.1.2 MEMBERSHIP

The MPCB membership shall include at least one member from each appropriate developer and sub-developer. GSFC will appoint a representative to be a voting member of the developer/sub-developer MPCB. Other members may be designated by GSFC or the MPCB chairman. Each member shall be supported in technical matters as required. Each member shall have the authority to commit his activity, organization, or company to assist as needed to support MPCB decisions within the scope of the applicable contract. Representation at individual meetings shall be required, consistent with the scheduled subject matter on the agenda.

10.1.3 DELEGATION.

The authority to conduct MPCB may be delegated by the prime developer MPCB chairman to major developers/sub-developers. Each organization so delegated shall supply the responsible activity MPCB with meeting minutes documenting decisions in a timely manner. All information shall be made available to each higher acquisition activity. Each higher acquisition activity retains the right of disapproval of delegated MPCB decisions.

10.1.4 MEETINGS

The MPCB shall conduct meetings as follows:

a. A post-award organizational MPCB meeting shall be convened by the developer. The chairman shall coordinate the date and location of the meeting with GSFC, and inform proposed member activities members of the schedule and meeting agenda. The purpose of this initial meeting is to establish responsibilities, procedures, and working relationships to allow the rapid transition to an operational MPCB.

b. Regularly scheduled meetings shall be held as determined necessary by the MPCB chairman. These meetings shall address, as a minimum, predefined agenda items for discussion.

c. Special MPCB meetings may be called by the MPCB chairman to discuss special items that may require expeditious resolution. Adequate notification shall be provided to all MPCB members.

d. MPCB meetings may be accomplished either in person, via telephone, or other media such as tele/video conference.

10.1.5 MPCB RESPONSIBILITIES

a. The MPCB shall establish and document formal operating procedures.

b. The MPCB shall develop and maintain a Materials and Processes List (MPL). The MPCB shall review and approve all MPs.

c. The MPCB shall define MP selection and approval criteria and shall prepare and maintain supporting documents for MP approval.

d. Through interface with design activity, the MPCB shall ensure the design selection and use of MP that meets the technical program requirements.

e. The MPCB shall ensure adequate design margins for mechanical parts used in deliverable end items. The MPCB shall review and approve any proposed deviations from the technical program requirements.

f. The MPCB shall ensure the review of the results of MRB actions and any other details pertaining to MP. All MP problems shall require disposition by the MPCB.

g. The MPCB shall ensure the timely identification of long lead MP items and other problem procurements.

h. The MPCB shall ensure the identification and configuration control of any changes to MPCB approved documentation.

i. The MPCB shall ensure that laboratories and analysis facilities used for evaluation of MP are reviewed for capabilities of equipment and personnel before performing analyses in compliance with these requirements.

l. The MPCB shall prepare and distribute the meeting minutes within 5 working days after the meeting. The minutes shall document all action items, significant areas of disagreement and the basis for all decisions from the meeting.

10.1.6 MPCB AUTHORITY

The MPCB shall ensure that all MP items approved for use meet mission reliability and performance requirements. All MPCB decisions shall be documented in the meeting minutes. All supporting technical analysis shall be provided and any additional analysis and tests in accordance with MPCB direction attached to the meeting minutes. The MPCB shall have the authority to approve technical changes to the detail MP requirements when baseline changes fall into one or more of the categories specified below without impact to the item performance in the intended application:

a. Variation from design and construction requirements of the detail specification.

b. Screening and lot acceptance tests and acceptance criteria deviations from the detail specifications.

10.2 MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, the developer shall, 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, toxicity, flammability and fracture toughness, as well as the properties required by each material usage or application.

10.2.1 MATERIALS IDENTIFICATION LIST

The developer shall maintain a Materials Identification List (MIL) of all materials planned for use in flight hardware, regardless of their approval status. The initial As-designed Materials and Processes List and subsequent updates shall be submitted to GSFC in accordance with Appendix A of this document. An As-Built Materials and Processes List (ABMPL) shall also be prepared and submitted to GSFC in accordance with the contract delivery requirements. The ABMPL is the final MIL with additional as-built information such as materials manufacturers.

The MIL shall include information for Polymeric Materials and Composites Usage, Inorganic Materials and Composites Usage, Lubrication Usage, and Material Process Utilization. Reference lists are provided in this document as a guide for the developer (Figures 10-3 through 10-6). The MIL can be submitted as one single document or file as long as it contains all the appropriate information referenced in the attached figures.

10.2.2 COMPLIANT MATERIALS

The developer shall 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 following applicable selection criteria:

- Hazardous materials requirements, including flammability, toxicity and compatibility as specified in AFSPCMAN 91-710, and NASA-STD-6001, Flammability, Odor, Off-gassing and Compatibility Requirements and;
- Vacuum Outgassing requirements as defined in paragraph 10.1.3;
- Stress corrosion cracking requirements as defined in MSFC STD-3029, Design Criteria for Controlling Stress Corrosion Cracking.

10.2.3 VACUUM OUTGASSING

Material vacuum outgassing shall be determined in accordance with ASTM E-595. A material is qualified on a product-by-product basis. However, GSFC 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% shall be approved for use in a vacuum environment. A waiver shall be submitted to the G-RBSP Project for materials planned to be used, which do not meet the CVCM and/or TML requirement.

10.2.4 NON-COMPLIANT MATERIALS

A material that does not meet the requirements of the applicable selection criteria above (see 10.1.2), or meets the requirements above but is used in an unconventional application, shall be considered to be a non-compliant material.

The proposed use of a non-compliant material requires a waiver to be submitted to the G-RBSP Program office in accordance with Appendix A of this document**.** This waiver can take the form of Materials Usage Agreement (Figure 10-1) and/or a Stress Corrosion Evaluation Form (Figure 10-2).

10.2.4.1 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 shall be treated as non-compliant. The developer shall submit a waiver to the G-RBSP Program office defining 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 shall 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.

10.2.5 CONVENTIONAL APPLICATIONS (DEFINITION)

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

10.2.6 NON-CONVENTIONAL APPLICATIONS (DEFINITION)

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage shall be considered a non-conventional application. 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.

10.2.7 POLYMERIC MATERIALS

The developer shall include polymeric materials and composites on the MIL. Material acceptability shall be determined on the basis of flammability, toxicity, vacuum outgassing and all other materials properties relative to the application requirements and usage environment.

10.2.8 SHELF-LIFE-CONTROLLED MATERIALS

Polymeric materials that have a limited shelf life shall 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, rosin core solder, lubricated bearings and paints shall be included. The use of materials with expired date code requires that the developer demonstrate by means of appropriate tests that the properties of the materials have not been compromised for their intended use; such materials shall be approved by GSFC by means of a waiver.

10.2.9 INORGANIC MATERIALS

The developer shall include inorganic materials and composites on the MIL. In addition, the developer may be requested to submit supporting applications data. The criteria specified in MSFC-STD-3029 shall be used to determine that metallic materials meet the stress corrosion cracking (SCC) criteria. A wavier shall be submitted to the G-RBSP Program office for each material usage that does not comply with the MSFC-STD-322 SCC requirements (Reference Figure 10-1 and 10-2 as a guide).

10.2.10 FASTENERS

The developer shall comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in 541-PG-8072.1.2, Goddard Space Flight Center Fastener Integrity Requirements (formerly known as GSFC S-313-100). Material test reports for fastener lots shall be submitted for information.

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

10.2.11 LUBRICATION

The developer shall prepare and document a lubrication usage list as part of the MIL. In addition, the developer may be requested to submit supporting application-specific data.

Lubricants shall 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.

The developer shall qualify by life testing all lubricated mechanisms in accordance with the Life Test Plan or heritage of an identical mechanism used in identical applications.

10.3 PROCESS SELECTION REQUIREMENTS

The developer shall prepare and document a material process utilization list as part of the MIL. A copy of any process shall be submitted for review upon request. Manufacturing processes (e.g., lubrication, heat treatment, welding, chemical or metallic coatings) shall be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

10.4 PROCUREMENT REQUIREMENTS

10.4.1 PURCHASED RAW MATERIALS

Raw materials purchased by the developer shall be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance.

10.4.2 RAW MATERIALS USED IN PURCHASED PRODUCTS

The developer shall require that the supplier meet the requirements of 10.3.1 and provide on request the results of acceptance tests and analyses performed on raw materials.

10.5 GIDEP ALERTS

See Section 12 of this document for GIDEP Alert requirements.

<table>
<tr><td colspan="4">MATERIAL USAGE AGREEMENT (MUA)</td><td colspan="5">USAGE AGREEMENT NO.:</td><td colspan="2">PAGE OF</td></tr>
<tr><td colspan="2">PROJECT:</td><td colspan="2">SUBSYSTEM:</td><td colspan="5">ORIGINATOR:</td><td colspan="2">ORGANIZATION:</td></tr>
<tr><td colspan="2">DETAIL DRAWING</td><td colspan="3">NOMENCLATURE</td><td colspan="4">USING ASSEMBLY</td><td colspan="2">NOMENCLATURE</td></tr>
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<tr><td colspan="6">MATERIAL & SPECIFICATION</td><td colspan="5">MANUFACTURER & TRADE NAME</td></tr>
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<tr><td colspan="11">APPLICATION:</td></tr>
<tr><td colspan="11">RATIONALE:</td></tr>
<tr><td colspan="5">ORIGINATOR:</td><td colspan="4">PROJECT MANAGER:</td><td colspan="2">DATE:</td></tr>
</table>

FIGURE 10-1 Material Usage Agreement

FIGURE 10-2: STRESS CORROSION EVALUATION FORM

1. Part Number ____
2. Part Name ____
3. Next Assembly Number ______________________________
4. Manufacturer _______________________________________
5. Material ____
6. Heat Treatment _____________________________________
7. Size and Form ______________________________________
8. Sustained Tensile Stresses-Magnitude and Direction
    a. Process Residual ____________________________________
    b. Assembly ____
    c. Design, Static ______________________________________
9. Special Processing ___________________________________
10. Weldments
    a. Alloy Form, Temper of Parent Metal ______________________
    b. Filler Alloy, if none, indicate ___________________________
    c. Welding Process ____________________________________
    d. Weld Bead Removed - Yes ( ), No ( ) ______________________
    e. Post-Weld Thermal Treatment ___________________________
    f. Post-Weld Stress Relief ________________________________
11. Environment _______________________________________
12. Protective Finish ____________________________________
13. Function of Part _____________________________________
14. Effect of Failure _____________________________________
15. Evaluation of Stress Corrosion Susceptibility _______________
16. Remarks: ____

POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT ____________ SYSTEM/EXPERIMENT ____________ GSFC T/O ____________

DEVELOPER/DEVELOPER ____________ 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 were selected. If for a particular property, please give the property.
   Example: Cost, availability, room temperature curing or low thermal expansion.

FIGURE 10-3 POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

INORGANIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT ______ SYSTEM/EXPERIMENT ______ GSFC T/O ______

DEVELOPER/DEVELOPER ______ 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 that 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

FIGURE 10-4 INORGANIC MATERIALS AND COMPOSITES USAGE LIST

LUBRICATION USAGE LIST

SPACECRAFT ____________________ SYSTEM/EXPERIMENT ____________________ GSFC T/O ____________

DEVELOPED/DEVELOPER ____________________ 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(1-10^2), B(10^2-10^4), C(10^4-10^6), 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.

FIGURE 10-5 LUBRICATION USAGE LIST

MATERIALS PROCESS UTILIZATION LIST

SPACECRAFT ____________ SYSTEM/EXPERIMENT ____________ GSFC T/O ____________

DEVELOPER/DEVELOPER ____________ ADDRESS ____________

PREPARED BY ____________ PHONE ____________ DATE PREPARED ____________

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

ITEM NO.	PROCESS TYPE(1)	DEVELOPER 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

FIGURE 10-6 MATERIALS PROCESS UTILIZATION LIST

Chapter 10. Contamination Control Requirements

11.0 GENERAL REQUIREMENTS

The developer shall plan and implement a contamination control program for G-RBSP hardware. The developer shall establish the specific cleanliness requirements and delineate the approaches to meet the requirements in a Contamination Control Plan (CCP), to be submitted to GSFC in accordance with Appendix A of this document.

Contamination includes all materials of molecular and particulate nature whose presence degrades hardware performance. The source of the contaminant materials may be the hardware itself, the test facilities, and the environments to which the hardware is exposed.

11.1 CONTAMINATION CONTROL PROGRAM

The developer shall implement a Contamination Control Program that details the procedures that will be followed to control contamination. The Contamination Control Program shall establish implementation and methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the item's lifetime. All mission hardware shall be compatible with the most contamination-sensitive components. 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 shall be described in detail for each subsystem or component at each phase of assembly, integration, test, and launch. The developer shall generate a project contamination control plan by providing support for the generation of requirements, details of instruments and I & T plans and procedures.

11.1.1 CONTAMINATION CONTROL VERIFICATION PROCESS

The developer shall implement a contamination control verification process. The verification process shall be performed in order to allow the:

a. Determination of contamination sensitivity;

b. Determination of a contamination allowance;

c. Determination of a contamination budget;

11.2 MATERIAL OUTGASSING

All materials shall be screened in accordance with NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data shall be established based on each component's operating conditions. Established material outgassing data shall be verified and shall be provided to the G-RBSP Program office for review.

11.3 THERMAL VACUUM BAKEOUT

The developer shall perform thermal vacuum bakeouts of all hardware as required to protect contamination-sensitive components. The parameters of such bakeouts (e.g., temperature, duration, outgassing requirements, and pressure) must be individualized depending on materials used, the fabrication environment, and the established contamination allowance. Thermal vacuum bakeout results shall be verified and shall be provided to the G-RBSP Program office for review.

A quartz crystal microbalance (QCM) or temperature controlled quartz crystal microbalance (TQCM) and cold finger shall be incorporated during all thermal vacuum bakeouts. These devices shall provide additional information to enable a determination of the duration and effectiveness of the thermal vacuum bakeout as well as compliance with the CCP.

Chapter 11. GIDEP Alerts and Problem Advisories

12.0 GIDEP ALERTS

a. The developer shall participate in the Government/Industry Data Exchange Program (GIDEP) per GIDEP Operation Manual SO300-BT-PRO-010 and GIDEP Requirements Guide SO300-BU-GYD-010 (Note: these documents are available through http://www.gidep.org)

b. The developer shall review the following for affect on NASA product: GIDEP ALERTs; GIDEP SAFE_ALERTs; GIDEP Problem Advisories; GIDEP Agency Action Notices; NASA Advisories and component issues, hereinafter referred to collectively as "Alerts". NASA Advisories and component issues will be distributed to the developer by the GSFC Project Office.

c. The developer shall take action to mitigate negative effects where NASA product is affected.

d. The developer shall report the results of the review and actions taken per DID 12-1– GIDEP Alert/NASA Advisory Disposition.

e. The developer shall prepare and submit the appropriate failure experience data report per the requirements of SO300-BT-PRO-010 and SO300-BU_GYD-010 whenever failed or nonconforming items that are available to other buyers are discovered.

f. The developer shall report significant parts, materials, and safety problems to the GSFC Project Office per DID 12-2– Significant parts, materials, and safety problems.

g. The developer shall report the status of NASA product that is affected by GIDEP and NASA documentation or by significant parts, materials, and safety problems at program milestones and readiness reviews (Refer to Section 6). The reporting shall include a summary of the review status for parts and materials lists and of actions taken to mitigate negative effects.

Chapter 12. Risk Management Requirements

13.0 GENERAL REQUIREMENTS

The developer shall document and report on identified safety and mission assurance risks in accordance with the Project's Risk Management Plan. The developer shall develop and implement a Risk Management Plan to aid in performing risk assessment and risk management. The Risk Management Plan shall apply to all software and hardware products and processes (flight and ground) in order to identify, analyze, plan mitigation actions, track, control, and communicate risks.

The developer shall:

a. Implement a continuous program to capture, acknowledge, and document safety and mission assurance risks before they become problems;

b. Analyze identified risks to estimate the probability of occurrence, severity of impact, timeframe when mitigation actions are needed, and classify into sets of related risks and prioritize;

c. Develop plans to implement risk mitigation strategies and actions and assign appropriate resources;

d. Track risks 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 instrument/instrument-suite;

g. Provide a "Top 10" risk list in a monthly report from Phase B onward;

h. Report on outstanding risk items at all management and design reviews.

13.1 RISK MANAGEMENT PLAN

The developer shall develop and implement a Risk Management Plan. The plan shall be developed in compliance with NPR 7120.5, "NASA Program and Project Management Processes and Requirements" and the guidelines described in NPR 8000.4, "Risk Management Procedures and Guidelines". The plan shall include risks associated with hardware (technical challenges, new technology qualification, etc.), software, system safety, performance, and programmatic risks (cost and schedule). The plan shall identify the tools and techniques to be used to manage risks. The risk areas that are identified shall be addressed at peer reviews and at government reviews. The developer shall ensure that adequate mitigation steps are in place to address risk items. The plan shall be available to GSFC Program personnel upon request.

Chapter 13. Applicable Documents List

DOCUMENT	DOCUMENT TITLE
541-PG-8072.1.2 (was GSFC S-313-100)	Goddard Space Flight Center Fastener Integrity Requirements
AFSPCMAN 91-710	Range Safety User Requirements
ANSI/ASQ Q9001-2000	Model for Quality Assurance in Design, Development, Production, Installation, and Servicing
ANSI/ESD S20.20-1999	ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
ANSI/J STD 001	Requirements for Soldered Electrical and Electronic Assemblies (not allowed for space flight hardware)
ASTM E-595	Total Mass Loss (TML) and Collected Volatile Condensable Materials (CVCM) from Outgassing in a Vacuum Environment
EEE-INST-002	Instructions for EEE Parts Selection, Screening , Qualification and Derating
GPR 8730.6	Electrostatic Discharge (ESD) Control
GSFC-STD-1001	Criteria for Flight Project Critical Milestone Reviews
GSFC-STD-7000	General Environmental Verification Specification for GSFC Flight Programs and Projects
IEEE 730	Software Quality Assurance Plans
IPC A-600	Acceptability of Printed Boards

IPC-A-610	Acceptability of Electronic Assemblies
IPC D275	Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies
IPC-2221	Generic Standard on Printed Wiring Board Design
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC-2223	Sectional Design Standard for Flexible Printed Boards
IPC-6011	Generic Performance Specification for Printed Boards
IPC-6012	Qualification and Performance Specification for Rigid Printed Boards Flight Applications – Supplemented with: GSFC/S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
IPC-6013	Qualification and Performance Specification for Flexible Printed Boards
IPC/EIA J-STD-001	Requirements for Soldered Electrical and Electronic Assemblies
ISO 17025	General Requirements for the Competence of Testing and Calibration Laboratories
KNPR 8715.3	Kennedy Space Center Safety Practices Procedural Requirements
MIL-HDBK-217	Reliability Prediction of Electronic Equipment
MIL-STD 1629A	Procedures for Performing a Failure Mode Effects and Criticality Analysis
MSFC-HDBK-527	Material Selection List for Space Hardware Systems

MSFC-STD-3029	Design Criteria for Controlling Stress Corrosion Cracking
NASA NPR 7120.5	NASA Program and Project Management Processes and Requirements
NASA NPR 8000.4	NASA Risk Management Procedural Requirements w/ Change 1 (4/13/04)
NASA NPR 8621.1	NASA Procedural Requirements for Mishap Reporting, Investigating and Recordkeeping
NASA NPR 8705.4	Probabilistic Risk Assessment (PRA) Procedures for NASA Programs and Projects
NASA NPR 8710.3	NASA Policy for Limiting Orbital Debris Generation
NASA NPR 8715.3	NASA Safety Manual
NASA Reference Publication (RP) 1124	Outgassing Data for Selecting Spacecraft Materials
NASA-STD-6001	Flammability, Odor, Off-gassing and Compatibility Requirements & Test Procedures for Materials in Environments That Support Combustion
NASA-STD-8739.1	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronics Assemblies (Replaces NAS 5300.4(3J-1))
NASA-STD-8739.2	NASA Workmanship Standard for Surface Mount Technology (Replaces NAS 5300.4(3M))
NASA-STD-8739.3	Requirements for Soldered Electrical Connections Replaces NHB 5300.4(3A-2)
NASA-STD-8739.4	Requirements for Crimping Inter-connecting Cables, Harnesses, and Wiring (Replaces NHB5300.4(3G))

NASA-STD-8739.5	Fiber Optics Termination Standard
NASA-STD-8719.13	NASA Software Safety Standard
NSS 1740.14	Guidelines and Assessment Procedures for Limiting Orbital Debris
S-311-M-70	Specification for Destructive Physical Analysis

Chapter 14. Acronyms

ABPL	As-Built Parts List
ABMPL	As-Built Materials and Processes List
ADPL	As-Designed Parts List
ANSI	American National Standards Institute
ASIC	Application Specific Integrated Circuits
ASQ	American Society for Quality
BB	Ball Bearing
BGA	Ball Grid Array
BOL	Beginning of Life
CCB	Configuration Control Board
CCP	Contamination Control Plan
CCR	Configuration Change Request
CDR	Critical Design Review
CIL	Critical Items List
CM	Configuration Management
CR	Confirmation Review
COTR	Contracting Officer's Technical Representative
COTS	Commercial Off-the-shelf
CPSL	Common Parts Selection List
CPT	Comprehensive Performance Test
CSI	Customer Source Inspection
CVCM	Collected Volatile Condensable Mass
CDRL	Data Item Description
DoD	Department of Defense
DOORS	Dynamic Object-Oriented Requirements System
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic, and Electromechanical
ELDR	Enhanced Low Dose Rate
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FMEA	Failure Modes and Effects Analysis
FOR	Flight Operations Review
FRB	Failure Review Board

FTA	Fault Tree Analysis
GEVS	General Environmental Verification Specification
GFE	Government-Furnished Equipment
GIDEP	Government Industry Data Exchange Program
GOTS	Government Off-the-shelf
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
I&T	Integration and Test
ISO	International Standards Organization
IV&V	Independent Verification and Validation
KSC	Kennedy Space Center
LRR	Launch Readiness Review
MAR	Mission Assurance Requirements
MCM	Multi-Chip Module
MIL	Materials Identification List
MOR	Mission Operations Review
MOTS	Modified Off-the-shelf
MPCP	Materials and Processes Control Plan
MRB	Material Review Board
MSFC	Marshall Space Flight Center
MSPSP	Missile System Program Safety Plan
MUA	Materials Usage Agreement
NAS	NASA Assurance Standard
NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
NPR	NASA Procedural Requirement – official name for document that formerly was called a NASA Procedure and Guideline (NPG)
NRCA	Nonconformance Reporting and Corrective Action
NSTS	National Space Transportation System
NSPAR	Nonstandard Parts Approval Request
PAPL	Project Approved Parts List
NSPAR	Nonstandard Parts Approval Request
PAPL	Project Approved Parts List
PDA	Percentage of Defectives Allowable
PDR	Preliminary Design Review
PEM	Plastic Encapsulated Microcircuit
PER	Pre-Environmental Review

PFR	Problem/Failure Report
PI	Principal Investigator
PIL	Parts Identification List
PIND	Particle Impact Noise Detection
PPE	Project Parts Engineer
PPL	Preferred Parts List
PRA	Probabilistic Risk Assessment
PRE	Project Radiation Engineer
PSM	Project Safety Manager
PSR	Pre-Shipment Review
PWB	Printed Wiring Board
QCM	Quartz Crystal Microbalance
QMS	Quality Management System
G-RBSP	Radiation Belt Storm Probes
RDM	Radiation Design Margin
RFA	Request for Action
RLAT	Radiation Lot Acceptance Testing
SAM	Systems Assurance Manager
SAR	Safety Assessment Report
SB	Sleeve Bearing
SCC	Stress Corrosion Cracking
SCM	Software Configuration Management
SCR	System Concept Review
SEL	Single Event Latch-up
SEM	Scanning Electron Microscope
SET	Single Event Transient
SEU	Single Event Upset
SMA	Safety and Mission Assurance
SMA	Space and Military Avionics
SOW	Statement of Work
SRB	Standing Review Board
SRO	Systems Review Office
SRR	System Requirements Review
TBS	To Be Supplied
TML	Total Mass Loss
TQCM	Temperature controlled Quartz Crystal Microbalance
V&V	Verification and Validation

Chapter 15. 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 or sub-developer'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 developer 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 (contract 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 lifecycle 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 developer), 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 developer'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.

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 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 verification; 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. Verification 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 verification 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.

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.

Maintainability: A measure of the ease and rapidity with which a system or equipment can be restored to operational status following a failure. It is characteristic of equipment design and installation, personnel availability in the required skill levels, adequacy of maintenance procedures and test equipment, and the physical environment under which maintenance is performed.

Margin: The amount by which hardware capability exceeds mission requirements.

Mission Assurance: the integrated use of the tasks of system safety, reliability assurance engineering, maintainability engineering, mission environmental engineering, materials and processes engineering, electronic parts engineering, quality assurance, software assurance, configuration management, and risk management to support NASA projects.

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 Verification: 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.

Red Tag/Green Tag: Physical tags affixed to flight hardware that mean: red (remove before flight) and green (enable before flight).

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

Reliability: The probability that an item will perform its intended function for a specified interval under stated conditions.

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, Verification 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: the process of evaluating software during or at the end of the software development process to determine whether it satisfies specified requirements.

Verification: the process of evaluating software to determine whether the products of a given development phase (or activity) satisfy the conditions imposed at the start of that phase (or activity).

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 verification 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).

APPENDIX A. Data Item Descriptions

DID 1-1: Quality Manual

Title: Quality Manual	CDRL No.:
Reference: Paragraphs 1.3	
Use: Documents the developer's quality management system.	
Related Documents: ANSI/ISO/ASQC Q9001:2000, SAE AS9100, and ISO 10013.	
Place/Time/Purpose of Delivery: Provide with proposal for GSFC review. Provide Quality Manual updates to GSFC Project Office for review prior to implementation. or Provide with proposal for information along with evidence of third party certification or registration of the developer's quality management system by an accredited registrar.	
Preparation Information: Prepare a Quality Manual addressing all applicable requirements of relevant quality standard (Q9001, AS9100, etc). Refer to ISO 10013 Quality Manual Development Guide for further guidelines on preparation of a quality manual. The Quality Manual shall contain: a. the title, approval page, scope and the field of application; b. table of contents; c. introductory pages about the organization concerned and the manual itself; d. the quality policy and objectives of the organization; e. the description of the organization, responsibilities and authorities, including the organization responsible for the EEE parts, materials, reliability, safety and test requirements implementation; f. a description of the elements of the quality system, developer policy regarding each element and developer implementation procedure for each clause or reference(s) to approved quality system procedures; system level procedures shall address the implementation of all requirements cited in this document. g. a definitions section, if appropriate; h. an appendix for supportive data, if appropriate. Quality Manual distribution and changes shall be implemented by a controlled process. The Quality Manual shall be maintained/updated by the developer throughout the life of the contract.	

DID 2-1: Problem Failure Report

Title: Problem Failure Report (PFR)	CDRL No.:
Reference: Paragraph 2.1.1.2	
Use: Used to record instances of failure, and change in status of failed item.	
Related Documents: ANSI/ISO/ASQC Q9001 Quality Management Systems; GPR 5340.2 Control of Nonconformances.	
Place/Time/Purpose of Delivery: a. Deliver PFR to the GSFC Project Office within 24 hours of each occurrence by hard copy or in electronic format. b. Deliver updated PFR to the GSFC Project Office. c. Provide to GSFC Project Office for approval immediately after developer closure.	
Preparation Information: Document all failures on existing developer PFR form that identifies all relevant failure information. Relevant failure information includes (who, what, when, and where): 1. Identification of project, system, and sub-system. 2. Identification of failed assembly, sub-assembly, or part. 3. Description of failed item. 4. Identification of next higher assembly. 5. Description of failure including activities leading up to failure, if known. 6. Names and contact information of individuals involved in failure. 7. Date and time of failure. 8. Status of failed item. 9. Individual originating report including contact information. 10. Date PFR submitted.	

DID 3-1: System Safety Program Plan

Title: System Safety Program Plan	CDRL No.:
Reference: Paragraph 3.1	
Use: The approved System Safety Program Plan (SSPP) provides a formal basis of understanding between the GSFC OSSMA and the developer on how the System Safety Program will be conducted to meet the applicable launch range safety requirements (ELV launch) or NSTS 1700.7B (Shuttle). The SSPP accounts for all contractually required tasks and responsibilities on an item-by-item basis. The SSPP describes in detail the tasks and activities of system safety management and engineering required to identify, evaluate, and eliminate or control hazards by reducing the associated risk to a level acceptable to Range Safety throughout the system life cycle.	
Related Documents: a. 302-PG-7120.2.1, Mission Assurance Guidelines Implementation b. AFSPCMAN 91-710, Range Safety User Requirements c. JMR 002, Launch Vehicle Payload Safety Requirements d. NPG 7120.5, Program and Project Management Processes and Requirements e. NPD 8700.1, NASA Policy for Safety and Mission Success f. NSTS 1700.7B, Safety Policy and Requirements for Payloads Using the STS g. CSG-RS-10A-CN Centre Spatial Guyanais (CSG) Safety Regulations Vol. 1: General Rules h. CSG-RS-21A-CN CSG Safety Regulations Vol. 2 Pt. 1: Specific Rules: Ground Installations i. CSG-RS-22A-CN CSG Safety Regulations Vol. 2 Pt. 2: Specific Rules: Spacecraft	
Place/Time/Purpose of Delivery: • **SSPP** - The Range User submits the SSPP to GSFC OSSMA for review and approval at SRR or first program review (whichever comes first). • GSFC OSSMA approves the SSPP before its submittal to the launch range.	

Product Preparation:

Provide a detailed SSPP to describe how the project will implement a safety program in compliance with launch range requirements. Integration of system/facility safety provisions into the SSPP is vital to the early implementation and ultimate success of the safety effort. The SSPP shall

a. Define the required safety documentation, applicable documents, associated schedules for completion, roles and responsibilities on the project, methodologies for the conduct of any required safety analyses, reviews, and safety package.

b. Provide for the early identification and control of hazards to personnel, facilities, support equipment, and the flight system during all stages of project development including design, fabrication, test, transportation and ground activities.

c. Ensure the program undergoes a safety review process that meets the requirements of NASA-STD-8719.8, "Expendable Launch Vehicle Payloads Safety Review Process Standard". Address compliance with the system safety requirements of range requirements.

d. Address compliance with the baseline industrial safety requirements of the institution, range safety, applicable Industry Standards to the extent practical to meet NASA and OSHA design and operational needs (i.e. NASA STD 8719.9 Std. for Lifting Devices and Equipment), and any special contractually imposed mission unique obligations (including applicable safety requirements).

e. Address the software safety effort to identify and mitigate safety-critical software products in compliance with NASA-STD-8719.13 "NASA Software Safety Standard".

DID 3-2: Safety Requirements Compliance checklist

<table>
<tr><td>Title:
Safety Requirements Compliance Checklist</td><td>CDRL No.:</td></tr>
<tr><td colspan="2">Reference:
Paragraph 3.2</td></tr>
<tr><td colspan="2">Use:
The checklist indicates for each requirement if the proposed design is compliant, non-compliant but meets intent, non-compliant (waiver required) or non-applicable.</td></tr>
<tr><td colspan="2">Related Documents:
AFSPCMAN 91-710, Range Safety User Requirements</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:
Deliver the Safety Requirements Compliance Checklist for <u>instrument/subsystems</u> with the SAR at PDR - 30 days.
Deliver the Safety Requirements Compliance Checklist for the <u>spacecraft</u> with the MSPSP at PDR - 30 days (S/C or Mission).</td></tr>
<tr><td colspan="2">Preparation Information:
A compliance checklist of all design, test, analysis, and data submittal requirements shall be provided.

The following items are included with a compliance checklist:
1. Criteria/requirement.
2. System.
3. Compliance.
4. Noncompliance.
5. Not applicable.
6. Resolution.
7. Reference.
8. Copies of all Range Safety approved non-compliances including waivers and equivalent levels of safety certifications</td></tr>
</table>

DID 3-3: Preliminary Hazard Analysis

Title: Preliminary Hazard Analysis	CDRL No.:
Reference: Paragraph 3.3	
Use: The Preliminary Hazard Analysis (PHA) is used to obtain an initial risk assessment and identify safety critical areas of a concept or system. Based on the best available data, including mishap data from similar systems and other lessons learned. Hazards associated with the proposed design or function shall be evaluated for hazard severity, hazard probability, and operational constraint. Safety provisions and alternatives needed to eliminate hazards or reduce their associated risk to an acceptable level shall be included. The PHA identifies safety provisions and alternatives needed to eliminate hazards or reduce their associated risk to a level acceptable to GSFC OSSMA,	
Related Documents: a. AFSPCMAN 91-710, Range Safety User Requirements b. NPR 8715.3, NASA Safety Manual c. MIL-STD-882, System Safety Program Requirements (provides guidance)	
Place/Time/Purpose of Delivery: Deliver the PHA as a component of the SAR or MSPSP. a. Deliver the PHA for instruments or subsystems with the SAR at PDR - 30 days. b. Deliver the PHA for the spacecraft with the MSPSP at PDR - 30 days (S/C or Mission).	

Preparation Information:

Perform and document a PHA, based on the hazard assessment criteria provided in Chapter 3 of NPR 8715.3, to obtain an initial risk assessment of the system. Based on the best available data, including mishap data (if assessable) from similar systems and other lessons learned, hazards associated with the proposed design or function shall be evaluated for hazard severity, hazard probability, and operational constraint. Safety provisions and alternatives needed to eliminate hazards or reduce their associated risk to an acceptable shall be included. The PHA shall consider the following for identification and evaluation of hazards at a minimum:

a. Hazardous components.

b. Environmental constraints including the operating environments.

c. Operating, test, maintenance, built-in-tests, diagnostics, and emergency procedures.

d. Facilities, real property installed equipment, support equipment.

e. Safety related equipment, safeguards, and possible alternate approaches.

f. Safety related interface considerations among various elements of the system. This shall include consideration of the potential contribution by software to subsystem/system mishaps. Safety design criteria to control safety-critical software commands and responses shall be identified and appropriate action taken to incorporate them in the software (and related hardware) specifications.

g. Malfunctions to the system, subsystems, or software. Each malfunction shall be specified, the causing and resulting sequence of events determined, the degree of hazard determined, and appropriate specification and/or design changes developed.

h. Include a system description and a description of the methodology used to develop the analysis.

DID 3-4: OPERATIONS HAZARD ANALYSIS

Title: Operations Hazard Analysis	CDRL No.:
Reference: Paragraph 3.4	
Use: The Operations Hazard Analysis (OHA) addresses the implementation of safety requirements for personnel, all procedures, and equipment used during, testing, transportation, storage, and integration operations.	
Related Documents: a. 540-PG-8715.1.1 and 1.2, Mechanical Systems Safety Manual" Volume I and II	
Place/Time/Purpose of Delivery: Deliver the OHA to the Project Safety Manager 45 days prior to PER . During I&T activities a Hazard Tracking Log shall be used to track and close all remaining open items. GSFC OSSMA will review/approve the OHA and Hazard Tracking Log (HTL) prior to initiating any I&T activities. NOTE: Closure methodology for the HTL mentioned above is the same as what is in DID 3-7 for the VTL.	

Preparation Information:

Contents. The OHA shall include the following information:

1.0 Introduction

a. Provide an abstract summarizing the major findings of the analysis and the proposed corrective or follow-up actions.

b. Define any special terms, acronyms, and/or abbreviations used.

2.0 System Description

a. Provide a description of the system hardware and configuration. List components of subsystems.

b. The most recent schedules for integration and testing of the instrument/spacecraft.

c. Photographs, diagrams, and sketches should be included to support the test.

3.0 Analysis of System Hazards

a. The analysis shall identify all real or potential hazards presented to personnel, equipment, and property during I&T processing.

b. A listing of all identified hazards shall be provided in a tabulated format. Each hazard shall be numbered and shall include the following information:

(1) System Component/Phase. The particular phase/component that the analysis is concerned with. This could be a system, subsystem, component, operating/maintenance procedure or environmental condition.

Preparation Information (continued):

(2) System Description and Hazard Identification, Indication.

(a) A description of what is normally expected to occur as the result of operating the component/subsystem or performing the operating/maintenance action.

(b) A complete description of the actual or potential hazard resulting from normal actions or equipment failures. Indicate whether hazard will cause personnel injury and/or equipment damage.

(c) A description of crew indications which include all means of identifying the hazard to operating or maintenance personnel.

(d) A complete description of the safety hazards of software controlling hardware systems where the hardware effects are safety critical.

(3) Effect on System. The detrimental results an uncontrolled hazard could inflict on the whole system.

(4) Risk Assessment. A risk assessment for each hazard as defined in paragraph shall be provided.

(5) Caution and Warning Notes. A complete list of specific warnings, cautions, procedures required in operating and maintenance manuals, training courses, and test plans.

(6) Status/Remarks.

(a) The status of actions to implement the recommended, or other, hazard controls.

(b) Any information relating to the hazard, not covered in the other blocks, for example, applicable documents, previous failure data in similar systems, or administrative directions.

4.0 References. List all pertinent references such as test reports, preliminary operating and maintenance manuals, and other hazard analysis.

5.0 Appendices. The appendix will contain charts, graphs, or data which are too cumbersome for inclusion in the previous sections, or are applicable to more than one section. It may also contain detailed formulation or analysis which is more conveniently placed in an appendix.

DID 3-5: Missile System Prelaunch Safety Package

<table>
<tr><td>Title:
Missile System Prelaunch Safety Package (MSPSP)</td><td></td></tr>
<tr><td colspan="2">Reference:
Paragraph 3.7</td></tr>
<tr><td colspan="2">Use:

Provides a detailed description of the payload design sufficient to support hazard analysis results, hazard analysis method, and other applicable safety related information. The developer shall include analyses identifying the ground operations hazards associated with the flight system, ground support equipment, and their interfaces. The developer shall take measures to control and/or minimize each significant identified hazard.

In addition to identifying hazards, the MSPSP shall also identify applicable hazard controls, and verifications methods for each hazard, and document them in Hazard Reports. The analysis shall be updated as the hardware progresses through the stages of design, fabrication, and test. A list of all hazardous/toxic materials and associated material safety data sheets shall be prepared and included in the final MSPSP, as well as a detailed description of the hazardous and safety critical operations associated with the payload.

The safety assessment shall begin early in the program formulation process and continue throughout all phases of the mission lifecycle. The spacecraft or instrument Project Manager shall demonstrate compliance with these requirements and shall certify to GSFC and the launch range, through the SDP/MSPSP, that all safety requirements have been met.</td></tr>
<tr><td colspan="2">Related Documents:

a. AFSPCMAN 91-710, Range Safety User Requirements

b. JSC 26943, Guidelines for the Preparation of Payload Flight Safety Data Packages and Hazard Reports

Note: Other launch range and launch vehicle requirements may apply</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:

Deliver the MSPSP to GSFC OSSMA for review and approval before submittal to the launch range according to the following schedule

Deliver the Preliminary MSPSP, Mission PDR - 30 days.

Deliver the Intermediate MSPSP, Mission CDR – 30 days.

Deliver the Final MSPSP no less than 60 days before shipment.

GSFC OSSMA will approve all delivered versions of the MSPSP.

NOTE: The first MSPSP delivery shall contain appropriate launch range safety requirements tailoring (if necessary).

*(See applicable launch range and launch vehicle requirements for details).</td></tr>
</table>

MSPSP (cont)

Preparation Information:

Prepare the Missile System Prelaunch Safety Package to include the following information:

1. Introduction. State, in narrative form, the purpose of the safety data package.

2. System Description. This section may be developed by referencing other program documentation such as technical manuals, System Program Plan, System Specification, etc.

   As applicable, either photos, charts, flow/functional diagrams, sketches, or schematics to support the system description, test, or operation.

3. System Operations.

   a. A description or reference of the procedures for operating, testing and maintaining the system. Discuss the safety design features and controls incorporated into the system as they relate to the operating procedures.

   b. A description of any special safety procedures needed to assure safe operations, test and maintenance, including emergency procedures.

   c. A description of anticipated operating environments and any specific skills required for safe operation, test, maintenance, transportation or disposal.

   d. A description of any special facility requirements or personal equipment to support the system.

4. Systems Safety Engineering Assessment. This section shall include:

   a. A summary or reference of the safety criteria and methodology used to classify and rank hazardous conditions.

   b. A description of or reference to the analyses and tests performed to identify hazardous conditions inherent in the system.

      (1) Hazard Reports for all hazards by subsystem or major component level that have been identified and considered from the inception of the program.

         a. A discussion of the hazards and the actions that have been taken to eliminate or control these items.

         b. A discussion of the effects of these controls on the probability of occurrence and severity level of the potential mishaps.

         c. A discussion of the residual risks that remain after the controls are applied or for which no controls could be applied.

         d. A discussion of or reference to the results of tests conducted to validate safety criteria requirements and analyses. These items shall be tracked and closed-out via a Verification Tracking Log (VTL).

MSPSP (cont)

Preparation Information (continued):

5. Conclusions and Recommendations. This section shall include:
   a. A short assessment of the results of the safety program efforts. A list of all significant hazards along with specific safety recommendations or precautions required ensuring the safety of personnel and property.
   b. For all hazardous materials generated by or used in the system, the following information shall be included.
      (1) Material identification as to type, quantity, and potential hazards.
      (2) Safety precautions and procedures necessary during use, storage, transportation, and disposal.
      (3) A copy of the Material Safety Data Sheet (OSHA Form 20 or DD Form 1813) as required.
   c. Appropriate radiation forms/analysis.
   d. Reference material to include a list of all pertinent references such as Test Reports, Preliminary Operating Manuals and Maintenance Manuals
   e. A statement signed by the Contractor System Safety Manager and the Program Manager certifying that all identified hazards have been eliminated or controlled and that the system is ready to test, operate, or proceed to the next acquisition phase. In addition, include recommendations applicable to the safe interface of this system with the other system(s).

6. The safety package shall be submitted for approval in accordance with the milestones required by the applicable launch site and launch vehicle safety regulation.

DID 3-6: VERIFICATION TRACKING LOG

Title: Verification Tracking Log	CDRL No.:
Reference: Paragraph 3.8	
Use: Provides documentation of a Hazard Control and Verification Tracking process or "closed-loop system" that assures safety compliance has been satisfied in accordance to applicable launch range safety requirements.	
Related Documents: AFSPCMAN 91-710, Range Safety User Requirements	
Place/Time/Purpose of Delivery: A Payload Safety Verification Tracking Log (VTL) identifying hazard controls still not verified closed shall be prepared and delivered with the final MSPSP to GSFC OSSMA. Regular updates to this log shall be provided as requested until all hazard control verifications have been closed. Open VTL items must be closed with appropriate documented rationale prior to first operational use/restraint.	
Preparation Information: The Hazard Log (or VTL) provides documentation that demonstrates the process of verifying the control of all hazards by test, analysis, inspection, similarity to previously qualified hardware, or any combination of these activities. All verifications that are listed on the hazard reports shall reference the tests/analyses/inspections. Results of these tests/analyses/inspections shall be available for review and submitted in accordance with the contract schedule and applicable launch site range safety requirements. The VTL shall contain the following information in tabular format: a. Log b. Hazard Report # c. Safety Verification # d. Description (Identify procedures/analyses by number and title) e. Constraints on Launch Site Operations f. Independent Verification Required (i.e., mandatory inspection points)? Yes/No g. Scheduled Completion Date h. Completion Date i. Method of Closure	

DID 3-7: ORBITAL DEBRIS ASSESSMENT

Title: Orbital Debris Assessment	CDRL No.:
Reference: Paragraph 3.10	
Use: Ensure NASA requirements for post mission orbital debris control are met.	
Related Documents: a. NPD 8710.3, NASA Policy for Limiting Orbital Debris Generation b. NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris	
Place/Time/Purpose of Delivery: Provide preliminary assessment at mission PDR – 30 days to GSFC, at PDR to NASA HQ. Final package at CDR – 60 days to GSFC, at CDR – 45 to NASA HQ... Additional information may be required after NASA HQ review of the report and should be provided as soon as possible to complete the assessment, NOTE: NASA HQ needs to provide approval prior to shipment to the launch ranges.	
Preparation Information: The assessment shall be done in accordance with NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris. The preliminary debris assessment should be conducted to identify areas where the program or project might contribute debris and to assess this contribution relative to the guidelines in so far as is feasible. Prior to CDR another debris assessment should be completed. This report should comment on changes made since the PDR report. The level of detail should be consistent with the available information of design and operations. When there are design changes after CDR that impact the potential for debris generation, an update of the debris assessment report should be prepared, approved, and coordinated with the Office of System Safety and Mission Assurance.	

DID 3-8: SAFETY NONCOMPLIANCE/WAIVER REQUESTS

Title: Safety Noncompliance/Waiver Requests	CDRL No.:
Reference: Paragraph 3.12	
Use: Documents variances of safety requirements that can not be met; explains the rationale for approval of each variance, as defined in NPR 8715.3 The request for Safety Variance may require Range Safety concurrence for the variance to be approved.	
Related Documents: a. AFSPCMAN 91-710, Range Safety User Requirements b. KNPR 1710.2, Kennedy Space Center Safety Practices Procedural Requirements c. NASA Non-Compliance Report/Corrective Action System (NCR/CAS) Web-based Online System d. NPR 8715.3 NASA Safety Manual	
Place/Time/Purpose of Delivery: Deliver to GSFC OSSMA as early as known.	
Preparation Information: Include in the Safety Variance the following information resulting from a review of each waiver or deviation request. a. A statement of the specific safety requirement and its associated source document name and paragraph number, as applicable, for which a waiver or deviation is being requested. b. A detailed technical justification for the exception. c. Analyses to show that the mishap potential of the proposed alternate requirement, method or process, as compared to the specified requirement. d. A narrative assessment of the risk involved in accepting the waiver or deviation. When it is determined that there are no hazards, the basis for such determination should be provided. e. A narrative on possible ways of reducing hazards severity and probability and existing compliance activities (if any). f. Starting and expiration date for waiver/deviation.	

DID 3-9: GROUND OPERATIONS PROCEDURES

Title: Ground Operations Procedures (GOP)	CDRL No.:
Reference: Paragraph 3.13	
Use: GOP documents all ground operations procedures to be used at GSFC facilities, other integration facilities, or the launch site for submittal to GSFC OSSMA for review and approval. Includes launch site ground operations procedures to be submitted to applicable Range Safety prior to use.	
Related Documents: a. AFSPCMAN 91-710, Range Safety User Requirements b. KNPR 1710.2, Kennedy Space Center Safety Practices Procedural Requirements c. 540-PG-8715.1.1 and 1.2, Mechanical Systems Safety Manual Volume I and II **Note**: Other launch vehicle and/or contractor, or commercial facility requirements as applicable.	
Place/Time/Purpose of Delivery: Launch Range Procedures: Provide to GSFC OSSMA 45 days after PSR and submit to applicable Range Safety 45 days prior to first use. GSFC Procedures: Provide all GSFC in-house procedures to GSFC OSSMA for review 7 days prior to first operational use. GSFC OSSMA will approve all hazardous operational procedures	
Preparation Information: Identify all hazardous ground operations as well as the procedures to control them.. Verify all launch site ground operation procedures comply with applicable launch site safety regulations.	

DID 4-1: Reliability Program Plan

<table>
<tr><td>Title:
Reliability Program Plan (RPP)</td><td>CDRL No.:</td></tr>
<tr><td colspan="2">Reference:
Paragraph 4.0</td></tr>
<tr><td colspan="2">Use:
To provide planning and control for the reliability program.</td></tr>
<tr><td colspan="2">Related Documents
a. NPD 8720.1, NASA Reliability and Maintainability (R&M) Program Policy.
b. NASA-STD-8729.1, Planning, Developing and Managing an Effective Reliability and Maintainability (R&M) Program.
c. NPR 8705.5 Risk Classification for NASA Payloads</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:
a. Preliminary to be included with proposal for GSFC review and evaluation.
b. Draft 30 days after contract award for GSFC review.
c. Final 30 days before developer PDR for GSFC review and approval.
d. Updates as required including changes for GSFC review and approval.</td></tr>
<tr><td colspan="2">Preparation Information:

Format: The Reliability Program Plan shall be in the developer’s format.
Content: The Reliability Program Plan shall include:
a. A discussion of how the developer intends to implement and comply with reliability program requirements.
b. Charts and statements describing organizational responsibilities and functions conducting each task to be performed as part of the Reliability Program.
c. A summary (matrix or other brief form) which indicates for each requirement, the organization responsible for implementing and generating the necessary documents.
d. Identify in the summary the approval, oversight, or review authority for each task.
e. Narrative descriptions, time or milestone schedules, and supporting documents describing the execution and management plan for each task.
f. Directives, methods, and procedures specific to each task in the plan.</td></tr>
</table>

DID 4-2: Failure Mode and Effects Analysis/Critical Items List

<table>
<tr><td>Title:
Failure Mode and Effects Analysis (FMEA)/Critical Items List (CIL)</td><td>CDRL No.:</td></tr>
<tr><td colspan="2">Reference:
Paragraph 4.1</td></tr>
<tr><td colspan="2">Use:
Used to evaluate design against requirements, and identify single point failures and hazards to assure mission success.
Used to identify all modes of failure within a system design, its first purpose is the early identification of all catastrophic and critical failure possibilities so they can be eliminated or minimized through design correction at the earliest possible time.</td></tr>
<tr><td colspan="2">Related Documents
a. Flight Assurance Procedure, FAP P-302-720, Performing a Failure Mode and Effects Analysis.
b. CR 5320.9, Payload and Experiment Failure Mode Effects Analysis and Critical Items List Ground Rules.
c. MIL-STD-1629, Procedures for Performing an FMECA.</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:
a. Preliminary 30 days before PDR for GSFC review.
b. Final 30 days before CDR for GSFC review.
c. Revisions as required for GSFC review.</td></tr>
<tr><td colspan="2">Preparation Information:
Format: The FMEA Report shall be in the developer's format.

Content: The FMEA Report shall include the following:
a. A discussion of the approach of the analysis, methodologies, assumptions, results, conclusions, and recommendations.
b. Objectives
c. Level of the analysis
d. Ground rules
e. Functional description
f. Functional block diagrams
g. Reliability block diagrams
h. Equipment analyzed
i. Data sources used
j. Problems identified
k. Single-point failures
l. Corrective action
m. Work sheets identifying failure modes, causes, severity category, and effects at the item, next higher level, and mission level, detection methods, and mitigating provisions.
n. Critical Items List (CIL) including item identification, cross-reference to FMEA line items, and retention rationale. Appropriate retention rationale may include design features, historical performance, acceptance testing, manufacturing product assurance, elimination of undesirable failure modes, and failure detection methods.</td></tr>
</table>

DID 4-3: Probabilistic Risk Assessment

Title: Probabilistic Risk Assessment	CDRL No.:
Reference: Paragraphs 4.1.3	
Use: Provides a structured, disciplined approach to analyzing system risk to support management decisions to: ensure mission success; improve safety in design, operation, maintenance and upgrade; improve performance; and reduce design, operation and maintenance costs.	
Related Documents a. NPR 8705.4 Probabilistic Risk Assessment (PRA) Procedures for NASA Programs and Projects b. NPR 8705.5 Risk Classification for NASA Payloads	
Place/Time/Purpose of Delivery: a. Draft 30 days before PDR for GSFC review. b. Final 30 days before CDR for GSFC approval. c. Updates as required for GSFC approval.	
Preparation Information: Format: The PRA shall be in the developer's format. Content: The PRA shall include the following: a. A definition of the objective and scope of the PRA Plan, and development of end-states-of-interest to the decision-maker, b. Definition of the mission phases and success criteria, c. Initiating event categories, d. Top level scenarios, e. Initiating and pivotal event models (e.g., fault trees and phenomenological event models), f. Data development for probability calculations, g. An integrated model and quantification to obtain risk estimates, h. An assessment of uncertainties, i. Summary of results and conclusions, including a ranking of the lead contributors to risk.	

DID 4-4: Parts Stress Analysis

Title: Parts Stress Analysis	CDRL No.:
Reference: Paragraph 4.1.4	
Use: Provides EEE parts stress analyses for verifying circuit design conformance to derating requirements; demonstrates that environmental operational stresses on parts comply with project derating requirements.	
Related Documents NASA Parts Selection List	
Place/Time/Purpose of Delivery: a. Final 45 days before CDR for GSFC review b. Revisions to include changes as required for GSFC review	
Preparation Information: Format: The Parts Stress Analysis Report shall be in the developer's format. Content: The Parts Stress Analysis Report shall contain: a. Analysis ground rules. b. Reference documents and data used. c. Results and conclusions including: • Design trade study results • Parts stress analysis results impacting design or risk decisions. d. Analysis worksheets; the worksheets at a minimum shall include: • Part identification (traceable to circuit diagrams), • Assumed environmental (consider all expected environments), • Rated stress, • Applied stress (consider all significant operating parameter stresses at the extremes of anticipated environments), • Ratio of applied-to-rated stress.	

DID 4-5: Reliability Assessments and Predictions

Title: Reliability Assessments and Predictions	CDRL No.:
Reference: Paragraph 4.1.4	
Use: Used to assist in evaluating alternative designs and to identify potential mission limiting elements that may require special attention.	
Related Documents: MIL-STD-756, Reliability Modeling and Prediction MIL-HDBK-217, Reliability Prediction of Electronic Equipment RADC-TR-85-229, Reliability Prediction for Spacecraft	
Place/Time/Purpose of Delivery: a. Available at PDR and CDR for information. b. Available on request	
Preparation Information: Format: The Reliability Assessment and Prediction Report shall be in the developer’s format. Content: Reliability Assessment and Prediction Report shall include the following: a. The methodology and results of comparative reliability assessments including mathematical models b. Reliability block diagrams c. Failure rates d. Failure definitions e. Degraded operating modes f. Trade-offs g. Assumptions h. Any other pertinent information used in the assessment process. i. A discussion to clearly show how reliability was considered as a discriminator in the design process.	

DID 4-6: Limited-Life Items List

Title: Limited-Life Items List	CDRL No.:
Reference: Paragraph 4.3	
Use: Defines and tracks the selection, use and wear of limited-life items, and the impact on mission operations	
Related Documents: None	
Place/Time/Purpose of Delivery: a. Preliminary 30 days before PDR for review. b. Final 30 days before CDR for approval. c. Updates as changes are made; between CDR and delivery, for approval.	
Preparation Information: List life-limited items and their impact on mission parameters. Define expected life, required life, duty cycles, and rationale for selecting and using the items. Include selected structures, thermal control surfaces, solar arrays, and electromechanical mechanisms. Atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue are used to identify limited-life thermal control surfaces and structural items. When aging, wear, fatigue and lubricant degradation limit their life, include batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators and scan devices.	

DID 5-: Software Management Plan

Title: Software Management Plan	CDRL No.:
Reference: Paragraphs 5.0	
Use: This data item provides an outline for the Software Management Plan. The Software Management Plan documents the software development processes and procedures, software tools, resources, and deliverables throughout the development life cycle.	
Related Documents: IEEE Standard 1058-1998	
Place/Time/Purpose of Delivery: a. Baseline due NLT PDR – 60 days. b. Updated periodically throughout the lifecycle, as necessary.	
Preparation Information: The Software Management Plan shall include/address: a. Introduction – Purpose, scope, definitions and references; b. Project Organization and Responsibilities - Resources and Schedules; c. Software Development Overview; d. Software Development Activities by life cycle: 1) Development and test environment; 2) Tools, techniques, and methodologies; 3) Software standards and development processes; e. Software Configuration Management; f. Software Assurance; g. Software Testing; h. Software Reviews; i. Risk Management; j. Software Metrics; k. Delivery and Operational Transition; l. Software Maintenance; m. Software Deliverables; n. Training.	

DID 7-1: System Performance Verification and Validation Plan

Title: System Performance Verification and Validation Plan	CDRL No.:
Reference: Paragraph 9.2.1	
Use: Provides the overall approach for accomplishing the verification program. Defines the specific tests, analyses, calibrations, alignments, etc. that will demonstrate that the hardware complies with the mission requirements	
Related Documents: None	
Place/Time/Purpose of Delivery: Preliminary with proposal for GSFC review. Final at CDR for GSFC approval. Updates as required.	
Preparation Information: Describes the approach (test, analysis, etc.) that will be utilized to verify that the hardware/software complies with mission requirements. If verification relies on tests or analyses at other level of assemblies, describe the relationships. A section of the plan shall be a "System Performance Verification Matrix" summarizing the flow-down of system specification requirements that stipulates how each requirement will be verified, and summarizes compliance/non-compliance with requirements. It shall show each specification requirement, the reference source (to the specific paragraph or line item), the method of compliance, applicable procedure references, report reference numbers, etc. The System Performance Verification Matrix may be made a separate document. The System Performance Verification Plan shall include a section describing the environmental verification program. This shall include level of assembly, configuration of item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, appropriate functional operations, personnel responsibilities, and requirements for procedures and reports. For each analysis activity, include objectives, a description of the mathematical model, assumptions on which the model will be based, required output, criteria for assessing the acceptability of the results, interaction with related test activity, and requirements for reports. Provide for an operational methodology for controlling, documenting, and approving activities not part of an approved procedure. Plan controls that prevent accidents that could damage or contaminate hardware or facilities, or cause personal injury. The controls shall include real-time decision-making mechanisms for continuation or suspension of testing after malfunction, and a method for determining retest requirements, including the assessment of the validity of previous tests. Include a test matrix that summarizes all tests to be performed on each component, each subsystem, and the payload. Include tests on engineering models performed to satisfy qualification requirements. Define pass/fail criteria. The Environmental Verification. The Environmental Test Plan section shall include a Environmental Test Matrix that summarizes all environmental tests that will be performed showing the test and the level of assembly. Tests on development/engineering models performed to satisfy qualification requirements shall be included in this matrix.	

DID 9-1: System Performance Verification Plan --- continued

Title: System Performance Verification Plan (cont.)	CDRL No.: 9-1 (cont.)
Reference: Paragraph 9.2.1	
Use: Provides the overall approach for accomplishing the verification program. Defines the specific tests, analyses, calibrations, alignments, etc. that will demonstrate that the hardware complies with the mission requirements	
Related Documents: None	
Place/Time/Purpose of Delivery: Preliminary with proposal for GSFC review. Final at CDR for GSFC approval. Updates as required.	
Preparation Information: (cont.) The Environmental Verification Plan may be made a separate document rather than be a section of the System Performance Verification Plan. As an adjunct to the environmental verification program, an Environmental Test Matrix Summarizing all tests performed and showing the test and the level of assembly will be maintained. The System Performance Verification Plan shall include an Environmental Verification Specification section that stipulates the specific environmental parameters used in each test or analysis required by the verification plan. Contains the specific test and analytical parameters associated with each of the tests and analyses required by the Verification Plan. Payload peculiarities and interactions with the launch vehicle shall be considered when defining quantitative environmental parameters under which the hardware elements must meet their performance requirements.	

DID 8-1: Printed Wiring Boards Test Coupons

Title: Printed Wiring Board (PWB) Test Coupons	CDRL No.:

Reference:

Paragraph 8.3.2.1

Use:

Validate printed wiring boards procured for space flight and mission critical ground applications are fabricated in accordance with applicable workmanship standards.

Related Documents:

IPC-6011, Generic Performance Specifications for Printed Boards (must use Class 3 Requirements)

IPC-6012, Qualification and Performance Specification for Rigid Printed Boards (must use Class 3 Requirements)

IPC-6013, Qualification and Performance Specification for Flexible Printed Boards (must use Class 3/A Requirements/Performance Specification Sheet for Space and Military Avionics)

IPC-6018, Microwave End Product Board Inspection and Test

IPC A-600, Guidelines for Acceptability of Printed Boards (must use Class 3 Requirements)

Place/Time/Purpose of Delivery:

Prior to population of flight PWBs. Applies individually to each procured lot of boards.

Preparation Information:

Prior to population of printed wiring boards:

- Contact GSFC Materials Engineering Branch (MEB), Code 541 of impending coupon shipment.
- Submit test coupons for destructive physical analysis (DPA) per Code 541 procedures.
- Do not release PWBs for population until notification by MEB that test coupons passed DPA.

DID 9-1: Parts Control Program Plan

Title: Parts Control Program Plan	CDRL No.:
Reference: Paragraph 9.0	
Use: Description of developer's approach and methodology for implementing PCP, including flow-down of applicable PCP requirements to sub-developers.	
Related Documents	
Place/Time/Purpose of Delivery: The PCP shall be developed and delivered as part of the proposal for GSFC review within 30 days after contract is awarded.	
Preparation Information: The PCP shall be prepared and shall address all parts program requirements. The PCP shall contain, as a minimum, detailed discussions of the following: a. The developer's plan or approach for conforming to parts requirements. b. The developer's parts control organization, identifying key individuals and specific responsibilities. c. Detailed Parts Control Board (PCB) procedures, to include PCB membership, designation of Chairperson, responsibilities, review and approval procedures, meeting schedules and method of notification, meeting minutes, etc. d. Part tracking methods and approach, including tools to be used such as databases, reports, NASA Parts Selection List (NPSL), etc. Describe system for identifying and tracking part approval status. e. Parts procurement, processing and testing methodology and strategies. Identify internal operating procedures to be used for incoming inspections, screening, qualification testing, derating, testing of parts pulled from stores, Destructive Physical Analysis, radiation assessments, etc. f. Part vendor surveillance and audit plan g. Electrostatic Control Plan h. Flow down of PCP requirements to sub-developers	

DID 9-2: As designed Parts List

Title: Parts List Requirements	CDRL No.:
Reference: Paragraph 9.1	
Use: Listing of all parts intended for use in space flight hardware	
Related Documents: Parts Control Program Plan	
Place/Time/Purpose of Delivery: The PIL, PAPL, ADPL, and ABPL shall be submitted to the PCB, ten days prior to the PCB meeting	

Preparation Information:

The PIL shall be prepared prior to the first PCB meeting. The PIL shall be compiled by instrument, instrument component, or spacecraft component, and shall include the following information, as a minimum:

a. Part name

b. Part number

c. Part description

d. Manufacturer

e. Manufacturer's generic Part number

f. Specifications

g. Comments

The PAPL shall include what is required in the PIL in addition to:

h. Spacecraft/Instrument Name

i. Procurement Part Number

j. Flight Part Number

k. Package Type

l. Additional Testing Required

m. Cage Code

n. Single Event Latch-Up (SEL)

o. Single Event Up-Set (SEU)

p. Displacement damage

q. Total Ionizing Dose (TID)

The ADPL shall include what is required in the PAPL in addition to:

r. Lot date code

s. Quantities

t. Distributor

u. Quantity Needed/Procured

v. Radiation Source Data (TID/SEE)

The ABPL shall include what is required in the ADPL in addition to:

w. Parts location to the sub-assembly level

Any format may be used provided the required information is included. All submissions to GSFC will include a paper copy and a computer readable form.

Updates to PIL, PAPL, ADPL, ABPL shall identify changes from the previous submission.

DID 10-1: Materials and Processes Control Program Plan

Title:	CDRL No.:
Materials and Processes Control Program Plan	

Reference:

Paragraph 10.0

Use:

Description of developer's approach and methodology for implementing MPCP, including flow-down of applicable MPCP requirements to sub-developers.

Related Documents

Place/Time/Purpose of Delivery:

The MPCP shall be developed and delivered as part of the proposal for GSFC review

Preparation Information:

The MPCP shall be prepared and shall address all MP program requirements. The MPCP shall contain, as a minimum, detailed discussions of the following:

i. The developer's plan or approach for conforming to MP requirements.

j. The developer's MP control organization, identifying key individuals and specific responsibilities.

k. Detailed Materials and Processes Control Board (MPCB) procedures, to include MPCB membership, designation of Chairperson, responsibilities, review and approval procedures, meeting schedules and method of notification, meeting minutes, etc.

l. MP tracking methods and approach, including tools to be used such as databases, reports, etc. Describe system for identifying and tracking MP approval status.

m. MP procurement, processing and testing methodology and strategies. Identify internal operating procedures to be used for incoming inspections, screening, qualification testing, testing of MP pulled from stores, etc.

n. MP vendor surveillance and audit plan

o. Flow down of MPCP requirements to sub-developers

DID 10-2: As designed Materials and Processes List

Title: As-designed Materials and Processes List (ADMPL)	CDRL No.:
Reference: Paragraph 10.2	
Use: Listing of all M&P intended for use in space flight hardware	
Related Documents: Materials and Processes Control Program Plan	
Place/Time/Purpose of Delivery: The ADMPL shall be submitted to the MPCB, ten days prior to the first MPCB meeting	
Preparation Information: The ADMPL shall be prepared prior to the first MPCB meeting. The ADMPL shall be compiled by instrument, instrument component, or spacecraft component, and shall include the following information, as a minimum: x. MP name y. MP number z. Manufacturer aa. Manufacturer's generic MP number bb. Procurement specification Any format may be used provided the required information is included. All submissions to GSFC will include a paper copy and a computer readable form. Updates to ADMPL shall identify changes from the previous submission.	

DID 10-3: Materials Usage Agreement

Title: Materials Usage Agreement	CDRL No.:
Reference: Paragraph 10.1.4	
Use: For usage evaluation and approval of non-compliant materials or lubrication usage.	
Related Documents: MSFC -STD-3029, MSFC-HDBK-527, NHB 1700.7, GMI 1700.3, NASA-STD-6001	
Place/Time/Purpose of Delivery: Provide to the MPCB, prior to the first MPCB meeting, with the polymeric and composite materials usage list, flammable materials usage list, odor and toxic offgassing materials usage list or the inorganic materials usage list for approval.	
Preparation Information: A Materials Usage Agreement (MUA) shall be provided for each non-compliant off-the-shelf-hardware material usage, non-compliant polymeric material outgassing, flammability or toxicity usage and non-compliant inorganic material stress corrosion cracking usage. The MUA shall be provided on a Material Usage Agreement form, a developer's equivalent form or the developer's electronically transmitted form. The form is available in the Mission Assurance Guide. The MUA form requires the minimum following information: MSFC 527 material rating, usage agreement number, page number, drawing numbers, part or drawing name, assembly, material name and specification, manufacturer and trade name, use thickness, weight, exposed area, pressure, temperature, exposed media, application, rationale for safe and successful flight, originator's name, project manager's name and date. The off-the-shelf-hardware usage shall identify the measures to be used to ensure the acceptability of the hardware such as hermetic sealing, material changes to known compliant materials, vacuum bake-out to the error budget requirements listed in the contamination control plan.	

DID 10-4: Stress Corrosion Evaluation Form

Title: Stress Corrosion Evaluation Form	CDRL No.:
Reference: Paragraphs 10.1.4	
Use: Provide detailed stress corrosion cracking engineering information required to demonstrate the successful flight of the material usage.	
Related Documents: MSFC -SPEC-522, MSFC-HDBK-527, NHB 1700.7, GMI 1700.3	
Place/Time/Purpose of Delivery: Provide to the MPCB, prior to the first MPCB meeting, with the polymeric and composite materials usage list, flammable materials usage list, odor and toxic offgassing materials usage list or the inorganic materials usage list for approval.	
Preparation Information: The developer shall provide the information requested on the stress corrosion evaluation form, the equivalent information on the developer's form or the equivalent information electronically. The form is available in the Mission Assurance Guide. 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, evaluation of stress corrosion susceptibility.	

DID 11-1: Contamination Control Plan

Title: Contamination Control Plan	CDRL No.:
Reference: Paragraph 11.0	
Use: To establish contamination allowances and methods for controlling contamination	
Related Documents: None.	
Place/Time/Purpose of Delivery: Provide to the Project Office 30 days before PDR for GSFC review and 30 days before the CDR for approval.	

Preparation Information:

Data on material properties, on design features, on test data, on system tolerance of degraded performance, on methods to prevent degradation shall be provided to permit independent evaluation of contamination hazards. The items should be included in the plan for delivery:

1. Materials
   a. Outgassing as a function of temperature and time.
   b. Nature of outgassing chemistry.
   c. Areas, weight, location, view factors of critical surfaces.
2. Venting: size, location and relation to external surfaces.
3. Thermal vacuum test contamination monitoring plan including vacuum test data, QCM location and temperature, pressure data, system temperature profile and shroud temperature.
4. On orbit spacecraft and instrument performance as affected by contamination deposits.
   a. Contamination effect monitor.
   b. Methods to prevent and recover from contamination in orbit.
   c. How to evaluate in orbit degradation.
   d. Photopolymerization of outgassing products on critical surfaces.
   e. Space debris risks and protection.
   f. Atomic oxygen erosion and re-deposition.
5. Analysis of contamination impact on the satellite on orbit performance.
6. In orbit contamination impact from other sources such as STS, space station, and adjacent instruments.

DID 12-1: GIDEP ALERT / NASA ADVISORY DISPOSITION

Title: GIDEP Alert / NASA Advisory Disposition	CDRL No.:
Reference: Paragraph 12.0	
Use: Document the developer's disposition of GIDEP ALERTs; GIDEP SAFE-ALERTs; GIDEP Problem Advisories; GIDEP Agency Action Notices; NASA Advisories and component issues, hereinafter referred to collectively as “Alerts” with respect to parts and materials used in NASA product	
Related Documents: GIDEP Operations Manual (SO300- BT-PRO-010) GIDEP Requirements Guide (S0300-BU-GYD-010)	
Place/Time/Purpose of Delivery: Deliver to: GSFC Project Office Timing: Disposition of Alerts for parts and materials lists are due within 30 days of parts and materials list submission (Refer to Sections 9 and 10). Disposition of Alerts against EEE parts added to the PIL or to subsequent parts list submissions (Refer to Section 9) are due within 30 days of their addition. Disposition of subsequent Alerts provided by the GSFC Project Office is due within 30 days of receipt by the developer. The purpose of the disposition is to document that the Alerts either do not apply to NASA product or that the effect has been mitigated.	
Preparation Information: The developer shall submit: A list in accordance with the requirements of the appropriate DID of Section 9 or Section 10 with a notation for each line item as to whether there are applicable Alerts. The lists submitted per Section 9 and Section 10 shall be continually updated with Alert information as parts and materials are added. GSFC Form 4-37, “Problem Impact Statement Parts, Materials and Safety” for Alerts provided by the GSFC Project Office.	

DID 12-2: SIGNIFICANT PARTS, MATERIALS, AND SAFETY PROBLEMS

Title: Significant parts, materials, and safety problems	CDRL No.:
Reference: Paragraph 12.0	
Use: Document the developer's significant parts, material, and safety problems.	
Related Documents: GIDEP Operations Manual (SO300- BT-PRO-010) GIDEP Requirements Guide (S0300-BU-GYD-010)	
Place/Time/Purpose of Delivery: Deliver to: GSFC Project Office Timing: Due within 30 days of discovery Purpose: To advise the GSFC Project Office of significant parts, materials, or safety problem that may affect the cost, schedule, or technical performance of NASA product	
Preparation Information: The developer shall submit all relevant information (failure analyses, test reports, root cause and corrective action evaluations etc.) to the GSFC Project Office. The developer shall pursue appropriate actions required by the GIDEP Manual in deciding if an Alert is merited and the kind of Alert that may be applicable.	