Procedures and Guidelines

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Title: **MISSION ASSURANCE GUIDELINES (MAG) FOR TAILORING TO THE NEEDS OF THE GODDARD SPACE FLIGHT CENTER (GSFC) PROJECTS**

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PREFACE

P.1 PURPOSE

Refer to Section 1.2.

P.2 APPLICABILITY

Refer to Sections 1.3 and 1.6.

P.3 AUTHORITY

None.

P.4 REFERENCES

Refer to Section 1.4.

P.5 CANCELLATION

Refer to Section 1.5.

P.6 SAFETY CONSIDERATIONS

None.

P.7 TRAINING

None.

P.8 RECORDS

None.

P.9 METRICS

None.

P.10 DEFINITIONS

Refer to Section 16.2.

Chapter 1. Overall Requirements

1.1 GENERAL

GSFC is assigned a wide variety of missions that range in complexity from relatively simple to extremely complex; from short duration to many years; and from high National interest to narrow specialized interest. The guidelines presented in this document have been prepared to address this wide range of programs and projects and to reflect Agency adoption of commercial practices, such as International Organization for Standardization (ISO) 9001 quality management requirements, where suitable for spacecraft applications. Some assurance areas (reviews, validation, workmanship standards, parts, materials and processes, reliability, and contamination) are not covered by ISO requirements. Therefore, flight projects must tailor their requirements in these areas to satisfy mission needs. The General Environmental Verification Specification for Space Transportation System (STS) & Expendable Launch Vehicle (ELV) Payloads, Subsystems, and Components (GEVS-SE) should be used as a baseline guide for developing validation requirements tailored to a specific mission.

One area of Mission Assurance that is not negotiable is the System Safety Requirements. The Safety requirements (see Chapter 3 in this document) are levied by the launch range and the launch vehicle provider and are mandatory requirements for all space flight hardware developers. The GSFC OSSMA provides assistance to the Flight Projects in meeting those requirements. The GSFC Project Manager must ensure that the applicable safety requirements are included into the contract statement of work (SOW). The OSSMA Project Safety Manager assigned to each GSFC flight project will assist in providing the appropriate contract language.

In all cases the guidelines are targeted at the optimum set of principles that have been proven in previous low-risk GSFC missions to achieve success. When selecting any particular guideline, the Project Manager should assess whether that guideline needs to be given increased or decreased emphasis to suit the specific mission needs. The Project Manager should exercise flexibility in choosing those guidelines that will add value to the mission. The Project Manager may choose to accept a developer's proposed mission assurance program. These guidelines should be used as a reference for the Project Manager's assessment of the adequacy of the developer's mission assurance program.

The language of specific sections in this document has been prepared so that it can be inserted directly into a contract SOW or other appropriate contract documents with only minor changes. The language states the guidelines as requirements. This was done to assist the Project Manager's team in preparing the SOW document. Each specific guideline may be reworded to provide specific emphasis desirable for a particular application. Text in italics are not requirements, but represent editorial comments.

1.2 PURPOSE

The purpose of this document is to serve as a resource to the Project Manager and OSSMA, in conjunction with 300-PG-7120.2.1, "Mission Assurance Guidelines (MAG) Implementation", in supporting the development of a realistic set of mission assurance requirements tailored to specific needs of an individual project. It is assumed that the project will select, tailor and then place the appropriate mission assurance requirements either directly into the contract SOW, and/or within a stand-alone Mission Assurance Requirements document.

1.3 SCOPE

The guidelines of this PG are intended for multiple missions and multiple instruments including Commercial Off-The-Shelf (COTS) items and apply to in-house, contracts, service level agreements and general support, all of which will be referred to as the developer.

1.4 REFERENCES

300-PG-7120.2.1, Mission Assurance Guidelines Implementation.

1.5 CANCELLATION

300-PG-7120.2.2B, MAG for Tailoring to the Needs of GSFC Projects.

1.6 APPLICABLE DOCUMENTS

To the extent referenced herein, applicable portions of the documents listed in Chapter 15 form a part of this document.

1.7 DESCRIPTION OF OVERALL REQUIREMENTS

The developer is required to plan and implement an organized Systems Safety and Mission Assurance Program that encompasses:

1. All flight hardware, either designed/built/provided by the developer or furnished by GSFC, from project initiation through launch and mission operations.
2. The ground system that interfaces with flight equipment to the extent necessary to assure the integrity and safety of flight items.
3. All software critical for mission success.

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

The Systems Safety and Mission Assurance Program is applicable to the project and its associated developers.

1.8 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 these requirements. The developer shall submit substantiating documentation in accordance with the SOW.

1.9 SURVEILLANCE OF THE DEVELOPER

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

The developer and/or suppliers shall grant access for National Aeronautics and Space Administration (NASA) and/or NASA representatives to conduct an assessment/survey upon notice. Resources shall be provided to assist with the assessment/survey with minimal disruption to work activities. The developer, upon request, shall provide government assurance representatives with documents, records, and equipment required to perform their assurance and safety activities. The developer shall also provide the government assurance representative(s) with an acceptable work area within developer facilities.

Note: see Federal Acquisition Regulation (FAR) Parts 46.103, 46.104, 46.202-2, 46.4 and 46.5 for Government quality assurance requirements at contractors' facilities. See FAR Part 52.246 for inspection clauses for contract type.

1.10 ACRONYMS AND GLOSSARY

Chapter 16 defines acronyms and terms as applied in this document.

1.11 CONTRACT DELIVERY REQUIREMENTS LIST

The Contract Delivery Requirements List (CDRL) identifies Data Item Descriptions (DIDs) describing data deliverable to the GSFC Project Office. Sample DIDs may be found in Chapter 17 of this document. The following definitions apply with respect to assurance deliverables:

***Deliver for Approval**:* *The GSFC Project approves within the period of time that has been negotiated and specified in the contract before the developer may proceed with associated work.*

***Deliver for Review**:* *The GSFC Project reviews and may comment within 30 days. The developer may continue with associated work while preparing a response to GSFC comments unless directed to stop.*

***Deliver for Information**:* *For GSFC Project information only. The developer's associated work schedule is not normally affected.*

Chapter 2. Quality Management System

This chapter establishes requirements for an effective Quality Management System (QMS). Augmentations to ISO requirements are included. These requirements may be tailored to meet the needs of the project.

2.1 GENERAL

The developer shall have a QMS that is compliant with the minimum requirements of American National Standards Institute (ANSI)/ISO/American Society for Quality (ASQ) Q9001 or equivalent. The developer's Quality Manual shall be provided in accordance with the SOW (refer to DID 2-1). Certificates issued to ANSI/ISO/ASQC Q9001: 1994 will have a maximum validity of 3 years from the publication date of ANSI/ISO/ASQ Q9001: 2000.

2.2 SUPPLEMENTAL QUALITY MANAGEMENT SYSTEM REQUIREMENTS

As mentioned previously, some assurance related activities are not covered by ISO requirements. These activities are identified in the following sections and should supplement the ANSI/ISO/ASQ Q9001 requirements.

2.2.1 Control of Nonconforming Product

The developer shall have a closed loop system for identifying and reporting nonconformances, 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 system shall include a nonconformance review process, which shall consist of a preliminary review and a Material Review Board (MRB). *Note: see section 5.5 for software related nonconformances.*

2.2.2 Preliminary Review

The preliminary review process shall be initiated with the identification and documentation of a nonconformance. A preliminary review shall be the initial step performed by developer-appointed personnel to determine if the nonconformance is minor and can readily be processed using the following disposition actions:

a) Scrapped, because the product is not usable for the intended purposes and cannot be economically reworked or repaired.

b) Re-worked, to result in a characteristic that completely conforms to the standards or drawing requirements.

c) Returned to supplier, for rework, repair or replacement.

d) Repaired using a standard repair process previously approved by the MRB and /or government Quality Assurance (QA) organization.

e) Referred to MRB when the above actions do not apply to the nonconformance.

Note: preliminary review does not negate the requirement to identify, segregate, document, and report and disposition nonconformances.

2.2.3 Material Review Board

The following should apply only if MRB privilege is granted to the developer.

Nonconformances not dispositioned by preliminary review, normally critical and major nonconformances, shall be referred to the MRB for disposition. MRB dispositions shall include scrap, rework, return to supplier, repair by standard or non-standard repair procedures, use-as-is, or request for major waiver.

The MRB shall consist of a core team, supplemented with other disciplines brought in as necessary. It shall be chaired by a developer representative responsible for ensuring that MRB actions are performed in compliance with this standard and implemented per developer procedures.

The MRB shall consist of the appropriate functional and project representatives who are needed to ensure timely determination, implementation and close-out of recommended MRB disposition. *Note: consideration may be given to including other representatives from quality, safety, design engineering, production and/or project management as appropriate.*

At developer/supplier facilities, NASA/Government representatives may participate in MRB activities as deemed appropriate by Government management or contract, otherwise, the MRB chairperson shall advise the Government of the MRB actions and recommendations. Notification will be provided to the developer/supplier early in the contract negotiation as to whether NASA will exercise the prerogative to review and approve all "use-as-is", standard and non-standard repair dispositions before they are initiated.

The MRB process shall investigate, in a timely manner, nonconforming item(s) in sufficient depth to determine proper disposition. For each reported nonconformance, there shall be an investigation and engineering analysis sufficient to determine cause and corrective actions for the nonconformance. Written authorization shall be provided to disposition the nonconformances.

2.2.4 Reporting of Failures

Reporting of failures shall begin as early in the lifecycle as possible, but no later than the first power application at the start of end item acceptance testing or the first operation of a mechanical item; it shall continue through formal acceptance by the GSFC project office. Failures shall be reported in accordance with the SOW (refer to DID 2-2). Developer review/disposition/approval of failure reports shall be described in applicable procedure(s) included or referenced in the Quality Manual.

2.2.5 Control of Monitoring and Measuring Devices

Testing and calibration laboratories shall be compliant with the requirements of ISO 17025, "General Requirements for the Competence of Testing and Calibration Laboratories".

2.2.6 New On-orbit Design

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

2.2.7 Flow-Down

The supplier's QA and safety programs shall ensure flow-down of requirements to all suppliers, including a process to verify compliance. Specifically, contract review and purchasing processes shall indicate the processes for documenting, communicating, and reviewing requirements with sub-tier suppliers to ensure requirements are met.

- Technical
- Safety
- Parts and Materials
- Reliability
- QA
- NASA Advisories
- GIDEP (Alerts, Safe-Alerts, Problem Advisories, Agency Action Notices)

Chapter 3. System Safety Requirements

3.1 GENERAL

The system safety program shall be implemented by all spacecraft and instrument developers for flight hardware, flight ground system equipment, associated software and support facilities. This is a mandatory contract element and shall be placed directly into the contract SOW, technical specification or other direct contract requirements, including the Contract Data Requirements List (CDRL) for mandatory safety deliverables. The system safety requirements may be referenced in the Mission Assurance and Risk Management sections but should not appear only in the Mission Assurance section.

3.2 SYSTEM SAFETY REQUIREMENTS

Spacecraft and instrument developers shall implement a system safety program in accordance with the requirements imposed by the appropriate launch range, launch vehicle manufacturer, facility integrator or launch service provider. 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 applicable requirements documents listed below (see 3.4.1). The system safety requirements shall be implemented based on the safety requirements defined by each of the appropriate launch range, launch vehicle manufacturer, facility integrator or launch service provider. The developer shall implement a program that provides for early identification and control of hazards during design, fabrication, test, transportation and ground activities. For STS launches the developer shall also include hazard identification and control for launch, orbital operations, landing and post-landing. These requirements are mandatory and are not negotiable.

3.3 SYSTEM SAFETY PROGRAM PLAN

The developer shall prepare a System Safety Program Plan (SSPP), see DID 3-1, that describes in detail, tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate and control hazards, or reduce the associated risk to a level acceptable throughout the system life cycle. The approved plan provides a formal basis of understanding between the Range User and Range Safety on how the SSPP will be conducted to meet the requirements of EWR 127-1, including general and specific provisions. The approved plan shall account for all contractually required tasks and responsibilities on an item-by-item basis. The Range User shall submit a draft SSPP to Range Safety for review and approval within 45 days of contract award and a final at least 45 days prior to any program CDR. Although a SSPP is not required for STS and ISS missions it is suggested that one be done.

3.4 SAFETY DATA PACKAGE

The developer shall prepare a Safety Data Package (SDP), Missile System Prelaunch Safety Data Package (MSPSP), or Safety Assessment Report (SAR), see DID 3-2, that identifies the hazards, hazard controls, verification and tracking methods, and establishes a "closed-loop" process for each identified hazard, see DID 3-3. The launch range defines required documentation. The safety assessment shall begin early in the program formulation process and continue throughout all phases of the mission lifecycle. The spacecraft/instrument Project Manager shall demonstrate compliance with these requirements and shall certify to the launch range, in the form of a SDP, MSPSP or SAR, that all requirements have been met. The following sections describe mandatory compliance requirements relevant to the applicable launch vehicles/launch services.

3.4.1 Safety Requirements Documentation

3.4.1.1 STS Missions (Flight and Ground)

a. NSTS 1700.7B, "Safety Policy and Requirements for Payloads Using the Space Transportation System".

b. NSTS/ISS 18798 – Interpretations of NSTS/ISS Payload Safety Requirements.

c. NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements

d. KHB 1700.7 – Space Shuttle Payload Ground Safety Handbook

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

f. 45 SPW S-100/KHB 1700.7, "Space Shuttle Payload Ground Safety Handbook".

g. KHB 1710.2, "Kennedy Space Center Safety Practices Handbook".

h. NSTS 14046, "Payload Verification".

i. NHB1700.1, "NASA Safety Policy and Requirements Document".

j. Facility Safety Requirements mandated by the launch vehicle contractor.

3.4.1.2 Expendable Launch Vehicle (ELV) Eastern Test Range (ETR) or Western Test Range (WTR) Missions

a. Eastern and Western Test Range (EWR) 127-1, "Eastern and Western Range Safety Requirements".

b. KHB 1710.2, "Kennedy Space Center Safety Practices Handbook."

c. NHB1700.1, "NASA Safety Policy and Requirements Document".

d. Facility Safety Requirements mandated by the launch vehicle contractor.

3.4.1.3 Wallops Flight Facility (WFF) Missions

a. Range Safety Manual (RSM)-93, "Range Safety Manual for GSFC/WFF".

3.4.1.4 Pegasus Missions

a. "Pegasus Design Safety Requirements Document" (SSD TD-0005).

b. "Pegasus Safety Requirements Document for Ground Operations" (SSD TD-0018).

Satisfactory compliance with the above requirements is required to gain payload access to the launch site and the subsequent launch.

As appropriate, all testing performed at GSFC will comply with the safety requirements contained in:

a. 5405-048-98, the Mechanical Systems Center Safety Manual.

b. NASA NPG 8715.3, "NASA Safety Manual".

c. GHB 1700.1, "Goddard Space Flight Center Health and Safety Program".

The developer shall submit a Launch Site Safety Plan (LSSP) in accordance with the contract schedule.

The spacecraft/instrument developer shall participate in Project activities associated with compliance to NSS 1740.14, NASA Policy for Limiting Orbital Debris Generation. Design and safety activities shall take into account the spacecraft's ability to conform to debris generation requirements.

3.5 GROUND OPERATIONS PROCEDURES

The developer shall submit, in accordance with the contract schedule, all ground operations procedures to be used at GSFC facilities, other integration facilities, or the launch site in accordance with the CDRL. All hazardous operations, see DID-3-4, as well as the procedures to control them shall be identified and highlighted. All launch site procedures shall comply with the launch site and NASA safety regulations.

3.6 SAFETY NONCOMPLIANCE/WAIVER REQUESTS

When a specific safety requirement cannot be met, the hardware developer shall submit an associated safety noncompliance/waiver request, see DID 3-5, which identifies the hazard and shows the rationale for approval of a noncompliance/waiver, as defined by applicable launch range requirements.

3.7 LAUNCH SITE SAFETY PLAN

The developer with overall safety responsibility shall submit a Payload Organization Launch Site Safety Plan, see DID-3-6, consistent with applicable launch range requirements in accordance with the CDRL.

3.8 SUPPORT FOR SAFETY WORKING GROUP MEETINGS

The developer shall provide technical support to the Project for safety working group meetings, Technical Interface Meetings, and technical reviews, when necessary.

3.9 ORBITAL DEBRIS ASSESSMENT

The developer shall supply an Orbital Debris Assessment, see DID-3-7, or the information required to produce the assessment consistent with NPD 8710.3, Policy for Limiting Orbital Debris Generation and NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris in accordance with the CDRL.

3.10 SAFETY COMPLIANCE

The developer shall demonstrate that the payload is in compliance with the requirements listed under DID 3-8. Safety compliance shall be granted only after meeting all Code 302 certification requirements, and launch site range safety requirements.

3.11 SOFTWARE SAFETY PROCESS

The developer shall look into the software safety process NASA-STD-8719.13 (standard provides a methodology for software safety in NASA programs). It describes the activities necessary to ensure that safety is designed into software that is acquired or developed by NASA. All Program/Project Managers are to assess the inherent safety risk of the software in their individual programs and are encouraged to tailor their software safety activity accordingly within the framework of NASA-STD-8719.13. The purpose of the software safety activities is to ensure that software does not cause or contribute to a system reaching a hazardous state; that it does not fail to detect or take corrective action if the system reaches a hazardous state; and that it does not fail to mitigate damage if an accident occurs. The software safety process shall:

a. Ensure that the system/subsystem safety analyses identify which software is safety-critical (Any software that has the potential to cause a hazard or is required to support control of a hazard, as identified by safety analyses, is safety-critical software).

b. Ensure that the system/subsystem safety analyses clearly identify the key inputs into the software requirements specification (e.g., identification of hazardous commands, limits, interrelationship of limits, sequence of events, timing constraints, voting logic, failure tolerance, etc.).

c. Ensure that the development of the software requirements specification includes the software safety requirements that have been identified by software safety analysis.

d. Ensure that the software design and implementation properly incorporate the software safety requirements.

e. Ensure that the appropriate verification and validation requirements are established to ensure proper implementation of the software safety requirements.

f. Ensure that test plans and procedures will satisfy the intent of the software safety verification requirements.

g. Ensure that the results of the software safety verification effort are satisfactory.

For additional software safety related information see section 5.2.2.

Chapter 4. Reliability & Maintainability Requirements

This chapter provides recommended Reliability and Maintainability (RM) requirements. These requirements should be tailored to meet the needs of the project.

4.1 GENERAL

The Reliability and Maintainability program shall be tailored in order to:

a. Use Probabilistic Risk Assessment (PRA) to assess, manage, and if necessary, quantitatively assess the need to reduce program risk.
b. Demonstrate that redundant functions, including alternative paths and workarounds, are independent to the extent practicable.
c. Demonstrate that the stress applied to parts is not excessive.
d. Identify single failure items/points, their effect on the attainment of mission objectives and possible safety degradation.
e. Show that the reliability design aligns with mission design life 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 during pre-launch activities.
h. Ensure that the design permits easy replacement of parts and components and that redundant paths are easily monitored.

4.2 RELIABILITY AND MAINTAINABILITY PROGRAM PLAN

Preparing a Reliability and Maintainability Program Plan (RMPP) is recommended for every program/project, since it will form the baseline of what reliability and maintainability activities, analyses, and assessments are best suited to the project, provide details of the approach and methodologies used, and highlight the schedule for completion. The plan should be initiated no later than the start of Phase B of a program to ensure the required resources are properly identified, budgeted and planned. Note: the relative importance of the maintainability portions of the plan will vary from project to project.

The developer shall develop a RMPP, in accordance with DID 4-1. The RMPP shall describe the planned approach for the RM activities for the project. The plan shall identify the RM tasks to be performed, and describe how the RM tasks will be implemented and controlled. The RMPP shall discuss the scheduling of RM tasks relative to project milestones. The plan shall describe the activities that ensure RM functions are an integral part of the design and development process and that RM functions interact effectively with other project disciplines, including systems engineering, hardware design and product assurance. The plan shall describe how reliability assessments will be integrated with the design process and other assurance practices to maximize the probability of meeting mission success criteria. The developer shall describe how reliability assessments will incorporate definitions of failure as well as alternate and degraded operating modes that clearly describe plausible acceptable and unacceptable levels of performance. Degraded operating modes will include failure conditions that could be alleviated or reduced significantly by implementing workarounds.

4.3 PROBABILISTIC RISK ASSESSMENT

In accordance with DID 4-2, a PRA planning document shall be prepared that defines the approach to performing a PRA. The PRA itself shall be performed in accordance with DID 4-2. Together the PRA and the PRA planning

document shall provide a comprehensive, systematic and integrated approach to identifying undesirable events, the scenarios leading to those events beginning with the initiating event or events, the frequency or likelihood of those events and the event consequences. The assessment shall be used to assist in identifying pivotal events that may protect against, aggravate or mitigate the resulting consequences.

The PRA shall be comprehensive and balanced, and shall consider all relevant critical factors, including safety of the public, astronauts and pilots, NASA workforce, adverse impacts on the environment, high value equipment and property, national interests, security, etc. The PRA implementation procedures shall reflect and incorporate the results of project risk analysis, including the identification of hazards, risks and recommended controls to manage risk.

The PRA planning document and PRA itself shall be performed, maintained and submitted to GSFC in accordance with the SOW.

4.4 RELIABILITY ANALYSES

Reliability analyses shall be performed concurrently with design so that identified problem areas can be addressed and corrective action(s) taken (if required) in a timely manner.

4.4.1 Failure Modes and Effects Analysis and Critical Items List

A Failure Modes and Effects Analysis (FMEA) shall be performed early in the design phase, in accordance with DID 4-3, to identify system design problems. As additional design information becomes available the FMEA shall be refined. Failure modes shall be assessed at the component interface level. Each failure mode shall be assessed for the effect at that level of analysis, the next higher level and upward. The failure mode shall be assigned a severity category based on the most severe effect caused by a failure. Mission phases (e.g., launch, deployment, on-orbit operation, and retrieval) 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 could result in Category 1 effects if all failed.
1S		Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition or fail to operate during such condition and lead to Category 1 consequences.
2	Critical	Failure modes that could result in loss of one or more mission objectives as defined by the GSFC project office.

2R		Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed.
3	Significant	Failure modes that could cause degradation to mission objectives.
4	Minor	Failure modes that could result in insignificant or no loss to mission objectives

FMEA analysis procedures and documentation 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 (e.g., no single instrument failure will prevent removal of power from the instrument). Identified discrepancies shall be evaluated by management and design groups to determine the need for corrective action.

The FMEA shall analyze redundancies to ensure that redundant paths are isolated or protected such that any single failure that causes the loss of a functional path will not affect the other functional path(s) or the capability to switch operation to that redundant path.

All failure modes that are assigned to Severity Categories 1, 1R, 1S1 and 2, shall be itemized on a Critical Items List (CIL) and maintained with the FMEA report, see DID 4-3. Rationale for retaining the items shall be included on the CIL. The FMEA and CIL shall be submitted to GSFC in accordance with the SOW, or as specified by the RMPP. Results of the FMEA, as well as the CIL, shall be presented at all design reviews starting with the Preliminary Design Review (PDR). 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.

4.4.2 Fault Tree Analysis

Fault tree analyses (FTA) shall be performed that addresses both mission failures and degraded modes of operation in accordance with the requirements of DID 4-4. Beginning with each undesired state (mission failure or degraded mission), the fault tree shall be expanded to include all credible combinations of events/faults and environments that could lead to the undesired state. Component hardware/software failures, external hardware/software failures and human factors shall be considered in the analysis. The fault tree in itself is not a quantitative model, but becomes a quantitative assessment when combined with quantitative data as part of the PRA.

4.4.3 Parts Stress Analyses

Each application of electrical, electronic, and electromechanical (EEE) parts shall be subjected to stress analyses for conformance with the applicable derating guidelines. The analyses shall be performed at the most stressful values that result from specified performance and environmental requirements (e.g., temperature and voltage) on the assembly or component. The results of the analyses shall be presented at all design reviews starting with the PDR. The analyses with summary sheets and updates shall be submitted to GSFC for review in accordance with DID 4-5. Presentations shall include comments on how the analysis was used to perform design trade-offs and how the results were taken into consideration when making design or risk management decisions.

4.4.4 Worst Case Analyses

Worst case analyses shall be performed on circuits where failure results in a severity category of 2 or higher and provides data that questions the flightworthiness of the design. Worst case analyses shall be performed in accordance with DID 4-6. The most sensitive design parameters, including those that are subject to variations that could degrade performance, shall be subjected to the analysis. The adequacy of design margins in the electronic circuits, optics, electromechanical and mechanical items shall be demonstrated by analyses, test or both to ensure flightworthiness.

The analyses shall consider all parameters set at worst case limits and worst case environmental stresses for the parameter or operation being evaluated. Depending on mission parameters and parts selection methods, part parameter values for the analyses will typically include:

a. Manufacturing variability.

b. Variability due to temperature.

c. Aging effects of environment.

d. Variability due to cumulative radiation.

The analyses shall be updated with design changes. The analyses shall be submitted in accordance with the contract schedule or RMPP, typically 30 days prior to Critical Design Review (CDR). The results of the analyses shall be presented at all design reviews starting with the PDR. Presentations shall include comments on how the analysis was used to perform design trade-offs and how the results were taken into consideration when making design or risk management decisions.

4.4.5 Reliability Assessments and Predictions

The developer shall perform comparative numerical reliability assessments and/or reliability predictions in accordance with DID 4-7 to:

a. Evaluate alternative design concepts, redundancy and cross-strapping approaches and part substitutions.

b. Identify the elements of the design that are the greatest detractors of system reliability.

c. Identify potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation and/or special operations.

d. Assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable.

e. Evaluate the impact of proposed engineering change and waiver requests on reliability.

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

4.4.6 Software Reliability

The developer shall develop a software reliability program that addresses the tolerance of minor defects and complete removal of critical defects. The software reliability program shall monitor and control defect removal, field performance and include a model to predict the bug removal rate or number of bugs remaining based on testing, running time or bug count. The software reliability model may be time domain (related to the number of bugs at a given time during development), data domain (estimated by running the program for a subset of input data), axiomatic (based on laws/rules applied during the programming process) or based on other methods resulting from input data sets, logic paths, etc.

The developer shall document actions to verify that the software design and software engineering techniques improve the duration or probability of failure free performance and ensure repeatability of the software. *For additional software reliability information see section 5.2.3.*

4.5 RELIABILITY ANALYSIS OF TEST DATA

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

4.5.1 Trend Analyses

As part of routine system assessment, the developer shall assess all subsystems and components to determine measurable parameters that relate to performance stability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring will be accomplished within the normal test framework; i.e., during functional tests and environmental tests. 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). Trend analysis data shall be reviewed with operational personnel prior to launch, and operational personnel shall continue recording trends throughout the system's mission life. A list of subsystem and components to be assessed, parameters to be monitored, and trend analysis reports shall be maintained and submitted in accordance with the SOW or the RMPP, see DID 4-8. The list of parameters to be monitored shall be presented at CDR, and trend analysis reports shall be presented at Pre-Environmental Review (PER) and Flight Readiness Review (FRR).

4.5.2 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 progress reports to the Project or in a separate monthly report. Results of analyses shall be presented at design reviews. 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.

4.6 LIMITED-LIFE ITEMS

Limited-life items shall be identified per DID 4-9, and managed by a Limited-Life Plan, which will be submitted for approval in accordance with the SOW. The plan shall present definitions, the impact on mission parameters, responsibilities and a list of limited-life items, including data elements as follows:

Expected life.

Required life.

Duty cycle.

Rationale for selection.

The useful life period starts with fabrication and ends with the completion of the final orbital mission.

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

4.7 MAINTAINABILITY

The degree of maintainability analysis and assessment performed for a program/project should be relative to the anticipated need and ability, to perform maintenance. The ability to perform maintenance on-orbit is either a well-planned activity (as in the case of a Hubble Space Telescope (HST) servicing mission), or does not exist (as in the case of an ELV launched spacecraft). However, maintainability needs to be considered for ground systems, and for flight hardware maintenance activities that may arise during Integration & Test (I&T) (as in the case of replacing a flight battery, or repairing a solar array).

Maintainability analyses shall be performed concurrently with design, and in conjunction with the reliability effort, so that identified problem areas can be addressed for timely consideration of corrective action. The maintainability analyses shall be based on the Mean Time Between Failure (MTBF) data produced in the reliability analyses for the line replaceable unit (LRU) level of the hardware and the required availability for each major function. The analyses shall focus on mean down times (to restore failed functions), with separate identification of Mean-Time-To-Repair (MTTR) and mean times for associated delays (including repair scenarios).

The maintainability analyses shall be used in appropriate tradeoffs to establish the project maintenance concept and maintainability plan and to determine spare parts/units requirements.

4.7.1 Maintainability Modeling (Allocations And Predictions)

MTTR requirements throughout the system, derived from tradeoffs shall be identified and documented in a Maintainability Demonstration Plan. The MTTR requirements shall be broken down to the LRU level to establish requirements for logistics planners. The top requirements shall be allocated to the planned levels of repair. Requirements consistent with the allocations shall be imposed on the sub-developers and suppliers.

Maintainability predictions shall be made showing the capability of the system/component/LRU to meet the allocated MTTR and/or specified mean down time requirements. The predictions shall be made using MIL-HDBK-472, “Maintainability Prediction”, or other documented source approved by GSFC. The predictions shall consider and identify pertinent requirements for accessibility and shall consider human factors. The predictions shall include a statement of the underlying ground rules and assumptions and be submitted in accordance with DID 4-10.

4.7.2 FMEA Maintainability Information

For each failure mode identified in the FMEA, the developer shall identify failure detection means and basic maintenance action information to support the original maintainability data collection and analysis activity.

4.7.3 Maintainability Design And Operating Standards

The developer shall develop, document and use design standards to facilitate maintainability of the system and maintenance operations. This shall include factors such as accessibility and human factors considerations (e.g. LRU weight and bulk) as well as engineering of equipment and cabling layout, junction/access boxes, cable identification labeling and power-shut-off security (for maintenance personnel safety). These standards shall include requirements to prevent unauthorized access to equipment, and to maintain logs and other records to track each access, each maintenance operation, and provide traceability to individuals involved.

4.7.4 Maintainability Data Collection And Analysis

The developer shall establish a maintainability data collection system to augment and update predictions with preliminary trial results during design, for measurement and evaluation of demonstration results and to track actual operations maintenance experience and trends. Maintenance records shall include data on operating time logs, failure frequency, repair times, total down time for each maintenance event and adequacy of sparing provisions. Data collection should be integrated as much as possible with reliability data collection requirements.

The data collection system shall be used as a means for identifying maintainability design problems/errors and initiating corrective actions. Procedures shall be identified for:

- Providing inputs to the system
- Analysis of problems.
- Feedback of corrective action into the design, manufacturing, integration and test and operational maintenance planning processes.

4.7.5 Maintainability Demonstration

The developer shall use the reliability predictions and other pertinent considerations to identify and list the most probable anticipated failures of critical real-time system functions. From this list, the developer shall identify and scope a group of candidate maintainability demonstration tests from which a selection will be made of specific tests to conduct as a part of the acceptance test program.

The objective of the maintainability demonstration tests is to verify the capability of the planned maintenance activities to meet the operational availability/mean down times required for identified system functions. Other objectives of the tests are to evaluate the adequacy of fault detection or isolation methods and the ability to achieve LRU replacements or on-site repairs to meet criteria stated in the maintenance plan.

The demonstrations shall be conducted in accordance with MIL-HDBK-470, "Designing and Developing Maintainable Products and Systems".

The developer shall describe the planned activities in a Maintainability Demonstration Plan. The plan shall describe candidate failure scenarios and identify and outline the test specification requirements of each candidate individual demonstration. Selection of candidates shall be made subsequently by an independent developer organization, Independent Acceptance and Test Organization (IATO), responsible for the acceptance test program. When the selection has been made, detailed test plans shall be documented by the IATO and used in the demonstration tests.

The Maintainability Demonstration test reports shall be submitted in accordance with DID 4-11.

4.8 CONTROL OF SUB-DEVELOPERS AND SUPPLIERS

The developer shall ensure that system elements obtained from sub-developers and suppliers will meet project RM requirements. All subcontracts shall include provisions for review and evaluation of the sub-developers' and suppliers' RM efforts by the prime developer at the prime developer's discretion, and by GSFC at its discretion.

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

- Incorporate quantitative RM requirements in subcontracted equipment specifications.
- Assure that sub-developers have RM programs that are compatible with the overall program
- Review sub-developers' assessments and analyses for accuracy and correctness of approach.
- Review sub-developers' test plans, procedures and reports for correctness of approach and test details.
- Attend and participate in sub-developers' design reviews.
- Ensure that sub-developers during the project operational phase comply with the applicable system RM requirements.

4.9 RM OF GOVERNMENT FURNISHED EQUIPMENT

When the overall system includes components or other elements furnished by the Government, the developer shall be responsible for identifying and requesting from the Project Office adequate RM data on the items. The data will be used for performing the RM analyses. When examination of the data or testing by the developer indicates that the reliability or maintainability of Government Furnished Equipment (GFE) is inconsistent with the RM requirements of the overall system, the Project Office shall be formally and promptly notified.

Chapter 5. Software Assurance Requirements

The Systems Assurance Manager (SAM) should ensure that software assurance processes and products are addressed in applicable mission assurance requirements. Software assurance should be addressed in the developer's QMS, system safety, reliability, maintainability, and risk management programs. These software assurance requirements may be specified in the SOW or reference documents such as a Mission Assurance Requirements document. All disciplines of Software Assurance should be addressed; however, tailoring is acceptable based on the size of the development team, size and complexity of the software, the amount of software reuse, and the criticality of the software.

For additional information/guidance on software assurance related activities, reference the following NASA Standards: NASA-STD-2201-93, Software Assurance Standard, NASA-STD-2100-91, Software Documentation Standard, NASA-STD-2202-93, Software Formal Inspections Standard.

5.1 GENERAL

[Note: If subcontractors are part of the development process, state the following up front.] For the purposes of Section 5, all references to the developer shall include the prime software developer, as well as any subcontractors tasked in the development process.

The developer's QMS shall address software development and software assurance functions for all flight and ground system software. The QMS 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.

The developer shall plan and document software development processes and procedures, software tools, resources, and deliverables throughout the development life cycle in a Software Development Plan, see DID 5.1.

5.2 SOFTWARE ASSURANCE

Software assurance is the planned and systematic set of activities that ensures that software lifecycle processes and products conform to requirements, standards, and procedures (Institute of Electrical and Electronics Engineers (IEEE) 610.12). As such, software assurance is comprised of a set of disciplines that strive to improve the overall quality of the product/software while employing risk mitigation techniques. These NASA disciplines include Software Quality Assurance (SQA), Software Safety, Software Reliability, Verification and Verification (V&V), and Independent Verification and Validation (IV&V).

5.2.1 Software Quality Assurance

The developer shall identify a Software Quality Manager responsible for software quality assurance. The developer shall prepare and document a Software Quality Assurance Plan that is consistent with DID 5.2 and the IEEE Standard 730, "Software Quality Assurance Plans". The plan shall document SQA roles and responsibilities, surveillance activities (i.e., process and product audits), supplier control, records collection, maintenance and retention, and risk management.

Product assurance activities shall consist of tasks to assure:

1. Standards and procedures for management, software engineering and software assurance activities are defined.
2. All plans (e.g., configuration management, risk management, software development plan, etc.) required by the contract are completed and comply with contractual requirements.

3. Standards, design, and code are evaluated for quality and security issues.
4. All software requirements are documented and traceable from system requirements to design, code and test (i.e., a software requirements traceability matrix).
5. Software requirement verification status is updated and maintained via a software requirements verification matrix.
6. Formal and acceptance-level software tests are witnessed and test artifacts are maintained.
7. Software products and related documentation (e.g., Version Description Documents and User Guides) have the required content and satisfy their contractual requirements.
8. Reports, schedules and records are reviewed.

Process assurance activities shall consist of tasks to assure:

1. Management, software engineering, and assurance personnel comply with specified standards and procedures.
2. All plans (e.g., configuration management, risk management, software development plan, etc.) and procedures are implemented according to specified standards and procedures. This includes software safety planning.
3. Contract requirements are passed down to any subcontractors, and that the subcontractor's software products satisfy the prime developer's contractual requirements.
4. Peer reviews (e.g., code inspections) and management reviews are conducted and action items are tracked to closure.
5. A software problem reporting system and corrective action process is in place and provides the capability to document, search, and track software problems and anomalies.
6. Static Code Checking tools (e.g., lint, Polyspace Verifier, etc.) or services (Reasoning Illuma, etc.) are used by the development team to identify software issues.
7. The software is tested to verify compliance with requirements.
8. Software safety processes, products, and procedures are followed.
9. Metric data is collected and analyzed (e.g., analysis of open and closed software problem reports).

5.2.2 Software Safety

Software safety is a systematic approach to identifying, analyzing, tracking, mitigating and controlling software hazards and hazardous functions (data and commands) to ensure safer software operation within a system. It ensures that safety issues related to software are addressed in reviews and that specific safety analyses and tests are performed that consider specific software safety issues and potential hazards. While much of software safety depends on a good software development process and the overall software assurance activities, software safety is specifically concerned with those features of the software whose failure could impact safety.

Any software that has the potential to cause a hazard or is required to support control of a hazard, as identified by safety analyses, is safety critical software. Software in a system that monitors, controls, interfaces with directly, or is resident in a processor handling critical or hazardous system functions is deemed software safety critical. Non-safety-critical software may become safety critical if it can impact safety-critical software resident with it (i.e., on

the same machine or network). Other safety-critical software performs analyses or "crunches numbers" that will be used with, or for, safety-critical equipment or by an operator to make safety critical decisions. If the software does not meet any of the above criteria, then it is probably not safety critical.

There exist several software safety standards and requirements within industry and NASA. Specifically, within the NASA environment there exists the NASA Software Safety Standard 8719.13, as well as EWR 127-1 (sections 3.16.1 and 3.16.3) which specifically address software safety related requirements and activities as they pertain to software safety critical functions (SCCFs). For software acquired or developed by NASA that is used as part of a system that possesses the potential of directly or indirectly causing harm to humans or damage to property external to the system, the NASA Software Safety Standard, NASA-STD-8719.13 applies. EWR-127-1 is applicable for all safety critical computing systems associated with the handling, checkout, test or launch of missiles or space vehicles at the launch ranges.

The developer shall conduct a software safety program that is integrated with the overall software assurance and systems safety program and is compliant with the software safety requirements levied upon the project by the customer.

The developer shall assess the inherent safety risk of the software and develop a tailored approach to address software safety. The developer shall document their approach to the software safety program in a Software Safety Plan (see DID 5-5) or the System Safety Program Plan (see DID 3-1). The developer shall ensure that software safety requirements are clearly identified, documented, traced and controlled throughout the lifecycle. In cases, where the developer cannot meet a software safety requirement and/or feels that it is not in the best interest of the project to implement, the developer shall document these items in a deviation/waiver package. The developer shall furnish this deviation/waiver package to the customer for review/disposition.

The developer shall determine and identify software that is safety critical based upon several factors including the allocation of safety critical system level requirements allocated to software, specific software safety requirements levied on the system, and any hazards identified via engineering analyses (e.g., PHA, FMEA (see DID 4-3), FTA (see DID 4-4), etc). The developer shall document all analyses used to determine software safety critical items. For software deemed software safety critical, the developer shall identify and document the software safety critical classification of each item in terms of criticality, severity, associated risks, and likelihood of occurrence. Software safety requirements shall also be clearly identified and distinguishable in the software requirements traceability matrix. The developer shall continually monitor, assess, and review the software development efforts for changes that may affect the safety critical classification of the software and as necessary update engineering analyses to reflect these changes.

The software safety program shall include the following activities:

1. Identification and tracking of software safety requirements throughout the development lifecycle.
2. Analysis of the consistency, completeness, correctness and testability of software safety requirements.
3. Analysis of design and code to identify potential hazards and ensure implementation of safety-critical requirements.
4. Use of safety specific coding standards *(e.g., C++ reduced instruction set).*
5. Closed-loop tracking of safety-related discrepancies, problems, and failures in baselined software products.
6. Testing of the 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. Testing shall show that hazards have been eliminated or controlled to an acceptable level of risk.
7. Analysis of proposed changes on system safety.

Reference Section 3.11, under System Safety, for additional content.

5.2.3 Software Reliability

The developer shall conduct a software reliability management program to optimize the reliability of software through a series of planned activities that emphasizes software error prevention, fault detection and removal, and the use of measurements to maximize reliability (IEEE 982.1-1998). The software reliability program shall be tailored to the appropriate level based upon criticality of the software to the mission, software safety criticality, as well as project constraints such as resources, schedule and performance (IEEE 982.1-1998). The software reliability management program shall be integrated with the software safety program and risk management program such that software safety critical issues/concerns, as well as risks associated with software, are proactively identified, understood and mitigated to avoid and/or minimize software failures.

As part of the software reliability management program, the developer shall collect product and process measures that are consistent with IEEE Standard 982.1-1988, IEEE Standard Dictionary of Measures to Produce Reliable Software.

Product measures to be collected include the following:

- Errors, Faults and Failures – e.g., count of defects with respect to human cause, programming bugs, or observed system malfunctions (see section 5.7, item 3).
- Mean-Time-to-Failure, Failure Rate – derivative measures of defect occurrence vs. time.
- Completeness and Consistency of the requirements, software design, and developer's test program – e.g., comprehensive traceability of requirements to design, code and test.
- Code Complexity – e.g., cyclomatic complexity and coupling of modules.
- Reliability Growth and Projection – assessment of change in failure-freeness of the product under testing and in operation.
- Remaining Product Faults – assessment of fault-freeness of the product in development, test or maintenance.

Process measures pertaining to the development, test and maintenance activities to be collected include the following:

- Management Control – e.g., process compliance with developer's software development plan and configuration management plan.
- Risk, Benefits, Cost Evaluation – e.g., the developer's implementation of risk management and the tradeoffs of cost, schedule and performance.

For more specific details on product and process measures, reference IEEE Standard 982.1-1988 and IEEE Standard 982.2 1988, IEEE Guide for the Use of IEEE Standard Dictionary of Measures to Produce Reliable Software.

The developer shall document their approach to their software reliability program in a software reliability plan (see DID 5-4) and/or the software development plan (see DID 5-1), as applicable. Items to be specifically addressed in the plan shall address the activities to be undertaken to achieve the software reliability requirements, as well as describe the activities to be undertaken to demonstrate that the software reliability requirements have been achieved. The developer shall document a software reliability case that provides justification of their software reliability

approach, and, throughout the project, documents the evidence that verifies that the software meets the reliability requirements.

For more specific details on the contents of a software reliability plan and/or software reliability case, reference SAE, JA1002, Software Reliability Program Standard, 1998.

5.2.4 Verification and Validation

The developer shall implement a Verification and Validation (V&V) program to ensure that software being developed or maintained satisfies functional and other requirements at each stage of the development process and that the final product meets customer requirements and expectations. To assist in the verification and validation of software requirements, the developer shall develop and maintain under configuration control a Software Requirements Verification Matrix. This matrix shall document the flow-down of each requirement to the test case and test method used to verify compliance and the test results. The matrix shall be made available to NASA upon request.

V&V activities shall be performed during each phase of the software lifecycle and shall include the following:

1. Analysis of system and software requirements allocation, verifiability, testability, completeness and consistency (including analysis of test requirements).
2. Interface analysis (requirements and design levels).
3. Design and code analysis including design completeness and correctness.
4. Walkthroughs or inspections.
5. Formal Reviews.
6. Documented test plans and procedures.
7. Test planning, execution, and reporting.

5.2.5 Independent Verification and Validation

The developer shall provide all information required for the NASA Independent Verification and Validation (IV&V) effort to NASA IV&V personnel. This includes, but is not limited to, access to all software reviews and reports, contractor 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 corrective action. The developer shall also notify NASA 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 for questions, clarification, and status meetings, as needed.

Note: The level of IV&V effort and associated programmatics shall be in accordance with the Software Independent Verification and Validation (IV&V) Policy, NPD 8730.4. The GSFC Program/Project Manager shall work jointly with the IV&V Facility to assess the level of IV&V support based on the cost, size, complexity, life span, risk, and consequence of failure. This assessment and the overall project approach to IV&V will be documented in an IV&V project plan. The NASA IV&V facility shall provide IV&V support for software developed for NASA. The SAM should ensure that the project complies with the requirements of the NASA Software IV&V program.

5.3 REVIEWS

5.3.1 Management Reviews

The developer's management process shall provide for a series of developer-presented formal reviews chaired by a GSFC review panel. The formal review program shall include:

1. Software Requirements Review (SRR)
2. Preliminary Design Review (PDR)
3. Critical Design Review (CDR)
4. Test Readiness Review (TRR)
5. Acceptance Review (AR)

The developer shall ensure that software safety is formally addressed as an agenda item at all reviews. *Note: software safety related analyses/items such as Preliminary Hazard Analysis, listing of potential system hazards, safety design features, controls in place, eliminated hazards, accepted risks/hazards, likelihood of occurrence or potential impact of each hazard, evidence that tests/procedures are in place to verify all the safety features, as well as actual verification results, may be presented at these reviews.*

The developer shall record and maintain minutes and action items from each review. The developer shall respond to Request for Action (RFAs) and any action items assigned by the GSFC review panel and/or the project as a result of each review and provide a status of all action items and RFAs at subsequent formal reviews.

Records of reviews not required by the contract but conducted by the developer in accordance with the developer's QMS shall be available for review by GSFC upon request.

5.3.2 Peer Reviews

The developer shall implement a program of engineering reviews (peer reviews) throughout the development lifecycle to identify and resolve concerns prior to formal, system level reviews. Peer review teams shall be comprised of technical experts with significant practical experience relevant to the technology and requirements of the software to be reviewed. These reviews shall be commensurate with the scope, complexity, and acceptable risk of the software system/product.

Topics that shall be addressed in the peer reviews include:

1. Design verification.
2. Coding standards and Style guides.
3. Code inspections (or walkthroughs).
4. Analyses and studies.
5. Software safety.
6. Risk assessment, resolution and contingency plans.
7. Procurements.
8. Configuration management.
9. Testability and test planning, including test anomalies and resolution.

Action items from peer reviews shall be recorded, maintained, and tracked throughout the development lifecycle.

5.4 SOFTWARE CONFIGURATION MANAGEMENT

The developer shall develop and implement a Software Configuration Management (SCM) system that provides baseline management and control of software requirements, design, source code, data, and documentation. As part of the SCM, the developer shall employ a source code version control tool (e.g., ClearCase, Starbase, etc.) that allows developers to check in/check out current or previous versions of a source file. The developer shall also use a requirements management tool (e.g., DOORS) to manage the software requirements baseline.

As part of the SCM system, the developer shall create and maintain a configuration control board (CCB) to manage, assess and control all changes. The SCM system in conjunction with the CCB shall classify proposed software changes as either a Class I change or a Class II change. Any changes classified by the CCB as a Class I change per the definition below shall be forwarded to GSFC for disposition and approval. Class I changes are defined as those which affect:

1. System requirements.
2. Software requirements.
3. Software safety.
4. Software reliability.
5. Cost.
6. Schedule.
7. External interfaces.

Any changes classified as Class II by the CCB shall be handled by the developer, but forwarded to GSFC for review and concurrence.

The developer shall ensure that the overall SCM system addresses configuration identification, configuration control, configuration status accounting and configuration authentication. Audits may include baseline audits, library control audits, physical configuration audits (PCAs), and functional configuration audits (FCAs). The developer shall describe the SCM system, and associated tools, in a SCM Plan, see DID 5-3.

5.5 SOFTWARE PROBLEM REPORTING AND CORRECTIVE ACTION

The developer shall implement a process for Software Problem Reporting and Corrective Action that addresses reporting, analyzing and correcting software nonconformances throughout the development lifecycle. The developer's QMS shall provide for a corrective action process that tracks every software nonconformance to its final disposition.

The Software Problem Reporting system and Corrective Action 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.

5.6 GFE, EXISTING AND PURCHASED SOFTWARE

If the developer will be provided software or firmware as GFE, or will use existing or purchased software or COTS, the developer shall ensure that the software meets the functional, performance and interface requirements placed upon it. The developer shall ensure that the software meets applicable standards, including those for design, code and documentation, or shall secure a GSFC project waiver to those standards.

5.7 SOFTWARE ASSURANCE STATUS REPORTING

Monthly status reports shall be provided to the Program/Project Office. The status reports shall include the following software assurance highlights:

1. Organization and key personnel changes.
2. Assurance accomplishments and resulting metrics for activities such as, but not limited to, inspection and test, reviews, contractor/subcontractor surveys, and audits.
3. Trends in metrics data (e.g., total number of software problem reports, including the number of problem reports that were opened and closed in that reporting period).
4. Significant problems or issues that could affect cost, schedule and/or performance.
5. Plans for upcoming software assurance activities.

5.8 NASA OVERSIGHT OF SOFTWARE DEVELOPMENT

The developer shall allow NASA representatives and/or their designate/assignee to perform insight/oversight activities throughout the entire software development lifecycle. Insight/oversight activities include, but are not limited to the following:

- The developer shall allow NASA representatives electronic access to their software problem reporting system remotely from GSFC.
- The developer shall provide NASA representatives the necessary software documentation to perform their job (e.g., software development plans, software quality assurance plans, configuration management plans, design documentation, etc.)
- The developer shall allow NASA representatives to review results and corrective action from process and product audits.
- The developer shall allow NASA representatives to be present at any peer reviews (e.g., code inspections) that NASA representatives deem appropriate. The NASA representative shall be allowed to submit RFAs or action items for developer consideration, including formal comments to code inspections.
- The developer shall allow NASA representatives to review the status of all RFA's and action items, as well as their resolution.

Chapter 6. Ground Data Systems Assurance Requirements

This chapter provides recommended Ground Data System (GDS) Assurance Requirements. GDS Assurance requirements for certain areas, such as, reliability and maintainability are specified in the Assurance Requirements for the specific area. These requirements should be tailored to meet the needs of the project.

Note: there exist various interpretations and sources of requirements for the development of GDS components. For some efforts, the GDS requirements will represent the entire set of requirements that the GDS must fulfill and will serve as the guiding force behind the entire development efforts (for example, a system requirements document for a level zero processing system/facility). However, in some cases, the GDS requirements may represent a subset of requirements, typically mission critical requirements, that are part of an overall set of requirements for a particular system (for example, only those mission critical requirements from a system requirements document for a level zero processing system/facility). This chapter attempts to provide assurance-requirements that cover both instances.

6.1 GENERAL

GDS components may include but are not limited to GDS software, firmware and hardware, ground support elements (simulators, etc), COTS, databases, key parameter and test checkout software, and any software developed under the project that is related to flight mission operations. These components may be developed in-house entirely by the developer, provided by a sub-developer/subcontractor to the developer, purchased by the government, purchased by the developer, or furnished by other parties including the government.

6.2 QUALITY MANAGEMENT SYSTEM

QMS related requirements are discussed in Chapter 2 of this document. It should be noted that the QMS shall be applied to the development and assurance functions for GDS components as well. In all cases the development effort shall provide evidence (quality records for GSFC review) as insight to the quality of the developing software, hardware and other GDS components as evidence of application of QMS processes, and as status of assurance problems, safety issues and organizational/personnel changes. Quality records shall include any corrective actions, relating to GDS development, recommended by QMS audits. The developer will allow NASA audits, when deemed necessary by the Project Manager, to assure compliance of the developer's QMS with ANSI/ISO/ASQ Q9001 and to assure that the QMS is applied to the contracted activities.

6.3 REQUIREMENTS

The developer shall identify, document and maintain GDS requirements that will serve as the basis of the development, implementation, operation and maintenance of the GDS and its components. These requirements may include but are not limited to functional, performance, reliability, maintainability, safety and test/verification requirements.

The developer shall review and analyze the GDS requirements to assure that they are consistent, clear, valid, feasible, compatible, complete, testable and do not include inappropriate level of design information. The developer shall work with GSFC and/or other entities as necessary to resolve any problems/issues associated with the GDS requirements.

The developer shall baseline the GDS requirements early in the development effort, specifically in conjunction with a formal requirement review. The developer shall maintain the GDS requirements under configuration control throughout the lifecycle. All changes to the GDS requirements, including those generated both internally and externally, shall be managed by the developer's Configuration Control Board (CCB) process and reviewed/approved as applicable by GSFC.

6.4 REVIEWS

Formal reviews are discussed in Chapter 8 of this document.

The developer shall implement a program of engineering reviews (peer reviews) throughout the development lifecycle to identify and resolve concerns prior to formal, system level reviews. The developer shall plan for such engineering working-level reviews such that they are represented on the project's development schedule. For each engineering review, the developer shall identify and document the following:

- Review process.
- Required participants in the reviews.
- Specific criteria/requirements for successful completion.
- Artifact(s)/documentation required for the review.
- Review results.
- Describe how follow-up actions are documented, tracked and controlled.

6.5 ASSURANCE ACTIVITIES

Note: the assurance related activities mentioned throughout this section should be tailored to reflect the GDS and its associated components criticality, mission objectives and accepted level of risk. Tailoring should take into account the size, complexity, reusability, flexibility, portability, interoperability, safety-criticality, reliability, maturity, system compatibility, etc. of the GDS and its components.

The developer shall perform various assurance-related activities throughout the development lifecycle to ensure that the GDS and its components meet GDS requirements. The developer shall initiate these activities as early in the development lifecycle as possible, specifically in the concept phase, and continue these activities into the operations and maintenance phase where applicable. Some of these assurance-related activities are applicable to all phases of the lifecycle and the developer shall conduct these activities throughout the entire lifecycle. These activities include but are not limited to the following:

- Planning, Tracking and Oversight.

6.5.1 Concept Phase

Specific assurance-related activities that the developer shall perform during the concept phase include but are not limited to the following:

- Tradeoff and evaluation studies and/or prototyping efforts to provide insight into the feasibility of GDS components meeting the operational concept, constraints and preliminary requirements.
- Define and document criteria used to perform tradeoff and evaluation studies and maintain all results from these studies for GSFC review.
- Participation in a system requirements reviews.

6.5.2 Requirements Phase

In addition to the activities mentioned above, specific assurance-related activities that the developer shall perform during the requirements phase include but are not limited to the following (note: some of these activities may be performed prior to this phase or subsequent to this phase where applicable):

- Analyze and refine the requirements to assure they are consistent, clear, valid, feasible, compatible, complete, testable and do not include inappropriate level of design information.
- Ensure requirements are generated, analyzed, refined, decomposed and allocated to appropriate GDS components through the use of a systems analysis and allocation process. This process shall be used to verify requirements are correct and complete at each level prior to further allocation and decomposition, and to verify them for feasibility and top-level design concept prior to further allocation.
- Document trade studies and analyses performed to aid in deciding which requirements to allocate to hardware, software and other components. When a system-level requirement is allocated to more than one configuration item (CI), a process is used to assure that the lower-level requirements taken together satisfy the system-level requirement.
- Establish functional, performance, safety, reliability, maintainability and test/verification requirements for each incremental system (delivery/build) as applicable. This process should assure all requirements are allocated to planned increments prior to the design and development of the increment.
- Ensure that the systems analysis and allocation methodology is compatible with other methodologies adopted on the project.
- Manage allocation of new and additional requirements between hardware, software and other components by a change review and control process; and manage the reallocation of existing requirements between hardware, software and other components by a change review and control process.
- Use a defined process to generate, review and allocate interface requirements.
- Maintain a process to provide, ensure and maintain two-way requirements traceability from system specifications to hardware, software and other components that serve as configuration items. This requirement traceability shall be established and documented as early in the lifecycle as possible.
- Generate, document and maintain a requirements verification matrix.
- Conduct a requirement review and at the end of each phase of the development process to ensure requirements are complete and testable.

6.5.3 Design Phase

Specific assurance-related activities that the developer shall perform during the design phase include but are not limited to the following (note: some of these activities may be performed prior to this phase as applicable):

- Select and document an engineering development lifecycle model consistent with the program requirements and needs. The rationale for selecting the lifecycle development models and methods shall be recorded and maintained.
- Establish and maintain the computer system architecture (hardware, software and other components), for determining the nature and number of the configuration items, and for maintaining traceability of the architecture to requirements. This process shall define the relationships between GDS architecture components (hardware, software, etc) including the system-level component hierarchy and control structure and the operational (human) interface as applicable.
- Maintain a process to define, maintain, and document interfaces (both internal and external) within the architecture.
- Evaluate how suitable the GDS architecture is for implementing all of the requirements, as well as how the design constraints are satisfied. The developer shall identify, document and maintain criteria used to perform

any architecture evaluations. Suitable development/project personnel shall participate and support these evaluation efforts.

- Evaluate the design based on the use of risk reduction techniques, such as the creation of models and prototypes (proofs, benchmarks) as necessary.
- Periodically reassess the adequacy of the GDS architecture over the development cycle. The developer shall identify, document and maintain criteria that are used to provide data to determine whether to stay with the original design or change.
- As requirements change, perform a review of the GDS architecture design for flexibility to adapt to new requirements, and (as necessary) updates, the ground data system architecture design.
- Review all architectural changes and their impact on design margins (such as memory, throughput, bus loading and data latency) as well as cost and schedule baselines prior to implementation. Any proposed change to the GDS architecture design shall be subject to GSFC review/approval.
- Document and maintain the rationale of all major systems engineering decisions and where applicable implement a process to arbitrate contention across trade-off studies for utilization of system-level resources and reserves.
- Conduct reviews and appropriate tests at the end of each phase of the development process to ensure that the requirements have been correctly implemented into design, code, documentation and data.
- Allocate and maintain traceability between the GDS architecture/components and the GDS requirements.
- Conduct design walkthroughs and reviews.

6.5.4 Implementation Phase

Specific assurance-related activities that the developer shall perform during the implementation phase include but are not limited to the following (note: some of these activities may be performed prior to this phase as applicable):

- Define and document the components of each build, delivery and/or release.
- Conduct peer reviews/walkthroughs for code.
- Conduct unit testing.
- Conduct reviews and appropriate tests at the end of this phase of the development process to ensure that the requirements have been correctly implemented into design, code, documentation and data.
- Allocate and maintain traceability between the GDS architecture/components and the GDS requirements.
- Conduct configuration reviews, Functional Configuration Audits (FCAs) and Physical Configuration Audits (PCAs) to define, document and ensure the configuration of the GDS and its components.

6.5.5 Testing Phase

Note: the testing phase may be comprised of various types of testing including but not limited to unit testing, integration & test, system level, acceptance test, interface, end-to-end, compatibility testing, data flow testing, regression testing and operational readiness testing. Unit testing, integration & test, and system level testing are typically performed solely by the developer with some level of oversight by an independent entity. Acceptance test, interface, end-to-end, compatibility testing, data flow and operational readiness testing are typically performed with support by other entities including other ground data system elements (Mission Operations Center (MOC), data

processing facilities, end-user facilities and the appropriate network elements) in order to fully demonstrate operational compatibility and the ability of the entire system to perform as required during the mission.

Specific assurance-related activities that the developer shall perform during the test phase include but are not limited to the following (note: some of these activities may be performed prior to this phase as applicable):

- Plan for and document test related activities early in the development stages of the project in a test plan(s). As necessary, a separate test plan may be required for each of the various types of testing mentioned above. The plan shall be maintained under configuration control and updated as requirements are changed. All test plans shall be made subject to GSFC review and approval as applicable. The developer's test plans shall include but is not limited to the following:
  - Number of system builds planned and when they will occur.
  - Description of the tests to be performed including the different levels of testing (from units to Computer Software Configuration Items (CSCIs) to subsystem to system-level test), expected test results, personnel responsible for testing, any required support from other organizations and data required for the test(s).
  - GDS components to be tested
  - Test environment under which the test(s) will be conducted including test facility requirements, special test support tools (i.e., simulators, emulators, etc.) and any special operating conditions required.
  - Requirements Verification Matrix (RVM) documenting traceability of requirements to test cases.
- Generate test procedures that implement the test plans and facilitate the verification and validation of GDS requirements. All test procedures shall be made subject to GSFC review and approval as applicable.
- Maintain a process to ensure that any test tools and test data are qualified prior to use during testing activities.
- Ensure that test personnel attend and participate as necessary in various reviews throughout the lifecycle, to include but not limited to requirements, architecture and design reviews.
- Identify and document test readiness criteria for both formal and informal testing activities. Test criteria shall be made subject to GSFC review and approval as applicable.
- Maintain and update the RVM generated earlier in the lifecycle to include the status (pass, fail, deferred, etc) of each requirement throughout the testing phases and various testing activities.
- Document all test results in a test report. Test reports should document the validation of requirements, specific tests completed, conformance of the test results to the expected results, the number, type and criticality of any identified discrepancies/nonconformances, identification of the hardware, software and other GDS components tested including version number, etc.
- Define and document a transition process/plan to progress from the test environment to the operations and maintenance environment.
- Document all defects/nonconformances encountered during the testing activities. These defects/nonconformances shall be assessed for criticality, severity, impact, etc to determine appropriate action and resolution. The developer shall track and report on the status of all defects/nonconformances.
- Identify all nonconformances that impact the developer's ability to meet GDS requirements and document these items in a waiver, which must be reviewed/approved by GSFC as applicable.

- Ensure an independent entity, either internal or external QA representatives/personnel, witness all testing activities as appropriate.
- Ensure and maintain configuration control of the test environment including hardware, software, simulators, test data, databases and other components throughout the test program.
- Assess all changes made to the system architecture and its components to determine the necessity for regression testing. The developer shall conduct regression testing based upon assessed and approved/implemented changes as appropriate.
- Conduct abnormal/erroneous condition testing as appropriate.
- Maintain a process for determining the level of test for safety critical GDS components. The developer shall develop test procedures to ensure that all safety critical GDS components are tested at and beyond the systems limits, with abnormal/erroneous conditions, as well as all transition points (e.g., mode to mode). The developer shall execute these test procedures for all safety critical GDS components.
- Conduct reviews and appropriate tests at the end of each phase of the development process to ensure that the requirements have been correctly implemented into design, code, documentation and data.
- Conduct pre-test briefings and generate briefing messages where appropriate to facilitate the coordination of various test related activities. Briefing message contents may include but are not limited to:
    - Test Case/Procedure Name/Number
    - Purpose of the Test
    - Testing Dates/Times
    - Test Participants and required resources (scheduling of lab and station support, data sources (e.g. s/c, s/c data tape, engineering test unit or s/c simulator), software, hardware and support system configurations (to include release/version numbers where appropriate).
    - GDS requirements to be verified.
    - Contact list to include names and numbers of test participants
- Conduct post-pass and post-test debriefings. During these debriefs, the developer shall summarize test results, disposition the test (pass/fail, etc), deviations from test procedures, requirements verified and discrepancy reports generated, etc.
- Conduct mission simulations to validate nominal and contingency mission operating procedures and to provide for operator familiarization training. In order to provide ample time for checkout of operational configurations, it is considered essential that users participate in mission simulations.
- Conduct reviews and appropriate tests at the end of each phase of the development process to ensure that the requirements have been correctly implemented into design, code, documentation and data.

6.5.6 Operations and Maintenance Phase

Specific assurance-related that the developer shall perform during the operations and maintenance phase include but are not limited to the following (note: some of these activities may be performed prior to this phase as applicable):

- Generate and deliver to GSFC formal acceptance data delivery packages identifying the contents of the delivery and any associated metadata/artifacts describing the delivery and its contents.

For those GDS instances where hardware is delivered, contents of the data delivery package shall include but is not limited to the following information:

a. As-Built configuration list.

b. List of parts used.

c. List of materials and processes used.

d. Test logbook including total operating time and cycle records.

e. List of open items (i.e., nonconformances, etc) with reasons for items being open and appropriate authorization/approvals/waivers.

f. Listing and status of all identified Limited-Life items.

g. Trend data.

h. Test results and verification success criteria.

i. Known problems and workarounds.

- For those GDS instances where software is delivered, contents of the data delivery package shall include but is not limited to the following information:

a. Software Delivery Letter.

- Description of delivery contents
- Build instructions.
- Special operating instructions.
- List of resolved anomaly reports and change requests.
- List of unresolved anomaly reports and change requests.
- Copy of resolved anomaly reports and change requests.
- Copy of unresolved anomaly reports and change requests.
- Matrix of requirements addressed by this release, including waivers for those requirements not met as appropriate.
- Release history summary matrix.
- Inventory of the delivered media.
- List of changes to documentation associated with this release.
- Verification success criteria
- Known problems and workarounds.

b. Software Delivery Media.

c. Accompanying Documentation

6.5.7 Activities Performed throughout the Lifecycle

6.5.7.1 Planning, Tracking and Oversight

- The developer shall define and document a Management Program to include planning, tracking and oversight activities for the project/program in a development plan, see DID 5-1 for guidance.
- The developer shall ensure that periodic and appropriate coordination among developers, acquisition organizations, users, maintainers, testers, QA and customers, regarding user needs, acquisition organization resources, technology status, and GDS requirements occurs throughout the development lifecycle.
- The developer shall ensure and maintain a system engineering process (as appropriate) that emphasizes an integrated product development approach. This approach shall define systems engineering interfaces with other engineering interfaces and disciplines with the development activities, as well as the interfaces between the system and subsystem developers and/or subcontractors/COTS vendors. The developer shall ensure and maintain a process to manage, provide an escalation path for, and resolve conflicts regarding intergroup issues, including system-level issues that arise internally or with subcontractors/COTS vendors. The developer shall identify and track critical dependencies between development groups participating in development activities.
- The developer shall utilize support tools that are compatible with other tools used by other project members to facilitate the communication, exchange and sharing of data.
- The developer shall identify and select metrics to be collected and analyzed on a routine basis to ensure development and management activities are proceeding per customer requirements. Metrics shall be based upon the program's defined system engineering process.
- The developer shall define the specific measurement data to be collected, their precise definitions, the intended use and analysis of each measurement and the process control points at which they will be collected and reported.
- The developer shall identify and maintain requirements for metrics, define variance thresholds, which when exceeded require corrective actions.
- The developer shall ensure that the measurement program is integrated with the program's development process across the lifecycle and any teaming/subcontracting arrangements.
- The developer shall maintain a quality plan that serves as the basis for the project's activities for quality management. The quality goals for the GDS and its associated components shall be defined, monitored, and revised throughout the lifecycle. Quality goals shall be allocated appropriately to the subcontractors delivering products and/or GDS components to the project whenever applicable.
- The project's quality plan shall contain provisions to ensure that quality is built into the GDS and its associated components. The plan shall identify points in the lifecycle process where quality is measured. The plan shall identify methods for analyzing quality measurements, for evaluating whether they meet customer's needs, and for determining the necessary corrective actions.
- The developer shall maintain/possess a QA organization/entity that is assigned the responsibility to monitor the development process, and the associated components/products. QA shall interface with all relevant disciplines participating in the lifecycle activities including engineering, configuration management and testing. The QA group is empowered to effect changes to the program when quality goals are not being met.
- The developer shall follow a written QA plan for measuring and monitoring the performance of the program's defined management and development processes. The developer shall verify adherence to the defined development and management processes. The developer shall perform audits on designated work products to verify compliance with quality goals, and adherence to the applicable standards and requirements.

6.6 GFE, COTS, EXISTING AND PURCHASED SOFTWARE

- If the developer will be provided software as GFE, or will use existing or purchased software and/or COTS products, the developer is responsible for these components meeting all functional, performance and interface requirements.
- The developer shall be responsible for ensuring that these components meet all applicable standards, including those for design, code and documentation, or for securing a GSFC project waiver to those standards.
- The developer shall be required to submit documentation providing indication of suitability for use and compliance to all applicable requirements and standards.
- Any significant modification to these components shall be subject to all of the provisions of the developer's QMS and the provisions of this document. Significant modification will be defined by the project and its CCB procedures and will be subject to GSFC review.

6.6.1 COTS Management

- The developer shall identify and maintain traceability of GDS requirements satisfied by COTS products/components.
- The developer shall conduct trade studies to identify potential COTS products that may meet GDS requirements.
- The developer shall identify and maintain criteria for COTS selection.
- The developer shall document the rationale/justification for the selection of all COTS components contained within the GDS.
- The developer shall maintain a CM program for all COTS products/components of the GDS.
- The developer shall maintain a COTS management plan for all COTS products/components of the GDS.
- The COTS management plan shall include and address the adequacy of existing COTS products/components in meeting or exceeding GDS requirements, processes utilized to ensure COTS updates/upgrades are routinely assessed and implemented based upon a documented criteria, etc.
- The developer shall demonstrate and document the fulfillment of GDS requirements by COTS products/components via the RVM.

6.7 REUSE REQUIREMENTS

Note: for some GDS development efforts, the use of reusable components may be desired to contain/save costs, leverage existing technologies/components/products, etc.

- The developer shall maximize future reuse potential of new developed system and software components within the constraints of the system cost, schedule and performance baselines.
- The developer shall identify, assess and document lifecycle impact of reuse-related decisions, including the choice of computer languages, processors, architectures, environments, the development of reusable assets and the maintenance of re-use repositories.

6.8 DEFECT PREVENTION REQUIREMENTS

- The developer shall develop and maintain a program/plan for defect prevention activities.

- The developer's program/plan shall at a minimum, include identification of defect causes and assessments for potential process improvement opportunities. The developer shall conduct causal analysis meetings as appropriate. Data on defects as identified in peer reviews, document reviews and testing shall be collected and analyzed by the developer. The developer shall identify, prioritize and systematically eliminate common causes of defects based upon their defect prevention program/plan.
- The developer shall revise development and management processes as a result of defect prevention actions as applicable.
- The developer shall document and track defect prevention data across entities coordinating defect prevention activities. The developer shall provide feedback on the status and results of the organization and program's defect prevention activities to project personnel on a periodic basis.

6.9 DATABASES

- The developer shall maintain a process and procedures for database development. The process shall include activities such as internal reviews, walkthroughs, statusing, test and discrepancy resolution.
- The developer shall ensure that the database development processes and procedures are compatible with the selected database methodology.
- The developer shall utilize a process for the verification and validation of the database system.
- The developer shall ensure that system/software releases and database releases are configured with one another.
- The developer shall test the interface between the software and Database Management System (DBMS) tested.
- The developer shall implement CM on the database system to ensure that the database release version is defined and documented, controlled and that the integrity of the data contained within is controlled.
- The developer shall ensure that appropriate security measures are implemented on the database system and on the data contained within the database system.

6.10 SECURITY ASSURANCE

- The developer shall conduct a security program to identify and mitigate security risks associated with the GDS and its components. All security risks shall be assessed/analyzed for impact and likelihood of occurrence.
- The security program shall ensure that security requirements are established, documented and implemented during all phases of the software lifecycle. Security tasks and activities shall include the addressing of security concerns during reviews, analyses, inspections, testing and audits.
- The developer shall identify and characterize system security vulnerabilities to include analyzing GDS assets/components, defining specific vulnerabilities, and providing an assessment of the overall system vulnerability.
- The developer shall identify and report upon all breaches of, attempted breaches of, or mistakes that could potentially lead to a breach of security.
- The developer shall ensure that solutions are verified and validated with respect to security.
- The developer shall be compliant with all NASA security related policies, procedures, standards and guidelines as appropriate.

6.11 ELECTROMAGNETIC COMPATIBILITY CONTROL

For GDS components subject to electromagnetic compatibility problems, the developer shall submit an Electromagnetic Compatibility Control (EMC) test plan in accordance with the contract schedule that identifies an overall implementation of an effective EMC test program. The test plan shall include test requirements that will assure compatibility within each element, within the project as a whole, and within the project's facilities. It shall describe any special testing requirements and the content of EMC sections of applicable Interface Control Documents (ICDs). The EMC test plan and the activities described within it shall comply with the requirements found in MIL-STD-461, "Electromagnetic Emission and Susceptibility Requirement for Control of Electromagnetic Interference", as applicable.

6.12 RELIABILITY AND AVAILABILITY

Note: the requirements below, along with those in Chapter 4, should be used as inputs to develop estimated spare parts requirements and related parameters, including maintenance manpower requirements, preventive maintenance policy, facility requirements and level or repair analysis.

Reliability and availability assurance requirements for the GDS and associated components shall include the following:

- The developer shall define, measure, control and report on reliability in all lifecycle phases as appropriate. The developer shall implement corrective actions whenever reliability related requirements are not being satisfied.
- The developer shall allocate basic reliability and mission reliability requirements to the GDS architecture component level (at which failures are postulated), necessary to identify redundancy. The developer shall ensure that reliability requirements are used to establish baseline requirements against which the design alternatives are evaluated. Requirements consistent with the allocations shall be imposed on any subcontractors, suppliers and/or COTS vendors whenever appropriate.
- The developer shall assure that equipment and components obtained from subcontractors, suppliers and/or COTS vendors meet allocated requirements and if not, such deficiencies shall be report to GSFC.
- The developer shall develop reliability predictions for the GDS and its components. These models and predications shall reflect applicable experience from previous projects and/or similar GDS components and shall be revised/maintained throughout the lifecycle as pertinent data becomes available. These models shall be documented, accessible for GSFC review and used continually throughout the design process. These reliability models shall be used to augment system engineering tradeoff studies. Appropriate prediction techniques are described in Chapter 4.
- The developer shall develop and document analyses to determine possible modes of failure and their effects on the GDS and its components. Appropriate analysis techniques are described in Chapter 4.
- The developer shall perform reliability evaluation on the GDS and its components via the collection of failure and time data throughout the lifecycle. Appropriate evaluation techniques are described in Chapter 4.

6.12.1 Reliability Acceptance Testing

The GDS and/or its components shall be subjected to a failure free acceptance test by government personnel and its representatives, as required. The length of the test will be as specified in the contract; for example, in the range from 300 to 1,000 hours. The developer shall provide the resources to create the test software, hardware and test data; as well as support testing operations, analyze results and make corrections as required.

The general guidelines to be followed include the following:

a. The developer shall certify in writing that the system is installed and ready to use, and shall provide documentation of a successful system checkout performed which demonstrates that the system, including hardware and software components, is in an acceptable operating condition. The system will then be turned over for testing by an Acceptance Test team.

b. If the equipment operates failure free in accordance with the specification during the specified performance period the equipment shall be deemed to have met the standard of performance.

c. If a failure occurs, the test shall be terminated and the developer shall be responsible for determining the cause of the failure. The equipment shall then be returned to working condition and resubmitted for test.

d. If the equipment fails to meet the standard of performance after the specified number of attempts, because of recurring failures, the Technical Officer may, at his option, notify the Contracting Officer to require a replacement of said equipment or to terminate the contract in accordance with the provisions of the default clause of this contract.

e. Operational use time for equipment is defined as the accumulated time during which the unit(s) is (are) in actual operation, including any interval of time between the start and stop of the central processing unit(s).

f. In addition to any diagnostic programs provided by the developer, the government may use additional test programs developed by the team with technical assistance from the developer, as required.

The developer shall provide test procedures and test reports in accordance with the contract schedule. The test procedures shall make full use of benchmark and standard system diagnostics to verify compliance to performance requirements including interfaces. Documentation on how to run the test(s) and interpret the results will be specified in the procedures.

6.13 MAINTAINABILITY REQUIREMENTS

Note: maintainability engineering includes a process for establishing design requirements and a number of engineering tasks that rate a part of the systems engineering process. These tasks focus primarily on the form, fit and function of the design that will allow for practical and economical maintenance within established project constraints. The requirements below, along with those in Chapter 4, should be used as inputs to develop estimated spare parts requirements and related parameters, including maintenance manpower requirements, preventive maintenance policy, facility requirements and level of repair analysis.

Maintainability assurance requirements for the GDS and associated components shall include the following:

- The developer shall define and evaluate the effort, cost and equipment required to support/maintain the GDS and its components.
- The developer shall define, measure, control and report on maintainability in all lifecycle phases as appropriate. The developer shall implement corrective actions whenever maintainability related requirements are not being satisfied.
- The developer shall allocate maintainability requirements to the GDS architecture component level as appropriate. The developer shall ensure that maintainability requirements are used to establish baseline requirements against which the design alternatives are evaluated. Requirements consistent with the allocations shall be imposed on any subcontractors, suppliers and/or COTS vendors whenever appropriate.
- The developer shall assure that equipment and components obtained from subcontractors, suppliers and/or COTS vendors meet allocated requirements and if not, such deficiencies shall be report to GSFC.
- The developer shall develop maintainability predictions for the GDS and its components. These models and predications shall reflect applicable experience from previous projects and/or similar GDS components and

shall be revised/maintained throughout the lifecycle as pertinent data becomes available. These models shall be documented, accessible for GSFC review, and used continually throughout the design process. These maintainability models shall be used to augment system engineering tradeoff studies. Appropriate prediction techniques are described in Chapter 4.

- The developer shall perform maintainability evaluation/demonstration tests on the GDS and its components to verify that all preventive and corrective maintenance activities, such as system and data level backups, can be successfully executed. Maintainability demonstration shall be conducted in the operational environment as available, or an environment that duplicates the operational environment as closely as possible. To the maximum extent possible, operators, technicians, system and/or database administrators of the system shall perform the maintenance actions during the maintainability demonstration.

6.14 SYSTEM SAFETY

Note: the objective of the safety program is to verify that the operation of the GDS and its components will not endanger life, property and/or adversely affect the operation of other GDSs or supported flight platforms. System safety is defined as the application of engineering and management principles, criteria and techniques to optimize safety within the constraints of operational effectiveness, time and cost throughout all phases of the system lifecycle. Refer to Chapter 3 for additional information pertaining to system safety.

- The developer shall initiate a safety program to identify and mitigate safety critical GDS components. If any GDS component(s) are identified as safety critical, the developer shall conduct a safety program on those components in compliance with NPG 8715.3, "NASA Safety Manual".
- For GDS components that are software and deemed as safety critical, the safety program shall be implemented in accordance with NASA-STD-8719.13 "NASA Software Safety Standard". *See sections 3.11 and 5.2.2 of this document for software safety related items.*
- The developer shall establish and identify procedures and instructions, which will be used to execute all system safety analyses. The developer shall perform system safety analyses assuring that:
  a. Safety is designed into the product; known hazardous conditions that cannot be eliminated through equipment design or operational procedures are controlled or reduced to an acceptable level. Residual hazards shall be tracked with their severity status and provided to NASA on a periodic basis.
  b. Results of previous trade studies and analyses are considered.
  c. Other related analyses, such as Failure Modes and Effects and Criticality Analysis (FMECA), are considered to preclude duplication of analytical work.
- All safety-related analyses, studies and assessments shall be accessible for GSFC review.

Chapter 7. Risk Management Requirements

This chapter provides recommended Continuous Risk Management (CRM) requirements. These standards may be tailored to meet the needs of the project.

7.1 GENERAL

Risk Management is a requirement established by the NPG 7120.5, "NASA Program and Project Management Processes and Requirements".

The developer shall implement a CRMS that provides for the identification, analysis, tracking, communication, resolution, mitigation and retirement of mission risks. Risk management applies to all software and hardware products, GDS components and processes (flight and ground).

The developer shall:

a. Search for, locate, identify and document reliability and quality risks before they become problems.

b. Evaluate, classify and prioritize all identified reliability and quality risks.

c. Develop and implement risk mitigation strategies, actions and tasks and assign appropriate resources.

d. Track risk being mitigated; capture risk attributes and mitigation information by collecting data; establish performance metrics; and examine trends, deviations and anomalies.

e. Control risks by performing risk close-out, re-planning, contingency planning, or continued tracking and execution of the current plan.

f. Communicate and document (via the risk recording, reporting, and monitoring system) risk information to ensure it is conveyed between all levels of the project.

g. Report on outstanding risk items at all management and design reviews. The GSFC Project Office, the GSFC Systems Review Office (SRO) (for design reviews only), and the developer will agree on what level of detail is appropriate for each review.

7.2 RISK MANAGEMENT PLAN

The developer shall develop a Risk Management Plan, see DID 7-1. The plan shall include risks associated with hardware (technical challenges, new technology qualification, etc), software, COTS, system safety, performance and programmatic risks (cost and schedule). The plan shall identify which tools and techniques will be used to manage the risks. The risk areas that are identified shall be addressed at the peer reviews and at independent and Code 300 reviews. The developer's surveillance plan (see section 1.9) shall address the risk areas to ensure adequate mitigation steps are in place.

All identified reliability and quality risks shall be documented and reported on in accordance with the Project's Risk Management Plan. Risk status shall be available to the Project for review. The status of risks shall also be provided in technical review reports. Although not all risks will be fully mitigated, all risks shall be addressed with mitigation and acceptance strategies agreed upon at appropriate mission reviews.

Note: the GSFC OSSMA has developed training and processes to aid GSFC and NASA missions in implementing an effective Risk Management Program. This training and assistance is available upon request from the GSFC Project Manager.

7.3 PROBABILISTIC RISK ASSESSMENT

The developer shall perform a PRA and provide all requested/required information to GSFC for review, see DID 4-2. The developer shall perform a Fault Tree Analysis and provide all requested/required information to GSFC for review, see DID 4-4. The information required will include parts lists and schematics. Additionally, the developer and their collaborators will cooperate with the Government as required to prepare these documents.

7.4 RISK ASSESSMENT

The developer shall provide all requested/required information to GSFC so that the Government can perform an on-going risk assessment of the program including flight hardware and software. Additionally, the developer and their collaborators shall cooperate with the Government as required to prepare this assessment.

Chapter 8. Technical Review Requirements

The developer shall support a series of comprehensive system-level design reviews that are conducted by the GSFC SRO. The reviews cover all aspects of flight and ground hardware, software, and operations for which the developer has responsibility. In addition, each developer shall conduct a program of planned, scheduled and documented component and subsystem reviews of all aspects of his or her area of responsibility.

8.1 GENERAL

For each specified system-level review conducted by the GSFC SRO, the developer shall:

a. Develop and organize material for oral presentation to the GSFC review team. Copies of the presentation material will be available at each review.

b. Support splinter review meetings resulting from the major review.

c. Produce written responses to recommendations and action items resulting from the review.

d. Summarize, as appropriate, the results of the developer reviews at the component and subsystem level.

8.2 IMPLEMENTATION

8.2.1 Structure and Function of the System Review Program

8.2.1.1 The System Review Team (SRT)

The SRT shall include personnel experienced in subsystem design, systems engineering and integration, testing, and all other applicable disciplines. The SRO will chair or co-chair these reviews. The review chairperson, in concert with the Project Manager and/or Principal Investigator (PI) and other Directorates, appoints independent key technical experts as review team members. Personnel outside the Center may be invited as members or co-chairperson of the SRT if it is felt their expertise will enhance the SRT. The reviews shall be based upon an appropriate selection from the following system reviews:

a. System Requirement Review (SRR) - this review is keyed to the end of the definition study phase and shall evaluate the design approaches, hardware/software tradeoffs, software requirements and the operational concepts (see DID 8-1 for guidance).

b. Preliminary Design Review (PDR) - this review occurs early in the design phase but prior to manufacture of engineering hardware and the detail design of associated software (see DID 8-2 for guidance). Where applicable, it should include the results of test bedding, breadboard testing and software prototyping. It should also include the status of the progress in complying with the launch range safety requirements. At PDR the flight hardware developer should have identified and documented all of the hazards associated with the flight hardware. Reentry considerations shall also be reviewed at PDR.

c. Critical Design Review (CDR) - this review occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software (see DID 8-3 for guidance). It shall emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing. The developer is also required to present the status of the controls for the safety hazards presented in the PDR and the status of all presentations to the launch range. Reentry considerations shall also be reviewed at CDR.

d. Mission Operations Review (MOR) - this mission-oriented review shall normally take place prior to significant integration and test of the flight system and GDS (see DID 8-4 for guidance). Its purpose is to

review the status of the system components, including the GDS and its operational interface with the flight system. Discussions shall include mission integration, test planning and the status of preparations for flight operations.

e. Pre-Environmental Review (PER) - this review occurs prior to the start of environmental testing of the protoflight or flight system (see DID 8-5 for guidance). The primary purpose of this review is to establish the readiness of the system for test and evaluate the environmental test plans.

f. Pre-Shipment Review (PSR) - this review shall take place prior to shipment of the instrument for integration with the spacecraft and for shipment of the spacecraft to the launch range (see DID 8-6 for guidance). The PSR shall concentrate on system performance during qualification or acceptance testing. The flight hardware developer is also required to present the status of the tracking of the safety items listed in the validation tracking log, the status of deliverable documents to the launch range and the status of presentations and any subsequent launch range issues or approvals prior to sending flight hardware to the range.

g. Flight Operations Review (FOR) - while all of the previous reviews involve operations, this review shall emphasize the final orbital operation plans as well as the compatibility of the flight components with ground support equipment and ground network, including summary results of the network compatibility tests (see DID 8-7 for guidance).

h. Launch Readiness Review (LRR) - this review is to assess the overall readiness of the total system to support the flight objectives of the mission (see DID 8-8 for guidance). The LRR is usually held at the launch site 2 to 3 days prior to launch.

8.2.1.2 Instruments Review Requirements

The System Review Program (SRP) for each instrument shall consist of SRR, PDR, CDR, PER and PSR. Where applicable, the SRP for identical follow-on instruments shall generally consist of PER and PSR.

The GSFC policies and practices will not be imposed on instruments provided by other NASA Centers and/or the Jet Propulsion Laboratory (JPL) which are not in-line with mission success, however, Goddard Program Management Council governs overall activities. The other NASA Centers and/or JPL will have the sole responsibility for instrument(s) performance and longevity. GSFC will only ensure system safety and that the system interfaces are such that an instrument failure will not adversely affect other elements of the spacecraft, GDS and/or Ground Support Equipment (GSE).

The review program for instruments provided by the other NASA Centers that are in-line with mission success shall be tailored as appropriate.

8.2.1.3 Spacecraft Review Requirements

The SRP for each spacecraft shall generally consist of SRR, PDR, CDR, MOR, PER, PSR, FOR and LRR. Instrument developer personnel shall attend and participate in these reviews to the extent required.

8.2.1.4 Ground Systems Review Requirements

The SRP for new, project unique GDSs shall consist of a PDR and CDR. The GDS is also a major subject of the mission-oriented reviews SRR, MOR, FOR, and LRR. Instrument developer personnel shall attend and participate in these reviews to the extent required.

8.3 DEVELOPER REVIEW REQUIREMENTS

The developer shall implement a program of peer reviews for missions at the component and subsystem level per Goddard Procedures and Guidelines (GPG) 8700.4 "Technical Review Program" and GPG 8700.6 "Engineering Peer Reviews".

Chapter 9. Design Verification Requirements

The design verification program, including environmental test, may be tailored to reflect system criticality, mission objectives, system characteristics, such as physical size and complexity, and the level of risk accepted by the project.

9.1 GENERAL

The developer shall conduct a verification program to ensure that the flight system meets the specified mission requirements. The program shall consist of functional demonstrations, analytical investigations, physical measurements and tests that simulate all expected environments. The developer shall provide adequate verification documentation including a verification plan and matrix, environmental test matrix and verification procedures.

The Verification Program begins with functional testing of assemblies. It continues through functional and environmental testing supported by appropriate analysis, at the unit/component, subsystem/instrument and spacecraft/payload levels of assembly. The program concludes with end-to-end testing of the entire operational system including the payload, the Payload Operations Control Center (POCC), and the appropriate GDS elements.

The GEVS-SE for STS & ELV Payloads, Subsystems, and Components shall be used as a baseline guide for developing the verification program. The GEVS-SE document is available at:

http://arioch.gsfc.nasa.gov/302/gevs-se/toc.htm. Alternative methods are acceptable provided that the net result demonstrates compliance with the intent of the requirements.

9.2 DOCUMENTATION REQUIREMENTS

The following documentation requirements shall be tailored to meet project needs, and shall be delivered and approved in accordance with the SOW.

9.2.1 System Performance Verification Plan

A System Performance Verification Plan, see DID 9-1, shall be prepared and define the tasks and methods required to determine the ability of the system to meet each project-level performance requirement (structural, thermal, optical, electrical, guidance/control, Radio Frequency (RF)/telemetry, science, mission operational, etc.) and to measure specification compliance. Limitations in the ability to verify any performance requirement shall be addressed, including the addition of supplemental tests and/or analyses that will be performed and a risk assessment of the inability to verify the requirement.

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

For each analysis activity, the plan shall include objectives, a description of the mathematical model, assumptions on which the models will be based, required output, criteria for assessing the acceptability of the results, the interaction with related test activity, if any, and requirements for reports. Analysis results shall take into account tolerance build-ups in the parameters being used.

The following documents may be included as part of the System Performance Verification Plan or as separate documents to meet project needs.

9.2.2 Environmental Verification Plan

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

The Environmental Verification Plan shall provide the overall approach to accomplishing the environmental verification program. For each test, it shall include the level of assembly, the configuration of the item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, necessary functional operations, personnel responsibilities and requirement for procedures and reports. It shall also define a rationale for retest determination that does not invalidate previous verification activities. When appropriate, the interaction of the test and analysis activity shall be described.

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

Because of the intended tailoring of the verification program, the preliminary plan shall provide sufficient verification philosophy and detail to allow assessment of the program. For example, for the environmental test portion of the verification, it is not sufficient to state that the GSFC GEVS requirements will be met. A program philosophy must be included. Examples of program philosophy are:

All components shall be subjected to random vibration.

Random vibration shall be performed at the subsystem or section level of assembly rather than at the component level.

All instruments shall be subjected to acoustics tests and 3-axis sine and random vibration.

All components shall be subjected to EMC tests.

All flight hardware shall see 8-thermal-vacuum cycles prior to integration on the spacecraft.

9.2.3 System Performance Verification Matrix

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

9.2.4 Environmental Test Matrix

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

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

9.2.5 Environmental Verification Specification

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

9.2.6 Performance Verification Procedures

For each verification test activity conducted at the component, subsystem, and payload levels (or other appropriate levels) of assembly, a verification procedure shall be prepared that describes the configuration of the test article, how each test activity contained in the verification plan and specification will be implemented, see DID 9-2 for guidance.

Test procedures shall contain details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, pass/fail criteria, quality control checkpoints, data collection, and reporting requirements. The procedures also shall address safety and contamination control provisions.

9.2.7 Verification Reports

After each component, subsystem, payload, etc. verification activity has been completed, a report shall be submitted in accordance with contract schedule, see DID 9-3 for guidance. For each analysis activity, the report shall describe the degree to which the objectives were accomplished, how well the mathematical model was validated by related test data, and other such significant results. In addition, as-run verification procedures and all test and analysis data shall be retained for review.

9.2.8 System Performance Verification Report

At the conclusion of the verification program, a final system Performance Verification Report shall be delivered comparing the hardware/software specifications with the final verified values (whether measured or computed). It is recommended that this report be subdivided by subsystem/instrument.

The System Performance Verification Report shall be developed and maintained "real-time" throughout the program summarizing the successful completion of verification activities, and showing that the applicable system performance specifications have been acceptably complied with prior to integration of hardware/software into the next higher level of assembly, see DID 9-3 for guidance.

CHAPTER 10. Workmanship Standards

This chapter recommends workmanship standards that provide process and acceptance requirements for the manufacture of reliable flight and ground support hardware. These standards may be tailored to meet the needs of the project.

10.1 GENERAL

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. See Chapter 13 for additional information on electrostatic discharge (ESD) control.

10.2 APPLICABLE DOCUMENTS

The current status and/or any application notes for these standards can be obtained at Uniform Resource Locator (URL): http://workmanship.nasa.gov/. The most current version of these standards shall be used for new procurements. However, if a specific revision is listed for a referenced standard, it is that revision only that is approved for use unless otherwise approved by project management.

- 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: Association Connecting Electronics Industries (IPC)/Electronics Industry Alliance (EIA) J-STD-001C, "Requirements for Soldered Electrical and Electronic Assemblies".
- Electronic Assemblies – Ground Systems: IPC-A-610, "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".
- ESD Control: ANSI/ESD S20.20, "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 Board Design".
  - IPC-2222, "Sectional Design Standard for Rigid Organic Printed Boards".
  - IPC-2223, "Sectional Design Standard for Flexible Printed Boards".
  - IPC D-275 "Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies".
- PWB 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: 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-6018 "Microwave End Product Board Inspection and Test."

10.3 DESIGN

10.3.1 Printed Wiring Boards

The PWB manufacturing and acceptance requirements identified in this chapter are based on using PWBs designed in accordance with the PWB design standards referenced above. Space flight PWB designs shall 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.).

10.3.2 Assemblies

The design considerations listed in the NASA workmanship and IPC standards listed above should be incorporated to the extent practical.

10.3.3 Ground Data Systems that Interface with Space Flight Hardware

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

10.4 WORKMANSHIP REQUIREMENTS

10.4.1 Training and Certification

All personnel working on GSFC hardware shall be certified as having completed the required training, appropriate to their involvement, as defined in the above standards or, when approved by project management, in the developer's quality manual. This includes, but is not limited to, the aforementioned workmanship and ESD standards. At a minimum, certification shall include successful completion of formal training in the appropriate discipline.

10.4.2 Flight and Harsh Environment Ground Systems Workmanship

10.4.2.1 Printed Wiring Boards

PWBs shall be manufactured in accordance with the Class 3 requirements in the above referenced IPC PWB manufacturing standards and GSFC/S312-P-003, "Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses". The developer shall provide PWB test coupons to the GSFC Materials Engineering Branch (MEB) or a GSFC/MEB approved laboratory for evaluation, see DID 10-1. Coupon acceptance shall be obtained prior to population of flight PWBs. Test coupons and test reports are not required for delivery to GSFC/MEB if the developer has the test coupons evaluated by a laboratory that has been approved by the GSFC/MEB, however, they shall be retained and included as part of the Project's documentation/data deliverables package.

10.4.2.2 Assemblies

Assemblies shall be fabricated 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.) and ANSI/ESD S20.20.

10.4.3 Ground Systems (non-flight) Workmanship

10.4.3.1 Printed Wiring Boards

PWBs shall be manufactured in accordance with the Class 2 requirements in the above referenced IPC PWB manufacturing standards.

10.4.3.2 Assemblies

Assemblies shall be fabricated using the Class 2 requirements of J-STD-001, IPC-A-610, and ANSI/ESD S20.20. If any conflicts between J-STD-001 and IPC-A-610 are encountered, the requirements in J-STD-001 shall take precedence.

10.4.4 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 by those standards.

Alternate standards may be proposed by the developer. Proposals shall be accompanied by objective data documenting that mission safety or reliability will not be compromised. Their use is limited to the specific project and allowed only after they have been reviewed and approved by program management.

10.5 NEW OR ADVANCED MATERIALS AND PACKAGING TECHNOLOGIES

New and/or existing advanced materials and packaging technologies (e.g., multi-chip modules (MCMs), stacked memories, chip on board (COB), ball grid array (BGA), etc.) shall be reviewed and approved by the Parts, Materials, and Processes Control Board (PMPCB).

10.6 HARDWARE HANDLING

The developer shall use proper safety, ESD control and, where appropriate, cleanroom practices when handling flight hardware. The electrostatic charge generation and contamination potential of materials, processes, and equipment (e.g., cleaning equipment, packaging materials, purging, tent enclosures, etc.) shall be addressed.

Chapter 11. Parts, Materials, and Processes Requirements

This chapter provides recommended Parts, Materials and Processes (PMP) requirements. These requirements may be tailored to meet the needs of the project.

11.1 GENERAL

The developer shall plan and implement a Parts, Materials, and Processes Control Program (PMPCP) to assure that all selected items for use in flight hardware meet mission objectives for quality and reliability. The developer shall prepare a PMPCP plan describing the approach and methodology for implementing a PMPCP, see DID 11-1.

Existing developer in-house documentation equivalent with DID 11-1 may be used and referenced in the plan as applicable to address how these requirements are to be met and shall be submitted to GSFC for approval. All appropriate sub-developers shall also participate in the parts, materials, and processes control program to the extent required by the prime developer and GSFC in order to meet these requirements. The plan shall address how the developer ensures the flow down of the applicable parts, materials, and processes control program requirements to the sub-developers. The PMPCP plan may be incorporated in the developer's Performance Assurance Implementation Plan.

The plan shall include:

a. Parts, Materials, & Processes Control Board (PMPCB) operating procedures, membership, responsibilities, authority, meeting schedules, PMP review procedures, PMP approval/disapproval procedures, GSFC involvement, and plans for updating the operating procedures; the definition of the role and authority of each PMPCB member; and relationships with various groups within the prime, associate, and sub-developer organizations (see section 11.2 for further information).

b. Shelf life control plan (see section 11.3.8 for further information).

c. Parts and materials application derating (see section 11.4.4 for further information).

d. PMP vendor surveillance and audit plan (see section 11.5.2 for further information).

e. PMP qualification plan that describes how new PMP should be qualified for the intended end item application (see section 11.9 for further information).

f. Incoming inspection and test plan (see section 11.4.6 for further information).

g. Destructive Physical Analysis (DPA) plan (see section 11.4.7.1 for further information).

h. Defective parts and materials controls program.

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

j. Radiation hardness assurance program plan as required (see section 11.6 for further information).

k. ESD control plan.

l. Corrosion prevention and control plan.

m. Contamination Prevention and Control Plan, as required.

n. Standardization of program PMP.

o. Alternate Quality Conformance Inspection (QCI) and small lot sample plans, as required (see section 11.4.8 for further information).

p. Traceability control plan.

q. PMPCB shall develop, update and maintain a Project Approved Parts List (PAPL).

11.2 PARTS, MATERIALS AND PROCESSES CONTROL BOARD

A PMPCB shall be responsible for the planning, management, and coordination of the selection, application, and procurement requirements of all parts, materials and processes intended for use in the deliverable end item(s). PMPCB findings, decisions, and directions shall be within the contractual requirements, and shall be binding on all applicable developers and sub-developers. The GSFC Parts Engineer (PE) and Materials Assurance Engineer (MAE) shall be permanent members of the PMPCB to ensure real-time approval/disapproval of PMPCB decisions and actions. If there are any parts or materials issues, which the developer and GSFC cannot resolve at the PMPCB level, then the GSFC PE or 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.

11.2.1 Chairmanship

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

11.2.2 Membership

The PMPCB 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 PMPCB. Other members may be designated by GSFC or the PMPCB 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 PMPCB decisions within the scope of the applicable contract. Representation at individual meetings shall be required, consistent with the scheduled subject matter on the agenda.

11.2.3 Delegation.

The authority to conduct PMPCB may be delegated by the prime developer PMPCB chairman to major developers/sub-developers. Each organization so delegated shall supply the responsible activity PMPCB 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 PMPCB decisions.

11.2.4 Meetings

The PMPCB shall conduct meetings as follows:

a. A post-award organizational PMPCB 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 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 PMPCB.

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

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

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

11.2.5 PMPCB Responsibilities

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

b. The PMPCB shall develop and maintain a Project Approved Parts, Materials and Processes List (PAPMPL). The PMPCB shall review and approve all PMPs.

c. The PMPCB shall define PMP selection and approval criteria and shall prepare and maintain supporting documents for PMP approval.

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

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

f. The PMPCB shall ensure the establishment of DPA policies, procedures and reporting formats. DPA problems and anomalies of concern shall be reviewed by the PMPCB.

g. The PMPCB shall ensure the review of the results of DPA, MRB actions, failure analyses, and any other details pertaining to PMP. All PMP problems shall require disposition by the PMPCB.

h. The PMPCB shall ensure the timely identification of long lead PMP items and other problem procurements.

i. The PMPCB shall ensure the identification and configuration control of any changes to PMPCB approved documentation.

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

k. The PMPCB shall ensure that all screening and testing of parts is conducted by acceptable laboratories with capable personnel, equipment and software.

l. The PMPCB 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.

11.2.6 PMPCB Authority

The PMPCB shall ensure that all PMP items approved for use meet mission reliability and performance requirements. All PMPCB decisions shall be documented in the meeting minutes. All supporting technical analysis shall be provided and any additional analysis and tests in accordance with PMPCB direction attached to the meeting minutes. The PMPCB shall have the authority to approve technical changes to the detail PMP 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.

11.3 MANAGEMENT OF PMP SELECTION

The developer shall manage the PMP in accordance with criteria specified herein. PMP shall be selected to assure that mission reliability and performance requirements are met. The developer shall develop a Parts, Materials, and Process List and/or an As-designed Parts, Materials, and Processes List (ADPMPL), see DID 11-2, to start the PMPCB activity. The list shall be submitted to the PMPCB, ten days prior to the meeting. All non-compliant materials and processes shall be documented on a Material Usage Agreement (MUA), see DID 11-3. All approved PMP by PMPCB shall be added to the Project Approved PMP list within 10 days of approval, and shall be the only source for procurement.

11.3.1 EEE Parts

11.3.1.1 EEE Parts Selection

Parts selection shall be guided by the NASA Parts Selection List (NPSL) and GSFC 311-INST-001, "Instructions for EEE Parts Selection, Screening, and Qualification", both of which provide for 3 part levels as described below. The NPSL is available at the following URL: http://nepp.nasa.gov/npsl.

- Level 1 parts are inherently low risk and are suitable for use in all applications including life support, mission critical, single-string and single-point failure. Level 1 active parts should be reviewed for radiation hardness.
- Level 2 parts have inherently higher risk than level 1 and are considered moderate risk. Level 2 parts are suitable for most general purpose space flight applications but are not recommended for life support, mission critical, single-string or single-point failure applications unless there is on-orbit reparability. Level 2 active parts need to be evaluated for radiation hardness.
- Level 3 parts are inherently high risk because there is little dependable data or history available for them and changes in their materials, designs and processes may occur continuously without notification. Level 3 parts are intended for mission applications where the use of high-risk parts is acceptable. Level 3 parts should not be used in single-point failure or single-string applications unless a very high risk for failure or malfunction is acceptable. Level 3 parts shall be evaluated for radiation hardness, radiation testing is recommended.

The inherent risk of the parts selected shall be mitigated to meet application needs by qualification and upscreening, in accordance with GSFC 311-INST-001, "Instructions for EEE Parts Selection, Screening, and Qualification". Further mitigation strategies may be recommended by the PMPCB. The project manager shall approve the quality level selected for the application.

A procurement document may be required for parts based on PMPCB recommendation. The procurement document shall fully identify the item being procured and shall include physical, mechanical, electrical, and environments and quality assurance provisions necessary to control manufacture and acceptance in accordance with GSFC 311-INST-001, "Instructions for EEE Parts Selection, Screening, and Qualification". When parts are procured to acceptable manufacturer's in-house specifications, the attribute screening data package for the lot shall also be procured. The manufacturer shall notify GSFC of any changes to a procured part's specification or design.

The use of Plastic Encapsulated Microcircuits (PEMs) is permitted on NASA GSFC spaceflight applications, provided each use is thoroughly evaluated for thermal, mechanical, and radiation implications of the specific application and found to meet mission requirements. PEMs shall be selected for their functional advantage and availability, not for cost saving; the steps necessary to ensure reliability usually negate any initial apparent cost advantage. A PEM shall not be substituted for a form, fit and functional equivalent, high reliability, hermetic device in spaceflight applications. All PEMs shall be approved by PMPCB and shall be processed in accordance with 311-INST-001 PEM supplement dated August 2002.

11.3.1.2 Project Approved Parts List

PMPCB chair is responsible to develop, maintain, and update the PAPL and will distribute to the members within 15 working days to the PMPCB members for review. PMPCB chair shall assure that only approved parts are procured and any additional testing requirements are properly implemented. Developer shall coordinate all sub-contractor PAPL and submit to GSFC within 15 days after PMPCB meetings.

11.3.2 Materials Selection

In order to anticipate and minimize materials problems during space hardware development and operation, when selecting materials and lubricants, the developer shall consider potential problem areas such as radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, toxic offgassing, flammability and fracture toughness, as well as the properties required by each material usage or application. In cases where it is determine that a PMPCB is not required, the GSFC MAE shall assume the role of the PMPCB.

11.3.3 Compliant Materials

The developer shall use compliant materials in the fabrication hardware to the extent practicable. In order to be compliant, a material must be used in a conventional application and meet the applicable selection criteria identified in Table 11-1. A compliant material does not require an MUA.

Table 11-1: MATERIAL SELECTION CRITERIA

Type Launch	Payload Location	Flammability and Toxic Offgassing	Vacuum Outgassing	Stress Corrosion Cracking (SCC)
STS	Orbiter Crew Compartment	Note 1	No Requirement	Note 5
STS	Cargo Bay	Note 2	Note 4	Note 5
ELV	All	Note 3	Note 4	Note 5

NOTES:

1. Flammability and toxic offgassing requirements as defined in NASA-STD-6001.
2. Flammability and toxic offgassing requirements specified in NSTS 1700.7, Paragraph 209.
3. Hazardous materials requirements, including flammability, toxicity and compatibility as specified in EWR 127-1 Range Safety Requirements, section 3.4.1.2.
4. Vacuum Outgassing requirements as defined in paragraph 11.3.7.
5. Stress corrosion cracking requirements as defined in Marshall Space Flight Center (MSFC)-SPEC-522.

11.3.4 Non-compliant Materials

A material that does not meet the requirements of the applicable selection criteria of Table 11-1, or meet the requirements of Table 11-1, but is used in an unconventional application, will be considered to be a non-compliant material. The proposed use of a non-compliant material requires that a MUA and/or a Stress Corrosion Evaluation Form (see DID 11-4) or developer's equivalent forms (Figures 11-1 and 11-2) be submitted to the PMPCB for approval in accordance with the SOW.

11.3.5 Polymeric Materials

The developer shall prepare and submit a polymeric materials and composites usage list, see DID 11-5, or the developer's equivalent (Figure 11-3). The list shall be submitted to the PMPCB for review and approval.

11.3.6 Flammability and Toxic Offgassing

Material flammability and toxic offgassing shall be determined in accordance with the test methods described in NASA-STD-6001, see DID 11-6 and DID 11-7. STS payload materials which will be located in the orbiter crew cabin shall meet the requirements of NASA-STD-6001, see DID 11-6. Materials for payload elements located in the orbiter cargo bay shall meet the requirements of NHB 1700.7, Paragraph 209. ELV payload materials shall meet the requirements of EWR 127-1 Range Safety Requirements.

11.3.7 Vacuum Outgassing

Material vacuum outgassing shall be determined in accordance with American Society for Testing of Materials (ASTM) E-595. In general, 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.

11.3.8 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, lubricated bearings and paints shall be included. The use of materials whose date code has expired 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 the PMPCB. This shall be accomplished by means of a waiver, see DID 11-8. When a limited-life piece part is installed in a subassembly, its usage shall be approved by the PMPCB. This shall be accomplished by including the subassembly item in the Limited-Life Plan.

11.3.9 Inorganic Materials

The developer shall prepare and document an inorganic materials and composites usage list (Figure 11-4) or the developer's equivalent (DID 11-9). The list shall be submitted to the PMPCB for review and approval. 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 criteria. An MUA shall be submitted for each material usage that does not comply with the MSFC-STD-3029 requirements. Additionally, for the PMPCB to approve usage of individual materials, a stress corrosion evaluation form or an equivalent developer form or any/all of the information contained in the stress corrosion evaluation form may be required from the developer. Nondestructive evaluation requirements are contained in the STS fracture control requirements.

The use of tin, zinc, and cadmium platings in any flight application requires an MUA prior to use of that material. Bright tin, cadmium, and zinc platings have the potential for developing whisker growths. For tin, these have been measured up to 12.5 microns in diameter and up to 10 mm in length. These whiskers can result in short circuits, plasma arcing, and debris generation within the spacecraft. Zinc and cadmium platings also evaporate in vacuum environments and may redeposit on optics or electronics, posing potential risks to flight hardware.

11.3.10 Fasteners

As part of the parts and materials list approval process, the PMPCB will approve all flight fasteners. Towards this end, the developer shall provide all information required by the PMPCB to ensure its ability to concur with the flightworthiness of flight 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, GSFC Fastener Integrity Requirements. The developer shall prepare a Fastener Control Plan, see DID 11-10, for submission to the PMPCB. Material test reports for fastener lots shall be submitted to the PMPCB 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.

11.3.11 Lubrication

The developer shall prepare and document a lubrication usage list (Figure 11-5) or the developer's equivalent (DID 11-11). The list shall be submitted to the PMPCB for review and approval. The developer may be requested to submit supporting applications 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. All lubricated mechanisms shall be qualified by life testing in accordance with the life test plan or heritage of an identical mechanism used in identical applications, see DID 11-12 Life Test Plan for Lubricated Mechanisms.

11.3.12 Process Selection

The developer shall prepare and document a material process utilization list (DID 11-13) or the developer's equivalent (Figure 11-6). The list shall be submitted to the PMPCB for review and approval. A copy of any process shall be submitted for review upon request. Manufacturing processes (e.g., lubrication, heat treatment, welding and chemical or metallic coatings) shall be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

11.4 MANAGEMENT OF PMP ENGINEERING REQUIREMENTS

11.4.1 System Design.

The PMPCB is responsible for ensuring that PMP used throughout the system meets the application, reliability, quality, and survivability requirements, as derived from the system level requirements. PMP engineering shall review and approve all drawings and specifications (A level, B level, device detail specifications, etc.) to ensure that PMP requirements are met. All PMP shall be selected to meet their intended application in the predicted mission radiation environment.

11.4.2 Custom Devices

Custom microcircuits, such as Application Specific Integrated Circuits (ASICs), hybrid microcircuits, MCMs etc., planned for use by the developer shall be subjected to a design review. The review may be conducted as part of the PMPCB activity. The design review shall address, at a minimum, derating of elements, method used to assure each

element reliability, assembly process and materials, and method for assuring adequate thermal analysis to meet application requirements.

11.4.3 Reuse of Parts and Materials

Parts and materials which have been installed in an assembly, and are then removed from the assembly for any reason, shall not be used again in any item of flight or spare hardware without prior approval of the PMPCB based on the submission of evidence that this practice does not degrade the system performance.

11.4.4 Derating

A uniform derating policy to meet the system requirements shall be established by the PMPCB in accordance with the derating guidelines of the NASA Parts Selection List and used by all developers in the program. The NASA Parts Selection List is available at the following URL: http://nepp.nasa.gov/npsl.

Exceptions to this derating policy shall require the approval of the PMPCB. The derating policy shall address degradation sensitive parameters and maximum rated variations expected over the program mission life including storage environments and radiation effects.

The developer's derating guidelines may be used when approved by the PMPCB. The developer shall maintain documentation on parts derating analysis and shall be available for PMPCB review.

11.4.5 Traceability and Lot Control.

The developer shall develop and maintain a traceability and lot control plan in accordance with the requirements specified below and approved by the PMPCB. When given a lot date code or batch number, the developer shall be capable of determining the unique piece of equipment (black box level) by serial number in which the part or material is installed or used. Traceability to the serial number of an individual device or to a lower level of assembly shall be as determined and specified by the PMPCB. Traceability shall be maintained for all flight printed circuit boards (PCBs) so that part number, serial number, and lot date code information is known for all PCBs; in addition, any vendor identification necessary to trace the PCBs to their representative coupons shall be maintained and provided as needed.

11.4.5.1 Electronic Parts

All EEE parts and cable assemblies shall have one hundred percent (100%) lot traceability to the production lot. Any other parts not included in the above that require traceability shall be identified in the traceability lot control plan. Identification and serialization data for EEE parts shall be maintained in the manufacturing and processing records and shall contain lot date code, lot and purchase order numbers, and manufacturer of the part. The developer shall ensure that markings for small chip devices (usually printed on the parts' packaging) are recorded in the manufacturing and processing records prior to use.

11.4.5.2 Mechanical Parts and Materials

One hundred percent (100%) lot traceability is required for parts and materials used in applications where a failure could jeopardize component or mission success. Traceability and production or batch lot control for parts and materials used in other applications shall be maintained where risk and cost so dictate.

11.4.5.3 Raw Materials

Raw materials purchased by the developer shall be accompanied by the results of non-destructive, chemical and physical tests, or Certificate of Compliance, see DID 11-14. These requirements also apply to any supplier used by the developer.

11.4.6 Incoming Inspection Requirements

Each developer shall perform, or be responsible for the performance of applicable incoming tests and inspections including DPA of parts and materials to ensure that they meet the requirements of the procurement specification. Unless previously accomplished and accepted by government or developer field personnel, incoming testing and inspections shall be accomplished upon receipt of the parts or materials. The inspection and testing of parts and materials shall be conducted in accordance with a plan approved by the PMPCB.

11.4.7 Electronic Parts

11.4.7.1 Destructive Physical Analysis

A sample of each lot date code of microcircuits, hybrids, semiconductors, relays and filters shall be subjected to a DPA. All other parts may require a sample DPA if it is deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concems. DPA tests, procedures, sample size and criteria shall be as specified in GSFC S-311-M-70, Destructive Physical Analysis. Developer's procedures for DPA may be used in place of GSFC S-311-M-70 and shall be submitted with the PMPCP for concurrence prior to use. The PMPCB on a case-by-case basis shall consider variation to the DPA sample size requirements, due to part complexity, availability or cost. Variations in sample sizes and the supporting justification shall be recorded in the PMPCB minutes.

11.4.7.2 Shelf-Life Control

The developer shall develop a shelf life control program that identifies the shelf life limitations for all parts and materials to be stored. This plan shall specify the length of time required and minimum requirements for re-inspection, retest, & any other action required to ensure maintenance of space flight quality and reliability. The plan shall be reviewed and approved by the PMPCB and controls shall be identified to ensure that the plan is followed before parts and materials are issued to assembly. Separate plans for material shelf life control and parts shelf life control are permissible.

11.4.7.2.1 Material Shelf Life Control

In addition to general age limitation considerations, the plan shall identify any specific temperature and humidity requirements for storage and any associated limitations on life. Any special environmental requirements (e.g., storage in dry nitrogen) shall be identified.

11.4.7.2.2 Parts Shelf Life Control

The shelf life control program shall identify those part types considered to be potentially age sensitive. The plan shall identify specific actions necessary in association with the potentially age sensitive parts. In general, the plan shall consider a pedigree review and actions similar to that shown below for all parts older than 5 years. The plan shall define the specific limit for each part based upon logistical considerations of parts procurement schedules, program manufacturing schedules, and required program life. When parts exceed specified age limits in storage,

actions shall be taken as specified in the control plan or the PMPCB shall provide direction based upon the following considerations:

a. Assess original part quality (e.g. mil specification quality levels V, Q or M for microcircuits, class K and H for hybrids, source control drawings (SCDs), etc.)

b. Assess lot history (suppliers percent defective, quantity used to date, number of failures, etc.).

c. Review of original screening/test data.

d. Review of problem/GIDEP Alerts.

e. Review of original DPA.

f. Review storage environment controls (temperature, ESD protection, handling, etc.).

g. When possible, consider application criticality, redundancy, etc.

h. Analyze construction details to identify age sensitive design characteristics

i. When retest/ re-screen appears warranted, assess availability of retest equipment, outside re-screen facilities, potential for part damage during re-screening, etc.

j. Program technical requirements for screening shall be used as guidance for any planned re-screening of product due to shelf life limitations.

k. Solderability of parts

11.4.8 Use of Alternate Quality Conformance Inspection and Small Lot Sampling Plans

The developer may implement an alternate QCI plan and a small lot sample plan for small lot quantities in accordance with the program's technical requirements. The PMPCB shall review and approve these plans. These plans may be used under the following conditions:

a. The product(s) being purchased is not listed in the program's space quality baseline.

b. Implementation criteria as defined in the program's technical requirements are satisfied.

11.5 MANAGEMENT OF PARTS, MATERIALS AND PROCESSES PROCUREMENT

11.5.1 Supplier and Vendor Selection and Surveillance

The PMPCB is responsible for the selection and qualification of PMP suppliers, vendors, laboratories and manufacturers.

11.5.2 PMP Supplier and Manufacturer Surveillance (Monitoring)

The PMPCB shall establish a policy and procedures for the periodic surveillance and auditing of suppliers, vendors, laboratories and manufacturers to ensure compliance to procurement, quality, reliability and survivability requirements. Developer surveillance of laboratories, suppliers, vendors, and manufacturers that have been approved as a part of Qualified Parts List (QPL) or Qualified Manufacturer's List (QML) program for products listed in the space quality baseline is not required. When surveillance/audit data is available from other sources (e.g. other developer programs, other developers/s sub-developers, independent audits reports, etc.) the developer may utilize the results of the data contingent on the review and approval by the PMPCB. Acceptability of the data shall be based on technical considerations, as well as timeliness and confidence in the source of the data.

11.5.3 Coordinated Procurements

Implementation of a coordinated procurement program is highly encouraged. When appropriate, the PMPCB shall establish policies for the use of coordinated procurements for all developers and sub-developers use. This may include the use of common specifications, management responsibilities, purchase agreements, monitoring, and quality assurance. The PMPCB (and procurement organizations) may ensure that a master purchase agreement allows authorized sub-developers to initiate their own procurements within the scope and framework of the master purchase agreement.

11.6 RADIATION HARDNESS ASSURANCE (RHA)

11.6.1 General

An appropriate radiation hardness assurance program shall be developed and conducted, through the PMPCB, based on program requirements. The program plan shall address all phases of the flight hardware program including the design, test, and production.

11.6.1.1 Specification of the Radiation Environment

The radiation environment for the mission of interest shall be specified using established codes and algorithms. This includes the trapped particle environment, galactic cosmic ray environment and solar particle event environment, and induced environments such as that caused by a radioisotope thermal generator (RTG).

11.6.1.2 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.

11.6.1.3 Evaluation of Radiation Effects in Microelectronic Devices and Integrated Circuits

The following potential failure modes of microelectronic components caused by radiation exposure during the mission shall be evaluated:

a. total ionizing dose effects, including enhanced low dose rate effects

b. single event effects, including single event upset, single event latch up and single event transients

c. displacement damage effects

d. other radiation effects determined to be relevant for the mission of interest

11.6.1.4 Qualification of Parts for Use

Parts shall be qualified for use in the mission if they have the same lot date code that has been used previously for similar applications in a radiation environment at least as severe as that of the mission under consideration. Alternatively, they shall be qualified if radiation testing shows that the effects specified in section 11.6.1.3 shall not compromise the mission.

11.7 GOVERNMENT FURNISHED EQUIPMENT

PMP contained in unmodified government furnished equipment used in the end item of the contract shall not be subject to PMP control.

11.8 COMMERCIAL OFF-THE-SHELF ITEM EQUIPMENT

The requesting user shall demonstrate to the PMPCB that the COTS items meet the quality, reliability, environmental and survivability (if required) requirements of the contract end item for the intended application.

11.9 PMP QUALIFICATION.

11.9.1 General

All PMP, including any processes developed to accomplish rework or retrofit, shall be qualified for program use. Only qualified PMP shall be used on flight hardware. For each non-qualified PMP, the developer(s) shall prepare a qualification plan and procedure. For electronic parts, the qualification plans and procedures shall be based on the application or program technical requirements. The qualification plan shall identify all conditions and testing necessary to meet the program and mission reliability and qualification requirements. These plans and procedures shall be reviewed and approved by the PMPCB. A summary report of qualification test results shall be submitted to the PMPCB. The PMPCB shall maintain an up-to-date listing of the qualification status of all program PMP. Test methods used for qualification of PMP shall be in accordance with applicable specifications and shall include test methods for any additional tests necessary to fully qualify the part for its intended use in the system.

Qualification of PMP shall be expedited by the following:

a. Initial selection of PMP using applicable military specified PMP previously qualified for use on space programs.

b. Proof testing of all parts and materials to the program requirement levels.

c. Vendor audits and certification.

11.9.2 Manufacturing Baseline

As part of the qualification plan for each non-qualified PMP item, the developer(s) shall insure that the non-qualified PMP item supplier has an established manufacturing baseline and review the manufacturing baseline for compliance to the program's technical requirements. The manufacturing baseline for all other PMP shall be reviewed and controlled.

11.9.3 Qualification by Extension

Parts, materials, or processes may be qualified by extension, when supporting data is available and shows that either of the following criteria are met:

a. The part, material, or process was successfully used in a prior but recent space application in which the application environment conditions of use and test were, at least, as severe as those required of the candidate PMP for qualification.

b. The part or material design and construction is the same as the previously qualified part or material. The part or material is manufactured by the same manufacturing facility to the same manufacturing baseline as the previously qualified part or material, and the utilization of the part or material does not result in critical stresses or mechanical strain (such as due to thermal mismatch) greater than the previously qualified part or material.

11.10 FAILURE ANALYSIS

Failure analysis shall be performed on part and material failures experienced during assembly and testing. Failures shall be analyzed to the extent necessary to understand the failure mode and cause, to detect and correct out-of-control processes, to determine the necessary corrective actions, and to determine lot disposition. When required, a failure analysis report shall be prepared and documented. The PMPCB shall determine and implement appropriate corrective action for each PMP failure. All failures, and the results of final failure analysis, shall be documented. Failure analysis reports shall be retrievable for the duration of the contract, and shall be available to GSFC.

11.11 PRESERVATION AND PACKAGING

Preservation, packaging, and packing shall be in accordance with the item and the system requirements. All parts that are subject to degradation by electrostatic discharge shall be packaged in accordance with the approved ESD procedures.

11.12 HANDLING

Handling (including storage) procedures shall be instituted to prevent part and material degradation. The handling procedures shall be retained through inspection, kitting, and assembly and shall be identified on "build to" documentation. The following criteria shall be used as a minimum for establishing handling and storage procedures for parts and materials:

a. Control of environment, such as temperature, humidity, contamination, and pressure.
b. Measures and facilities to segregate and protect parts and materials routed to different locations such as, to the materials review crib, or to a laboratory for inspection, or returned to the manufacturer from unaccepted shipments.
c. Easily identifiable containers to identify space quality parts shall be used.
d. Control measures to limit personnel access to parts and materials during receiving inspection and storage.
e. Facilities for interim storage of parts and materials.
f. Provisions for protective cushioning, as required, on storage area shelves, and in storage and transportation containers.
g. Protective features of transportation equipment design to prevent packages from being dropped or dislodged in transit
h. Protective bench surfaces on which parts and materials are handled during operations such as test, assembly, inspection, and organizing kits.
i. Required use of gloves, finger cots, tweezers, or other means when handling parts to protect the parts from contact by bare hands.
j. Provisions for protection of parts susceptible to damage by electrostatic discharge.
k. Unique parts and materials criteria.

11.13 DATA RETENTION

The program shall maintain records or incoming inspection tests, lot qualification and acceptance test data, radiation hardness assurance test data, traceability data and other data as determined by the PMPCB for a period of time specified by the GSFC.

FIGURE 11-1: MUA

MATERIAL USAGE AGREEMENT		USAGE AGREEMENT NO.:	PAGE OF
PROJECT:	SUBSYSTEM:	ORIGINATOR:	ORGANIZATION:

DETAIL DRAWING	NOMENCLATURE	USING ASSEMBLY	NOMENCLATURE

MATERIAL & SPECIFICATION	MANUFACTURER & TRADE NAME

USAGE	THICKNESS	WEIGHT	EXPOSED AREA	ENVIRONMENT		
				PRESSURE	TEMPERATURE	MEDIA

APPLICATION:
RATIONALE:

ORIGINATOR:	PROJECT MANAGER:	DATE:

FIGURE 11-2: 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: _____

GSFC 18-59A 3/78 **FIGURE 11-3: POLYMERIC MATERIALS AND COMPOSITES USAGE LIST**

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 that 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.

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FIGURE 11-4: INORGANIC 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 11-5: LUBRICATION 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($1\text{-}10^2$), B($10^2\text{-}10^4$), C($10^4\text{-}10^6$), D($>10^6$)

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

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

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

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FIGURE 11-6: MATERIALS PROCESS UTILIZATION 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 subject ed to the process. E.g., 6061-T6

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

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Chapter 12. Contamination Control Requirements

12.1 GENERAL

The developer shall plan and implement a contamination control program appropriate for the hardware. The program shall establish the specific cleanliness requirements and delineate the approaches to be followed in a Contamination Control Plan (CCP), see DID 12-1.

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.

12.2 CONTAMINATION CONTROL VERIFICATION PROCESS

The developer shall develop a contamination control verification process. The verification process shall be performed in order

a. Determination of contamination sensitivity;

b. Determination of a contamination allowance;

c. Determination of a contamination budget;

d. Development and implementation of a contamination control plan.

Each of the above activities shall be documented and submitted to GSFC for concurrence/approval.

12.3 CONTAMINATION CONTROL PLAN

The developer shall prepare a CCP that describes the procedures that will be followed to control contamination. It shall establish the implementation and describe the methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the item's lifetime. In general, all mission hardware should be compatible with the most contamination-sensitive components.

12.4 MATERIAL OUTGASSING

In accordance with ASTM E595, NASA RP 1124 may be used as a guide. Individual material outgassing data shall be established based on each component's operating conditions. Established material outgassing data shall be verified and shall be reviewed by GSFC.

12.5 THERMAL VACUUM BAKEOUT

The developer shall perform thermal vacuum bakeouts of all hardware. 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 reviewed by GSFC.

12.6 HARDWARE HANDLING

The developer shall practice cleanroom standards in handling hardware. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging shall be described in detail for each subsystem or component at each phase of assembly, integration, test, and launch.

Chapter 13. Electrostatic Discharge Control

This chapter establishes requirements for an effective ESD Control Program in order to prevent damage to electronic hardware from ESD events. These requirements may be tailored to meet the needs of the project.

13.1 GENERAL

The developer shall document and implement an ESD Control Program to assure that all manufacturing, inspection, testing, and other processes will not compromise mission objectives for quality and reliability due to ESD events.

13.2 APPLICABLE DOCUMENTS

The current status and/or any application notes for these standards can be obtained at the following URL:

http://workmanship.nasa.gov

The most current version of these standards should be used for new procurements. Included shall be ANSI/ESD S20.20 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). However, if a specific revision is listed for a referenced standard, it is that revision only that is approved for use unless otherwise approved by project management.

13.3 ELECTROSTATIC DISCHARGE CONTROL REQUIREMENTS

- The developer shall document and implement an ESD Control Program in accordance with ANSI/ESD S20.20, Protection of Electrical and Electronic Parts, Assemblies and Equipment (excluding electrically initiated explosive devices) suitable to protect the most sensitive component involved 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.
- All personnel who manufacture, inspect, test, otherwise process electronic hardware, or require unescorted access into ESD protected areas shall be certified as having completed the required training, appropriate to their involvement, as defined in ANSI/ESD S20.20 or in the developer's quality manual prior to handling any electronic hardware.
- Electronic hardware shall be manufactured, inspected, tested, or otherwise processed only at designated ESD protective work areas. These work areas shall be verified on a regular schedule as identified in the developer's ESD Control Program; an ESD Control Program that has been approved by the procuring organization
- Electronic hardware shall be properly packaged in ESD protective packaging at all times when not actively being manufactured, inspected, tested, or otherwise processed.
- Alternate standards may be proposed by the developer. Their use is limited to the specific project and are allowed only after they have been reviewed and approved by the GSFC Project Office.
- Materials selected for packaging or protecting ESD sensitive devices shall not leach chemicals, leave residues, or otherwise contaminate parts or assemblies (e.g., "pink poly" is well known for its outgassing of contaminants and should only be used for storing documentation or other non-hardware uses).

Chapter 14. GIDEP Alerts and Problem Advisories

This chapter establishes requirements for GIDEP participation in order to detect problems that affect or potentially affect the suitability of electronic parts and materials for use in GSFC products or that affect or potentially affect personnel or system safety.

14.1 GENERAL

The developer shall participate in the GIDEP in accordance with the requirements of the GIDEP S0300- BT-PRO-010 and S0300-BU-GYD-010, available from the GIDEP Operations Center, Post Office (PO) Box 8000, Corona, California 91718-8000.

The developer shall review all GIDEP ALERTS, GIDEP SAFE-ALERTS, GIDEP Problem Advisories, GIDEP Agency Action Notices, NASA Advisories and any informally documented component issues presented by Code 303, to determine if they affect the developer products produced for NASA. For GIDEP ALERTS, GIDEP SAFE-ALERTS, GIDEP Problem Advisories, GIDEP Agency Action Notices and NASA Advisories that are determined to affect the program, the developer shall take action to eliminate or mitigate any negative effect to an acceptable level. The developer shall generate the appropriate failure experience data report(s) (GIDEP ALERT, GIDEP SAFE-ALERT, GIDEP Problem Advisory) on a monthly basis, in accordance with the requirements of GIDEP S0300-BT-PRO-010 and S0300-BU-GYD-010 whenever failed or nonconforming items, available to other buyers, are discovered during the course of the contract.

Chapter 15. Applicable Documents List

DOCUMENT	DOCUMENT TITLE
ANSI/ASQC Q9000-3	Quality Management and Quality Assurance Standards – Part 3: Guidelines for the Application of ISO 9001 to the Development, Supply and Maintenance of Software
ANSI/ISO/ASQC Q9001-2000	American National Standard Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation and Servicing
ANSI/ISO/ASQ Q9001-2000	American National Standard Quality Management System - Requirements
ANSI/ESD S20.20	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/IPC-A-600	Acceptability of Printed Boards.
ASTM E-595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment
EWR 127-1	Eastern and Western Range Safety Requirements
FAR	Federal Acquisition Regulations
GEVS-SE	General Environmental Verification Specification for STS and ELV Payloads, Subsystems and Components.

Goddard Management Instruction (GMI) 1700.3B	Flight System Safety Requirements
GPG 8700.4	Technical Review Program
GPG 8700.6	Engineering Peer Reviews
GSFC S-312-P003	Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
GSFC 311-INST-001	Instructions for EEE Parts Selection, Screening, and Qualification
GSFC 731-0005-83	General Fracture Control Plan for Payloads Using the Space Transportation System
ICD-2-19001	Shuttle Orbiter/Cargo Standard Interfaces
IEEE STD 610.12	IEEE Standard Glossary for Software Engineering Terminology
IEEE STD 730	IEEE Standard for Software Quality Assurance Plans
IEEE STD 982.1	IEEE Standard Dictionary of Measures to Produce Reliable Software
IEEE STD 982.2	IEEE Guide for the Use of IEEE Standard Dictionary of Measures to Produce Reliable Software
IPC-A-610	Acceptability of Electronic Assemblies

IPC/EIA J-STD-001	Requirements for Soldered Electrical and Electronic Assemblies
IPC-2221	Generic Standard on Printed Board Design
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC-2223	Sectional Design Standard for Flexible Printed Boards
IPC-6011	Generic Performance Specifications for Printed Boards
IPC-6012	Qualification and Performance Specification for Rigid Printed Boards
IPC-6013	Qualification and Performance Specification for Flexible Printed Boards
IPC-6018	Microwave End Product Board Inspection and Test
ISO 10013	Guidelines for Quality Management System Documentation
ISO 17025	General Requirements for the Competence of Testing and Calibration Laboratories
JSC 07700	Shuttle Orbiter/Cargo Standard Interfaces
JSC 26943	Guidelines for the Preparation of Payload Flight Safety Data Packages and Hazard Reports

KHB 1700.7	Space Transportation System Payload Ground Safety Handbook
KHB 1710.2	Kennedy Space Center Safety Practices Handbook
MIL-HDBK-217	Reliability Prediction of Electronic Equipment
MIL-HDBK-470	Designing and Developing Maintainable Products and Systems
MIL-HDBK-472	Maintainability Prediction
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirement for Control of Electromagnetic Interference
MIL-STD-756	Reliability Modeling and Prediction
MIL-STD-1629	Procedures for Performing a Failure Mode Effects and Criticality Analysis
MSFC CR 5320.9	Payload and Experiment Failure Mode Effects Analysis and Critical Items List Ground Rules
MSFC-HDBK-527	Material Selection List for Space Hardware Systems
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking
NASA RP-1124	Outgassing Data for Selecting Spacecraft Materials

NASA RP-1161	Evaluation of Multi-layer Printed Wiring Boards by Metallographic Techniques
NHB 1700.1	NASA Safety Policy and Requirements Document
NHB 1700.7	Safety Policy and Requirements for Payloads using the Space Transportation System
NHB 8060.1	Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion
NPD 8710.3	NASA Policy for Limiting Orbital Debris Generation
NPD 8730.4	NASA Policy for Software Independent Verification and Validation
NPG 7120.5	NASA Program and Project Management Processes and Requirements
NPG 8715.3	NASA Safety Manual
NASA-STD-2100-91	Software Documentation Standard
NASA-STD-2201-93	Software Assurance Standard
NASA-STD-2202-93	Software Formal Inspections Standard
NASA-STD-6001	Flammability, Odor, Off-gassing and Compatibility Requirements & Test Procedures for Materials in Environments that Support Combustion

NASA-STD 8719.13	NASA Software Safety Standard
NASA-STD 8719.14	Guidelines and Assessment Procedures for Limiting Orbital Debris
NASA-STD-8739.1	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies
NASA-STD-8739.2	Workmanship Standard for Surface Mount Technology
NASA-STD-8739.3	Workmanship Standard for Soldered Electrical Connections
NASA-STD-8739.4	Workmanship Standard for Crimping, Interconnecting Cables, Harnesses and Wiring
NASA-STD-8739.5	Workmanship Standard for Fiber Optic Terminations, Cable Assemblies and Installation
NSS 1740.13	NASA Software Safety Standard
NSS 1740.14	Guidelines and Assessment Procedures for Limiting Orbital Debris
NSTS 1700.7	Safety Policy and Requirements for Payloads using the International Space Station
NSTS 14046	Payload Verification
NSTS 22648	Flammability Configuration Analysis for Spacecraft Applications

NSTS/ISS 13830	Payload Safety Review and Data Submittal Requirements
NSTS/ISS 18798	Interpretations of NSTS/ISS Payload Safety Requirements
RSM-93	Range Safety Manual for GSFC/WFF
S-302-89-01	Procedures for Performing a Failure Mode and Effects Analysis
S-311-M-70	Specification for Destructive Physical Analysis
SAE AS9100	Aerospace Standard, Quality Systems Model for Quality Assurance, Design, Development, Production, Installation and Servicing
SAE JA1002	Software Reliability Program Standard
SSD TD-0005	Pegasus Design Safety Requirements Document
SSD TD-0018	Pegasus Safety Requirements Document for Ground Operations
300-PG-7120.2.1	Mission Assurance Guidelines Implementation
541-PG-8072.1.2	GSFC Fastener Integrity Requirements
5405-048-98	Mechanical Systems Center Safety Manual

Chapter 16. Acronyms and Glossary

16.1 ACRONYMS

ADPMPL	As-Designed Parts, Materials and Processes List
ANSI	American National Standards Institute
AR	Acceptance Review
ASIC	Application Specific Integrated Circuits
ASQ	American Society for Quality
ASQC	American Society for Quality Control
ASTM	American Society for Testing of Materials
BB	Ball Bearing
BGA	Ball Grid Array
CCB	Configuration Control Board
CCP	Contamination Control Plan
CDR	Critical Design Review
CDRL	Contract Delivery Requirements List
CI	Configuration Item
CIL	Critical Items List
CM	Configuration Management
CO	Continuous Oscillation
COB	Chip on Board
COTR	Contracting Officer Technical Representative
COTS	Commercial Off-The Shelf
CPT	Comprehensive Performance Test
CRM	Continuous Risk Management
CRMS	Continuous Risk Management System
CS	Continuous Sliding
CSCI	Computer Software Configuration Item
CUR	Continuous Unidirectional Rotation
CVCM	Collected Volatile Condensable Mass
DBMS	Database Management System

DID	Data Item Description
DoD	Department of Defense
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic, and Electromechanical
EIA	Electronics Industry Alliance
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
ESD	Event Sequence Diagram
ETA	Event Tree Analysis
ETM	Environmental Test Matrix
ETR	Eastern Test Range
EWR	Eastern and Western Test Ranges
FAP	Flight Assurance Procedure
FAR	Federal Acquisition Regulations
FCA	Functional Configuration Audit
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes and Effects and Criticality Analysis
FOR	Flight Operations Review
FRB	Failure Review Board
FRR	Flight Readiness Review
FTA	Fault Tree Analysis
G	Gear
GDS	Ground Data System
GEVS	General Environmental Verification Specification
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems and Components
GFE	Government-Furnished Equipment
GHB	Goddard Space Flight Center Handbook
GIA	Government Inspection Agency
GIDEP	Government Industry Data Exchange Program
GMI	Goddard Management Instruction

GPG	Goddard Procedure and Guidelines
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HST	Hubble Space Telescope
I&T	Integration and Test
IAC	Independent Assurance Contractor
IATO	Independent Acceptance and Test Organization
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
IO	Intermediate Oscillation
IOC	In Orbit Checkout
IPC	Association Connecting Electronics Industries
IR	Intermediate Rotation
IS	Instrument Sliding
ISO	International Organization for Standardization
ISS	International Space Station
IV&V	Independent Verification and Validation
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KHB	Kennedy Space Center Handbook
LEO	Launch and Early Orbit
LO	Large Oscillation
LRR	Launch Readiness Review
LRU	Line Replaceable Unit
LSSP	Launch Site Safety Plan
MAE	Materials Assurance Engineer
MAG	Mission Assurance Guidelines
MAPTIS	Materials and Processes Technical Information Service
MCM	Multi-Chip Module
MEB	Materials Engineering Branch
MLD	Master Logic Diagram
MOC	Mission Operations Center
MOR	Mission Operations Review

MPCB	Mass Properties Control Board
MRB	Material Review Board
MSFC	Marshall Space Flight Center
MSPSP	Missile System Prelaunch Safety Data Package
MTBF	Mean Time Between Failure
MTTR	Mean Time To Restore
MUA	Materials Usage Agreement
NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
NPD	NASA Policy Directive
NPG	NASA Procedures and Guidelines
NPSL	NASA Parts Selection List
NRCA	Nonconformance Reporting and Corrective Action
NSS	NASA Safety Standard
NSTS	National Space Transportation System
ODA	Orbital Debris Assessment
OPM	Oscillations Per Minute
OSSMA	Office of Systems Safety and Mission Assurance
PAPL	Project Approved Parts List
PAPMPL	Project Approved Parts, Materials and Processes List
PCA	Physical Configuration Audit
PCB	Parts Control Board
PCP	Parts Control Plan
PDR	Preliminary Design Review
PE	Parts Engineer
PEM	Plastic Encapsulated Microcircuit
PER	Pre-Environmental Review
PFR	Problem/Failure Report
PG	Procedures and Guidelines
PHA	Preliminary Hazards Analysis
PI	Principal Investigator
PMP	Parts, Materials and Processes
PMPCB	Parts, Materials and Processes Control Board

PMPCP	Parts, Materials and Processes Control Program
PO	Post Office
POCC	Payload Operations Control Center
PPL	Preferred Parts List
PQR	Procedure Qualification Record
PRA	Probabilistic Risk Assessment
PSM	Project Safety Manager
PSR	Pre-Shipment Review
PWB	Printed Wiring Board
QA	Quality Assurance
QCI	Quality Conformance Inspection
QCM	Quartz Crystal Microbalance
QML	Qualified Manufacturer's List
QMS	Quality Management System
QPL	Qualified Parts List
RF	Radio Frequency
RFP	Request for Proposal
RH	Relative Humidity
RHA	Radiation hardness Assurance
RM	Reliability and Maintainability
RMA	Reliability, Maintainability and Availability
RMPP	Reliability and Maintainability Program Plan
RP	Reference Publication
RPM	Revolutions Per Minute
RSM	Range Safety Manual
RVM	Requirements Verification Matrix
SAE	Society of Automotive Engineers
SAM	Systems Assurance Manager
SAR	Safety Assessment Report
SB	Sleeve Bearing
SCC	Stress Corrosion Cracking
SCD	Source Control Drawing
SCM	Software Configuration Management

SDP	Safety Data Package
SEC	Sliding Electrical Contacts
SO	Small Oscillation
SOW	Statement of Work
SQA	Software Quality Assurance
SQE	Software Quality Engineering
SQMS	Software Quality Management System
SRO	Systems Review Office
SRP	System Review Program
SRR	Software Requirements Review
SRR	System Requirement Review
SRT	System Review Team
SS	Sliding Surfaces
SSIP	System Safety Implementation Plan
STD	Standard
STS	Space Transportation System
TML	Total Mass Loss
TR	Torque Ratio
TRR	Test Readiness Review
URL	Uniform Resource Locator
UV	Ultraviolet
V&V	Verification and Validation
VS	Variable Speed
VTL	Verification Tracking Log
WFF	Wallops Flight Facility
WSTF	White Sands Test Facility
WTR	Western Test Range

16.2 DEFINITIONS

The following definitions apply within the context of this document:

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

Assembly: See Level of Assembly.

Audit: A review of the developer's 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:

a. **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.
b. **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:

a. **Prototype Hardware**: Hardware of a new design; it is subject to a design qualification test program; it is not intended for flight.
b. **Flight Hardware**: Hardware to be used operationally in space. It includes the following subsets:
   (1) **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.
   (2) **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.

(3) **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.
(4) **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:

a. **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.
b. **Subassembly**: A subdivision of an assembly. Examples are wire harness and loaded printed circuit boards.
c. **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.
d. **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.
e. **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.
f. **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.
g. **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).
h. **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.
i. **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.
j. **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.

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).

Chapter 17. Data Item Descriptions

DID 2-1: Quality Manual

Title:	CDRL No.:
Quality Manual	2-1

Reference:

Paragraphs 2.1

Use:

Documents the developer's quality management system.

Related Documents:

ANSI/ISO/ASQC Q9001: 1994, ANSI/ISO/ASQ 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/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 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 2-2: Problem Failure Reports

Title:	CDRL No.:
Problem Failure Reports (PFRs)	2-2

Reference:

Paragraph 2.2.4

Use:

To report failures promptly to the Failure Review Board (FRB) for determination of cause and corrective action.

Related Documents:

Place/Time/Purpose of Delivery:

a. Provide information to the GSFC Project Office within 24 hours of each occurrence;

b. Provide to GSFC Project Office for approval immediately after developer closure.

Preparation Information:

Reporting of failures shall begin with the first power application at the start of end item acceptance testing of the major component, subsystem, or instrument level (as applicable to the hardware level for which the developer is responsible) or the first operation of a mechanical item; it shall continue through formal acceptance by the GSFC project office and the post-launch operations, commensurate with developer presence and responsibility at GSFC and launch site operations.

All failures shall be documented on existing developer PFR form, which shall identify all relevant failure information.

PFRs and updated information shall be submitted to GSFC by hard copy or in electronic format. PFRs submitted to the GSFC for closure include a copy of all referenced data and shall have had all corrective actions accomplished and verified.

DID 3-1: System Safety Program Plan

Title:	CDRL No.:
System Safety Program Plan	3-1

Reference:

MAG, Paragraphs 3.3, 5.2.2

Use:

The approved plan provides a formal basis of understanding between the Range User and Range Safety on how the SSPP will be conducted to meet the requirements of EWR 127-1, including general and specific provisions. The approved plan shall account for all contractually required tasks and responsibilities on an item-by-item basis.

Related Documents:

a. 302-PG-7120.2.1, Mission Assurance Guidelines Implementation

b. EWR 127-1, Eastern Western Range System Safety Requirements

c. NPG 7120.5, Program and Project Management Processes and Requirements

d. NPD 8700.1, NASA Policy for Safety and Mission Success

Place/Time/Purpose of Delivery:

The Range User shall submit a draft SSPP to Range Safety for review and approval within 45 days of contract award and a final at least 45 days prior to any program CDR.

Preparation Information:

The SSPP shall describe in detail tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate and control hazards, or reduce the associated risk to a level acceptable to Range Safety throughout the system life cycle.

DID 3-2: Safety Data Package

Title:	CDRL No.:
Safety Data Package (SDP)	3-2

Reference:

MAG, Paragraph 3.4

Use:

Provide 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 minimize each significant identified hazard.

Related Documents:

a. EWR-127, Eastern Western Range System Safety Requirements

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

c. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook

d. NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements

e. NSTS 1700.7, Safety Policy & Requirements for Payloads Using the Space Transportation System

f. RSM-93, Wallops Flight Facility (WFF) Range Safety Manual for Goddard Space Flight Center (GSFC)

Note: Other launch range and launch vehicle requirements may apply.

Place/Time/Purpose of Delivery:

*STS: *Flight Safety Data Package*	*Ground Safety Data Package*
Provide Phase O - Early in conceptual phase	Phase O – Early in conceptual phase
Provide Phase 1 - 45 days prior to PDR	Phase 1 – 45 days prior to PDR
Provide Phase 2 - 45 days prior to CDR	Phase2 – 45 days prior to CDR
Provide Phase 3 - 30 days prior to PSR	Phase 3 – 30 days prior to PSR

*Non-STS: In general provide preliminary (combined flight and ground safety package) with Preliminary Design Review (PDR) package, update at Critical Design Review (CDR), final 60 days before Pre Ship Review (PSR).

*(See applicable launch range and launch vehicle requirements for details).

DID 3-2: Safety Data Package ---continued

Preparation Information:

The Safety Package shall 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) A list of 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.

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).

DID 3-2: Safety Data Package ---continued

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) Materiel 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. Reference material to include a list of all pertinent references such as Test Reports, Preliminary Operating Manuals and Maintenance Manuals

   d. 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 3-3: Hazard Control Verification and Tracking

Title:	CDRL No.:
Hazard Control Verification and Tracking	3-3

Reference:

MAG, Paragraph 3.4

Use:

To provide a Hazard Control and Verification Tracking process or "closed-loop system" to assure safety compliance has been satisfied in accordance to applicable launch range safety requirements.

Related Documents:

a. EWR-127, Eastern Western Range System Safety Requirements
b. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook
c. NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements
d. NSTS 14046, Payload Verification Requirements
e. NSTS 1700.7, Safety Policy & Requirements for Payloads Using the Space Transportation System
f. RSM-93, Wallops Flight Facility (WFF) Range Safety Manual for Goddard Space Flight Center (GSFC)

Place/Time/Purpose of Delivery:

Provide hazard control verification and tracking system in accordance with applicable launch site range safety requirements. Documented methods of hazard controls shall be submitted with the initial SDP, MSPSP, or SAR and updated with each consecutive submittal. All open hazard control verification items must be closed in accordance with applicable launch site range safety requirements.

Preparation Information:

Provide 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.

DID 3-4: Ground Operations Procedures

Title:	CDRL No.:
Ground Operations Procedures	3-4

Reference:

MAG, Paragraph 3.5

Use:

All ground operations procedures to be used at GSFC facilities, other integration facilities, or the launch site shall be submitted to the GSFC Project Safety Manager for review and concurrence. Launch site ground operations procedures shall be submitted to applicable Range Safety 45 days prior to use.

Related Documents:

a. EWR-127, Eastern Western Range System Safety Requirements

b. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook

c. KHB 1710.2, Kennedy Space Center Safety Practices Handbook

Note: Other launch vehicle and/or contractor, or commercial facility requirements may apply

Place/Time/Purpose of Delivery:

Provide preliminary 120 days prior to PSR, final 60 days before PSR, and submit to applicable Range Safety 45 days prior to use.

Preparation Information:

All hazardous operations as well as the procedures to control them shall be identified and highlighted. All launch site procedures shall comply with the applicable launch site safety regulation.

DID 3-5: Safety Noncompliance Requests

Title:	CDRL No.:
Safety Noncompliance Requests	3-5

Reference:

MAG, Paragraph 3.6

Use:

The hardware developer shall submit to the Project Safety Manager (PSM) an associated safety noncompliance request that identifies the hazard and shows the rationale for approval of a noncompliance when a specific safety requirement cannot be met, as defined in the applicable launch site safety regulation. The request may require Range Safety concurrence for the noncompliance request to be approved.

Related Documents:

a. EWR-127, Eastern Western Range System Safety Requirements
b. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook
c. KHB 1710.2, Kennedy Space Center Safety Practices Handbook
d. NASA Non-Compliance Report/Corrective Action System (NCR/CAS) Web-based Online System

Place/Time/Purpose of Delivery:

As identified to the GSFC Project Safety Manager

Preparation Information:

The noncompliance request shall include the following information resulting from a review of each waiver or deviation request.

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.

A detailed technical justification for the exception.

Analyses to show that the mishap potential of the proposed alternate requirement, method or process, as compared to the specified requirement.

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.

A narrative on possible ways of reducing hazards severity and probability and existing compliance activities (if any).

Starting and expiration date for waiver/deviation.

DID 3-6: Launch Site Safety Plan

Title:	CDRL No.:
Launch Site Safety Plan	3-6

Reference:

MAG, Paragraph 3.7

Use:

Ensure the developer's Launch Site Safety Plan is consistent with the launch site requirements.

Related Documents:

a. EWR-127, Eastern Western Range System Safety Requirements

b. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook

c. KHB 1710.2, Kennedy Space Center Safety Practices Handbook

Note: Other Launch vehicle contractor requirements may apply.

Place/Time/Purpose of Delivery:

Provide preliminary with PER package, final 60 days before PSR

Preparation Information:

The Plan shall be submitted for approval in accordance with the milestones required by the applicable launch site safety regulation.

DID 3-7: Orbital Debris Assessment

Title:	CDRL No.:
Orbital Debris Assessment	3-7

Reference:

MAG, Paragraph 3.9

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 prior PDR, updated package 45 days prior to CDR and a final package at PER

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 orbital debris generation, and update of the debris assessment report should be prepared, approved, and coordinated with the Office of System Safety and Mission Assurance.

Orbital Debris Assessment Software is available for download from Johnson Space Center at ftp site:

ftp://jsc-sn-io.jsc.nasa.gov/

DID 3-8: Safety Compliance

Title:	CDRL No.:
Safety Compliance	3-8

Reference:

MAG, Paragraph 3.10

Use:

Verify the developer's SDP, MSPSP, or SAR meets the launch site safety requirements and that Code 302 safety certification has been obtained.

Related Documents:

a. 302-PG-7120.2.1, Mission Assurance Guidelines Implementation
b. EWR 127-1, Eastern Western Range System Safety Requirements
c. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook
d. KHB 1710.2, Kennedy Space Center Safety Practices Handbook
e. NPG 8715.3, NASA Safety Manual
f. NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements

Place/Time/Purpose of Delivery:

Provide 45 days prior to PSR to verify flight/ground safety compliance.

Preparation Information:

Code 302 safety certification shall be obtained in accordance with 302-PG-7120.2.1. Safety Compliance shall be submitted for approval in accordance with the milestones required by the applicable launch site safety regulation. A letter of safety compliance shall be signed by the Program Manager with concurrence from the PSM.

DID 4-1: Reliability and Maintainability Program Plan

Title:	CDRL No.:
Reliability and Maintainability Program Plan (RMPP)	4-1

Reference:

Paragraph 4.2

Use:

To provide planning and control for the reliability and maintainability programs.

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.

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.

Preparation Information:

The RMPP shall describe how reliability and maintainability program requirements shall be complied with, and shall include the following:

a. Charts and statements describing the organizational responsibilities and functions associated with conduct of the R&M program and each of the tasks to be performed as part of the R&M Program. A summary (matrix or other brief form) shall be included which indicates for each reliability program requirement, the principal organization responsible for implementation and the specific organization responsible for generating the necessary documentation. The summary shall identify each organization that has approval, oversight, or review authority relative to documents generated. The narrative shall include the following for each task:

   – Duties of each organizational element relative to each task and its accomplishment,

   – Delineation of interfaces in responsibilities and functions where more than one organizational element is involved,

   – Relationship of the reliability organization to each of the other organizational elements performing reliability tasks with the lines of authority and oversight clearly identified.

b. Narrative descriptions, time or milestone schedules, and supporting documents, which describe in detail the plan for execution and management of each task in the reliability, program. Directives, methods and procedures relative to each task shall be documented in the plan.

DID 4-2: Probabilistic Risk Assessment

Title:	CDRL No.:
Probabilistic Risk Assessment (PRA)	4-2

Reference:

Paragraphs 4.3, 7.3

Use:

PRAs provide a structured, disciplined approach to analyzing system risk to support management decisions to: ensure mission success; improve safety in design, operation, maintenance and upgrade; improve performance; and reduce design, operation and maintenance costs.

Related Documents

N/A.

Place/Time/Purpose of Delivery:

a. PRA Planning Document 6 months before PDR for review and approval.
b. Preliminary PRA 30 days before PDR for review.
c. Final PRA 30 days before CDR for approval.
d. Updates as changes are made; between CDR and delivery, for approval.

Preparation Information:

As part of the PRA, a PRA Planning Document shall be prepared that identifies what types of analyses are to be performed for each scenario, and what modeling tools and techniques are to be used (e.g., Master Logic Diagrams (MLD), Failure Mode and Effects Analysis (FMEA), Fault Tree Analyses (FTA), Event Tree Analyses (ETA), Event Sequence Diagrams (ESD)).

The PRA shall include:

a. A definition of the objective and scope of the PRA, 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 4-3: Failure Mode and Effects Analysis and Critical Items List

Title:	CDRL No.:
Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL)	4-3

Reference:

Paragraph 4.4.1, 5.2.2

Use:

The FMEA is a reliability analysis to evaluate design relative to requirements, identify single point failures, and identify hazards so as to guide preventive design actions. The CIL provides a list of critical items, which require the highest level of attention in design, fabrication, verification, and problem correction during the development, handling, and mission use of the system.

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.

Place/Time/Purpose of Delivery:

a. Preliminary 30 days before PDR for GSFC review.

b. Final 30 days before CDR for GSFC review.

c. Updates as required including changes for GSFC review.

Preparation Information:

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

The Critical Items List shall include 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.

DID 4-4: Fault Tree Analysis

Title:	CDRL No.:
Fault Tree Analysis (FTA)	4-4

Reference:

Paragraphs 4.4.2, 5.2.2, 7.3

Use:

A fault tree is an analytical technique, whereby an undesired state of the system is specified, and the system is then analyzed in the context of its environment and operation to find all credible ways in which the undesired event can occur. The analysis provides a methodical approach to understanding the system, its operation, and the environment it will operate in. Through this understanding, informed decisions regarding system design and operation can be made.

Related Documents

a. NUREG-0492, Fault Tree Handbook

Place/Time/Purpose of Delivery:

a. Preliminary 30 days before PDR for GSFC review.
b. Final 30 days before CDR for GSFC review.
a. Updates as required including changes for GSFC review.

Preparation Information:

The Fault Tree Analysis Report shall contain:

a. Ground rules for the analysis, including definitions of the undesirable end states analyzed,
b. References to documents and data used,
c. The fault tree diagrams,
d. Statement of the results and conclusions.

DID 4-5: Parts Stress Analysis

Title:	CDRL No.:
Parts Stress Analysis	4-5

Reference:

Paragraph 4.4.3

Use:

Provides EEE parts stress analyses for evaluating circuit design and conformance with derating guidelines, and 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 GSFC CDR for GSFC review

b. Updates to include changes as required for GSFC review

Preparation Information:

The stress analysis report shall contain:

a. Ground rules for the analysis,

b. References to documents and data used,

c. Statement of the results and conclusions,

d. Analysis worksheets. The worksheets at a minimum shall include:

- Part identification (traceable to circuit diagrams),
- Environmental conditions assumed (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 4-6: Worst Case Analysis

Title:	CDRL No.:
Worst Case Analysis	4-6

Reference:

Paragraph 4.4.4

Use:

To demonstrate the adequacy of margin in the design of electronic and electrical circuits, optics, and electromechanical and mechanical items.

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 R&M Program.

Place/Time/Purpose of Delivery:

a. Available 30 days prior to component CDR

b. Updates with design changes.

Preparation Information:

These analyses shall address the worst case conditions for the analysis performed on each component. Each analysis shall encompass the mission life and consider the critical parameters set at maximum and minimum limits and include the effect of environmental stresses on the operational parameters being evaluated.

DID 4-7: Reliability Assessments and Predictions

Title:	CDRL No.:
Reliability Assessments and Predictions	4-7

Reference:

Paragraph 4.4.5

Use:

Reliability analysis 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:

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

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

DID 4-8: Trend Analysis

Title:	CDRL No.:
Trend Analysis	4-8

Reference:

Paragraph 4.5.1

Use:

To monitor parameters on components and subsystems throughout the normal test program that relate to performance stability (any deviations from the nominal that could indicate trends). Operational personnel continue monitoring trends through mission duration.

Related Documents

None

Place/Time/Purpose of Delivery:

a. List of parameters to be monitored at time of CDR for information.

b. Trend Analysis Reports at time of PER and FRR for information.

Preparation Information:

The system for selecting parameters related to performance stability, recording any changes from the nominal, analyzing trends, and coordinating results with design and operational personnel shall be documented.

List of parameters to be monitored, updates to the list and trend reports shall be prepared. In addition a log shall be kept for each black box or unit (e.g. tape recorder) of the accumulated operating time. The log shall include the following minimum information:

a. Identification

b. Serial Number

c. Total operating time since assembly of unit

d. Total operating time at each parameter observation

e. Total additional operating time projected for the unit prior to launch.

DID 4-9: Limited-Life Items List

Title:	CDRL No.:
Limited-Life Items List	4-9

Reference:

Paragraph 4.6

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 4-10: Maintainability Modeling

Title:	CDRL No.:
Maintainability Modeling (Allocations and Predictions)	4-10

Reference:

Paragraph 4.7.1

Use:

Maintainability modeling assists in evaluating alternative designs and in determining whether or not the proposed design is consistent with maintainability requirements.

Related Documents

MIL-HDBK-472, Maintainability Prediction.

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:

The Maintainability Modeling report shall document:

a. Approach, methodology, and procedures followed,

b. Assumptions made,

c. Data sources,

d. Results, summary and conclusions.

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

DID 4-11: Maintainability Demonstration Test Report

Title:	CDRL No.:
Maintainability Demonstration Test Report	4-11

Reference:

Paragraph 4.7.5

Use:

This report provides the results, conclusions, data analysis, and records of the maintainability demonstration.

Related Documents

MIL-HDBK-470, Designing and Developing Maintainable Products and Systems.

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:

Reports of the results of each individual demonstration test shall include a:

- Discussion of the methods and conditions of the demonstration, including methods of evaluating the data obtained and comparison of the conditions with those anticipated in ultimate deployment and use of the item.
- Results obtained, including specific identification and discussion of objectives demonstrated satisfactorily and those not demonstrated satisfactorily.
- Conclusions, corrective action anticipated, recommendations to correct deficiencies, suggested improvements based on evaluation of the demonstration results.
- Analysis and supporting data and worksheets with pertinent information including:
  - Test number and designation in the MD Plan;
  - Scenario description;
  - Failure introduced;
  - Time and method to detect existence of a malfunction;
  - Time to isolate to correct LRU, and diagnostic tools used;
  - Availability and storage location of spare LRU and of repair tools;
  - Time to fetch spare;
  - Repair time;
  - Formal checkout procedure used, and number (if existing);
  - Custom-generated procedure used and authority;
  - Total down time and specified maximum allowable downtime.

DID 5-1: Software Development Plan

Title: Software Development Plan	CDRL No.: 5-1
Reference: Paragraphs 5.1, 5.2.3, 6.5.7.1	
Use: This data item provides an outline for the Software Development Plan. The Software Development Plan documents the software development processes and procedures, software tools, resources, and deliverables throughout the development life cycle.	
Related Documents: N/A	
Place/Time/Purpose of Delivery: a. Initial draft due upon project inception. b. Final due no later than requirements phase. c. Updated periodically throughout the lifecycle as necessary.	
Preparation Information: The Software Development Plan shall include/address: a. Purpose and Description; b. Reference documents; c. Resources, Budgets, Schedules, and Organizations; d. Development Activities (by life cycles): 1) Development and test environment; 2) Tools, techniques, and methodologies; 3) Software standards and development processes. e. Software Configuration Management; f. Quality Assurance; g. Risk Management; h. Technical Reviews; i. Delivery and Operational Transition; j. Software Deliverables. Include an alphabetized list of definitions for abbreviations, acronyms, and special terms used in the document, i.e., terms used in a sense that differs from or is more specific than the common usage for such terms. Material that is too detailed or sensitive to be placed in the main body of text may be placed in an appendix or included as reference. Include the appropriate reference in the main body of the text. Appendices may be bound separately, but are considered to be part of the document and shall be placed under configuration control as such.	

DID 5-2: Software Quality Assurance Plan

Title:	CDRL No.:
Software Quality Assurance Plan	5-2

Reference:

Paragraph 5.2.1

Use:

The Software Quality Assurance Plan documents the Software Quality Assurance roles and responsibilities, surveillance activities, supplier control, records collection, maintenance and retention, and risk management.

Related Documents

IEEE Standard 730-2002, Software Quality Assurance Plans

Place/Time/Purpose of Delivery:

As specified in the Software Development Plan

Preparation Information:

The Software Quality Assurance Plan shall follow the format as specified in the IEEE Standard 730-2002:

a. Purpose;
b. Reference documents;
c. Management;
d. Documentation;
e. Standards, practices, conventions, and metrics;
f. Software Reviews;
g. Test;
h. Problem Reporting and Corrective Action;
i. Tools, Techniques, and methodologies;
j. Media control;
k. Supplier control;
l. Records, collection, maintenance, and retention;
m. Training;
n. Risk Management;
o. SQAP Change procedure and history.

Include an alphabetized list of definitions for abbreviations, acronyms, and special terms used in the document, i.e., terms used in a sense that differs from or is more specific than the common usage for such terms.

Material that is too detailed or sensitive to be placed in the main body of text may be placed in an appendix or included as reference. Include the appropriate reference in the main body of the text. Appendices may be bound separately, but are considered to be part of the document and shall be placed under configuration control as such.

DID 5-3: Software Configuration Management Plan

Title:	CDRL No.:
Software Configuration Management Plan	5-3

Reference:

Paragraph 5.4

Use:

The purpose of the Software Configuration Management Plan is to define the configuration management process for the software and its associated products and tools.

Related Documents

ANSI-IEEE Standard 1042-1987, Guide to Software Configuration Management.

Place/Time/Purpose of Delivery:

As specified in the Software Development Plan

Preparation Information:

The Software Configuration Management Plan shall follow the following format:

a. Introduction;

b. Reference Documents;

c. Configuration Management Process Overview;

d. Software Configuration Management Activities: 1) Configuration Identification, 2) Configuration Control, 3) Configuration Status Accounting, 4) Audits and Reviews.

e. Tools, Techniques, and Methodologies;

f. Supplier Control;

g. Records collection, maintenance, and retention.

Include an alphabetized list of definitions for abbreviations, acronyms, and special terms used in the document, i.e., terms used in a sense that differs from or is more specific than the common usage for such terms.

Material that is too detailed or sensitive to be placed in the main body of text may be placed in an appendix or included as reference. Include the appropriate reference in the main body of the text. Appendices may be bound separately, but are considered to be part of the document and shall be placed under configuration control as such.

DID 5-4: Software Reliability Plan

Title:	CDRL No.:
Software Reliability Plan	5-4

Reference:

Paragraph 5.2.3

Use:

Software reliability plan documents the management and technical activities that bear on the achievement of software reliability. It should be traceable to system reliability planning and to avoid unnecessary replication, should be integrated with software development and quality management planning.

Related Documents:

SAE JA1002 Software Reliability Program Standard, IEEE Std 982.1 and IEEE Std 982.2.

Place/Time/Purpose of Delivery:

As specified in the Software Development Plan

Preparation Information:

The Software Reliability Plan shall include/address:

a. Allocating reliability requirements to software;
b. The strategy for software reliability achievement;
c. The techniques, methods and tools, including measurements to be used for the evaluation of the achieved software reliability at each lifecycle phase;
d. Risk analysis for the software reliability objectives;
e. Identification of database tools that support data collection, analysis and storage;
f. The identification, selection and integration of OTS software;
g. The means by which staff, including subcontractors, are made aware of their specific responsibilities in meeting the software reliability requirements;
h. Specific training activities related to reliability models, methods and techniques;
i. The procedures for software reliability progress reporting, including the phased update of the Software Reliability Case and how information in the Case is validated;
j. The distribution of resources employed o address software reliability issues, including the involvement of the customer and any third party; and
k. The timing of the elements of the Software Reliability Plan relative to the System Reliability Plan.

DID 5-5: Software Safety Plan

Title: Software Safety Plan	CDRL No.: 5-5
Reference: Paragraph 5.2.2	
Use: Software safety plan documents the processes and activities intended to improve the safety of safety-critical software. This plan should be developed in conjunction with the overall system safety program.	
Related Documents: NASA Software Safety Standard 8719.13, EWR 127-1; IEEE Standard 1228-1994, Standard for Software Safety Plan.	
Place/Time/Purpose of Delivery: As defined in the Software Development Plan.	

Preparation Information:

The Software Safety Plan shall include/address:

a. Purpose;
b. Definitions, Acronyms and References;
c. Software Safety Management including:
   - Organization and Responsibilities
   - Resources
   - Staff Qualification and Training
   - Software Lifecycle
   - Documentation Requirements
   - Software Safety Program Records
   - Software Configuration Management Activities
   - Software Quality Assurance Activities
   - Software Verification and Validation Activities
   - Tool Support and Approval
   - Previously Developed and/or Purchased Software
   - Subcontract Management
   - Process Certification
d. Software Safety Analyses
   - Software Safety Analyses Preparation
   - Software Safety Requirements Analyses
   - Software Safety Design Analyses
   - Software Safety Code Analyses
   - Software Safety Test Analyses
   - Software Safety Changes Analyses

DID 5-5: Software Safety Plan --- continued:

e. Post Development
   - Training
   - Deployment
     - Installation
     - Startup and Transition
     - Operations Support
   - Monitoring
   - Maintenance
   - Retirement and Notification

f. Plan Approval

DID 7-1: Risk Management Plan

Title:	CDRL No.:
Risk Management Plan	7-1

Reference:

Paragraphs 7.2

Use:

The purpose of the Risk Management Plan is to define the process by which the developer identifies, evaluates and minimizes the risks associated with software development.

Related Documents

N/A

Place/Time/Purpose of Delivery:

As specified in the contract/SOW.

Preparation Information:

Topics to be included in the Risk Management Plan are:

a. Risk Assessment and Evaluation Process;

b. Technical Risks;

c. Safety Risks;

d. Security Risks;

e. Resource Risks;

f. Schedule Risks;

g. Cost Risks.

Include an alphabetized list of the definitions for abbreviations and acronyms used in this document.

Include an alphabetized list of definitions for special terms used in the document, i.e., terms used in a sense that differs from or is more specific than the common usage for such terms.

Material that is too detailed or sensitive to be placed in the main body of text may be placed in an appendix or included as reference. Include the appropriate reference in the main body of the text. Appendices may be bound separately, but are considered to be part of the document and shall be placed under configuration control as such.

DID 8-1: System Requirements Review

Title:	CDRL No.:
System Requirements Review (SRR)	8-1

Reference:

Paragraph 8.2.1.1a

Use:

To evaluate the requirements, requirements flow-down, and the operational concepts.

Related Documents

None

Place/Time/Purpose of Delivery:

End of definition study phase

Preparation Information:

Contact Systems Review Office (SRO).

Prepare to discuss Level I and Level II requirements, rationale, and flow-down plans to lower level requirements. Show how the current concept meets Level I and Level II requirements.

DID 8-2: Preliminary Design Review

Title:	CDRL No.:
Preliminary Design Review (PDR)	8-2

Reference:

Paragraph 8.2.1.1 b

Use:

The PDR is the first major review of the detailed design and is normally held prior to the preparation of formal design drawings.

Related Documents

None

Place/Time/Purpose of Delivery:

Early in the design phase but prior to manufacture of engineering hardware and the detail design of associated software.

Preparation Information:

Contact Systems Review Office (SRO).

PDR should cover the following items:

- Science/Technical Objectives, Requirements, General Specification
- Closure of Actions from Previous Review/Changes since the last review
- Performance Requirements
- Error budget determination
- Weight, Power, Data rate, Commands, EMI/EMC
- Interface Requirements
- Mechanical/structural design, analyses, and life tests
- Electrical, thermal, optical/radiometric design and analyses
- Software requirements and design
- Ground Support Equipment design
- System Performance budgets
- Design verification, test flow and calibration/test plans
- Mission and ground system operations
- Launch Vehicle interfaces and drivers
- Parts selection, qualification, and Failure Mode and Effects Analysis (FMEA) plans
- Contamination requirements and control plan
- Quality Control, Reliability and redundancy
- Materials and Processes
- Acronyms and abbreviations
- Safety hazards identified for flight, range, ground hardware and operations
- Orbital Debris Assessment

DID 8-3: Critical Design Review

Title:	CDRL No.:
Critical Design Review (CDR)	8-3

Reference:

Paragraph 8.2.1.1 c

Use:

Serves as a gateway to start configuration control and manufacturing.

The CDR represents a complete and comprehensive presentation of the entire design. It presents the final design and interfaces by means of block diagrams, power flow diagrams, signal flow diagrams, interface circuits, layout drawings, software logic flow and timing diagrams, design language, modeling results, breadboard and engineering model test results and changes required to the design presented at the PDR.

Related Documents

None

Place/Time/Purpose of Delivery:

After design has been completed but prior to the start of manufacturing flight components or the coding of software.

Preparation Information:

Contact Systems Review Office (SRO).

The CDR should include all of the items specified for a PDR, updated to the final present stage of development process, plus the following additional items:

- Evolution and Heritage of the Final Design
- Combined optical, thermal, and mechanical budgets or total system performance
- Closure of Actions from the Previous Review
- Interface Control Documents
- Final implementation plans including: engineering models, prototypes, flight units, and spares
- Engineering Model/Breadboard Test Results and Design Margins
- Completed design analyses
- Qualification/Environmental Test Plans and Test Flow
- Launch Vehicle Interfaces
- Ground Operations
- Progress/status and control methods for all safety hazards identified at, but not limited to, the PDR
- Reliability analyses results: FMEA, Worst Case Analysis, Fracture Control
- Plans for shipping containers, environmental control and mode of transportation
- Problem Areas/Open Items
- Schedules

DID 8-4: Mission Operations Review

Title:	CDRL No.:
Mission Operations Review (MOR)	8-4

Reference: Paragraph 8.2.1.1.d

Use:

To review the status of the system components, including the ground system and its operational interface with the flight system.

Related Documents: None

Place/Time/Purpose of Delivery:

This mission-oriented review normally takes place prior to significant integration and test of the flight system and ground system.

Preparation Information:

Contact Systems Review Office (SRO).

The mission operations review should occur prior to significant integration and test of the flight system and ground system and should address the following items:

- Objectives
- Overall schedule and status including: documentation (i.e. spacecraft operations concept, ground system requirements, flight operations and contingency plans and Interface Control Documents)
- Closure of previous reviews (e.g. Project-unique ground system reviews)
- Mission, science, spacecraft, flight software, and ground system overviews
- Flight software maintenance approach
- Flight operations team build up and training plans
- Pre-launch test plans including: RF and POCC compatibility tests, data flow and end-to-end tests, simulations and exercises, launch site and pad tests
- Launch and early orbit overview including deployment activities and coverage
- In-orbit checkout overview
- Project database and procedure development
- Spacecraft and instrument operations constraints
- Spacecraft subsystem level activities
- Mission planning and scheduling
- On-board data memory management
- Real-time operations including: health and safety monitoring, safe mode operation
- Trend analysis plans including reports and archive
- Science operations planning, data processing and analysis
- Ground system requirements and development status
- Mission readiness testing
- Preliminary list of all launch critical facilities and function
- Issues and concerns

DID 8-5: Pre-Environmental Review

Title:	CDRL No.:
Pre-Environmental Review (PER)	8-5

Reference:

Paragraph 8.2.1.1.e

Use:

Primary purpose is to establish the readiness of the system for test and evaluate the environmental test plans.

Related Documents

None

Place/Time/Purpose of Delivery:

Occurs prior to the start of environmental testing of the protoflight or flight system.

Preparation Information:

Contact Systems Review Office (SRO).

Prepare to discuss the readiness of system for test and to evaluate the environmental test plans.

The following gives a list items, which should be presented at the PER:

- Changes since the Critical Design Review
- Program status and general test readiness
- Test Plans and procedures addressing:
- Test objectives/conditions/levels/configuration
- Test facilities and certification
- Test fixtures and support equipment
- Instrumentation
- Success/abort criteria
- Progress/status of safety data submissions, procedures and verification
- Test flow including: calibration, when Comprehensive Performance Tests (CPTs) will be performed and no. of T/V cycles
- Schedule
- Documentation Status
- Functional and environmental test history of the hardware
- Product Assurance and Safety
- Previous anomalies, deviations, waivers and their resolution
- Identification of residual risk items
- Open items and plans for close-out
- Final Calibration

DID 8-6: Pre-Shipment Review

Title:	CDRL No.:
Pre-Shipment Review (PSR)	8-6

Reference:

Paragraph 8.2.1.1.f

Use:

To evaluate system performance during qualification or acceptance testing, and evaluate readiness to ship from vendor.

Related Documents

None

Place/Time/Purpose of Delivery:

Prior to shipment of the instrument for integration with the spacecraft.

Preparation Information:

Contact Systems Review Office (SRO).

The solutions to all problems encountered during the environmental test and validation program and the solution rationale are to be presented.

Items that should also be considered as part of the presentation are:

- Any rework/replacement of hardware, regression testing, or test plan changes should be highlighted during the test flow discussions
- Compliance with the test verification matrix
- Measured test margins versus design estimates
- Demonstrate qualification/acceptance temperature margins
- Any data that has been trended to identify compliance with specification should be presented, especially it there has been a change or drift to the trend.
- Total failure-free operating time of the item
- Could-not-duplicate failures should be presented along with assessment of the problem and the residual risk that may be inherent in the item
- Project assessment of any residual risk
- Update from CDR on shipping containers, monitoring/transportation/control plans
- Ground support equipment status
- Post shipment plans
- Launch preparation plan
- Approval of safety status for flight, range, ground hardware and operations

DID 8-7: Flight Operations Review

Title:	CDRL No.:
Flight Operations Review (FOR)	8-7

Reference:

Paragraph 8.2.1.1.g

Use:

To evaluate the final orbital operation plans as well as the compatibility of the flight components with ground support equipment and ground network, including summary results of the network compatibility tests.

Related Documents

None

Place/Time/Purpose of Delivery:

The FOR is held near the completion of pre-launch testing between the flight segment and the ground system.

Preparation Information:

Contact Systems Review Office (SRO).

The FOR should include all of the items specified for a MOR, updated to the present stage of progress, plus the following additional items:

- Closure of actions from the MOR.
- New requirements and changes in plans.
- Test result summaries including the Project's assessment of the criticality of open problems.
- Work remaining including tests, simulations, and closure of problems.
- Personnel location for Launch &Early Orbit (LE&O) and In-Orbit Checkout (IOC) including Project office, operations, and spacecraft subsystem expert personnel.
- Contingency procedures, development and verification/validation status.

DID 8-8: Launch Readiness Review

Title:	CDRL No.:
Launch Readiness Review (LRR)	8-8

Reference:

Paragraph 8.2.1.1.h

Use:

To review the total system to support the flight objectives of the mission. To review the flight hardware and software, the launch vehicle, all the ground support systems, and the launch and orbital operations for their readiness to support the launch.

Related Documents

None

Place/Time/Purpose of Delivery:

At launch site, 2 to 3 days prior to launch.

Preparation Information:

Contact Systems Review Office (SRO).

The review is to cover all the activity since the Pre-Shipment Review and the Flight Operations Readiness review, the closure of any actions from those reviews and a summation of all the testing and launch operations planning and rehearsals to the present. Any open items and residual risks are to be presented at this time. Closure of this review and any actions generated from the review indicate the mission is ready for launch.

DID 9-1: System Performance Verification Plan

Title: System Performance Verification Plan	CDRL No.: 9-1
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:	CDRL No.:
System Performance Verification Plan (cont.)	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 9-2: Performance Verification Procedure

Title:	CDRL No.:
Performance Verification Procedure	9-2

Reference:

Paragraph 9.2.6

Use:

Describes how each test activity defined in the Verification Plan will be implemented

Related Documents

None

Place/Time/Purpose of Delivery:

30 days prior to test for GSFC approval.

Preparation Information:

Describe the configuration of the tested item and the step-by-step functional and environmental test activity conducted at the unit/component, subsystem/instrument, and payload levels. Give details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, quality control checkpoints, pass/fail criteria, data collection and reporting requirements. Address safety and contamination control provisions. A methodology shall be provided for controlling, documenting and approving all activities not part of an approved procedure and establish controls for preventing accidents that could cause personal injury or damage to hardware and facilities.

DID 9-3: Verification Reports

Title:	CDRL No.:
Verification Reports	9-3

Reference:

Paragraphs 9.2.7, 9.2.8

Use:

Summarize compliance with system specification requirements and/or provide a summary of testing and analysis results, including conformance, nonconformance, and trend data.

Related Documents

None

Place/Time/Purpose of Delivery:

Verification Reports: Preliminary report 72 hours after test for GSFC information.

Final report 30 days after verification activity for GSFC information

System Performance Verification Report: Preliminary at CDR.

Final report 30 days following on-orbit check out.

Preparation Information:

Verification Report: Provide after each unit/component, subsystem/instrument, and payload verification activity. For each analysis activity the report shall describe the degree to which the objectives were accomplished, how well the mathematical model was validated by the test data, and other significant results.

System Performance Verification Report: Compare hardware/software specifications with the verified values (whether measured or computed). It is recommended that this report be subdivided by subsystem/instrument.

DID 10-1: Printed Wiring Boards Test Coupons

Title:	CDRL No.:
Printed Wiring Board (PWB) Test Coupons	10-1

Reference:

Paragraph 10.4.2.1

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 Requirements)
IPC-6018,	Microwave End Product Board Inspection and Test
IPC A-600,	Guidelines for Acceptability of Printed Boards (must use Class 3 Requirements)
S312-P-003,	Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses (must use in conjunction the IPC Standards)

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.
- 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 11-1: Parts, Materials and Processes Control Program Plan

Title: Parts, Materials and Processes Control Program Plan	CDRL No.:11-1

Reference:

Paragraph 11.1

Use:

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

Related Documents

Place/Time/Purpose of Delivery:

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

Preparation Information:

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

a. The developer's plan or approach for conforming to PMP requirements.

b. The developer's PMP control organization, identifying key individuals and specific responsibilities.

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

d. PMP 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 PMP approval status.

e. PMP procurement, processing and testing methodology and strategies. Identify internal operating procedures to be used for incoming inspections, screening, qualification testing, derating, testing of PMP pulled from stores, Destructive Physical Analysis, radiation assessments, etc.

f. PMP vendor surveillance and audit plan

g. Electrostatic Control Plan

h. Flow down of PMPCP requirements to sub-developers

DID 11-2: As designed Parts, Materials, and Processes List

Title: As-designed Parts, Materials, and Processes List (ADPMPL)	CDRL No.: 11-2

Reference:

Paragraph 11.3

Use:

Listing of all PMP intended for use in space flight hardware

Related Documents

Parts, Materials and Processes Control Program Plan

Place/Time/Purpose of Delivery:

The ADPMPL shall be submitted to the PMPCB, ten days prior to the first PMPCB meeting

Preparation Information:

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

a. PMP name

b. PMP number

c. Manufacturer

d. Manufacturer's generic PMP number

e. 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 ADPMPL shall identify changes from the previous submission.

DID 11-3: Materials Usage Agreement

Title: Materials Usage Agreement	CDRL No. 11-3
Reference: Paragraph 11.3	
Use: For usage evaluation and approval of non-compliant materials or lubrication usage.	
Related Documents: MSFC -SPEC-522, MSFC-HDBK-527, NHB 1700.7, GMI 1700.3, NASA-STD-6001	
Place/Time/Purpose of Delivery: Provide to the PMPCB, prior to the first PMPCB 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 11-4: Stress Corrosion Evaluation Form

Title: Stress Corrosion Evaluation Form	CDRL No.:11-4
Reference: Paragraphs 11.3.4	
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 PMPCB, prior to the first PMPCB 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 11-5: Polymeric Materials and Composites Usage List

Title: Polymeric Materials and Composites Usage List	CDRL No.:11-5

Reference:

Paragraph 11.3.5

Use:

For usage evaluation and approval of all polymeric and composite materials applications.

Related Documents:

NASA RP-1124, ASTM E 595, MSFC-HDBK-527, NHB 1700.7, EWR 127.1 GMI 1700.3, NASA-STD-6001

Place/Time/Purpose of Delivery:

Provide to the GSFC Project Office 30 days before developer PDR for review, 30 days before developer CDR for approval and 30 days before acceptance for approval.

Preparation Information:

The developer shall provide the information requested on the polymeric materials and composites usage list form, the equivalent information on the developer's form or the equivalent information electronically. The form is in the Mission Assurance Guide.

The polymeric materials and composites usage list (1) form requires, as a minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, developer, address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, date evaluated, item number, material identification (2), mix formula (3), cure (4), amount code, expected environment (5), outgassing values and reason for selection (6). Notes 1 through 6 are listed below:

1. List all polymeric materials and composites applications utilized in the system except lubricants that 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.

DID 11-6: Flammable Materials Usage List

Title: Flammable Materials Usage List	CDRL No.:11-6
Reference: Paragraph 11.3.6	
Use: For usage evaluation and approval of all flammable materials applications for STS.	
Related Documents: MSFC-HDBK-527, NSTS 22648, NHB 1700.7, GMI 1700.3, NASA-STD-6001	
Place/Time/Purpose of Delivery: Provide to the GSFC Project Office 30 days before developer PDR for review, 30 days before developer CDR for approval and 30 days before acceptance for approval.	

Preparation Information:

The flammability rating of all materials on the polymeric and composite materials usage list shall be provided on the flammable materials usage list. Each material usage shall be examined for flammability characteristics for use on the STS. For the orbiter payload bay area, an oxygen value of 20.9% should be examined. For the crew compartment area, oxygen values of 30% should be examined.

The flammable materials lists shall contain STS stowage location for the assembled piece of flight hardware (i.e., crew compartment or payload bay), and the listing of materials with an associated flammability rating. MSFC-HDBK-527 gives a partial listing of flammability ratings for various materials. MSFC also has a resource, the Materials And Processes Technical Information Service (MAPTIS), which is available to help in gathering flammability ratings. This service is available through computer Telnet applications. The materials lists should also state if a material is not rated, or has not yet been tested. Depending on the operational requirements of the flight hardware, flammability testing may be required. NASA-STD-6001 details the requirements of the flammability tests.

The routine and non-routine operation of the hardware shall not result in a release of flammable materials any area of the STS. Orbiter entry, landing and post landing operations shall not cause ignition of a flammable atmosphere in the payload bay area.

If flammable or untested materials are listed in the materials list, a flammability assessment should then be performed. NSTS 22648 guides the Materials Engineer through the configuration analysis. Flammable materials can be acceptable for STS application provided the flammability reduction methods and container guidelines of NSTS 22648 are used.

DID 11-7: Odor and Toxic Offgassing Materials Usage List

Title:	
Odor and Toxic Offgassing Materials Usage List	CDRL No.:11-7

Reference:

Paragraph 11.3.6

Use:

For usage evaluation and approval of all odor and toxic offgassing material applications in habitable areas of STS.

Related Documents

MSFC-HDBK-527, KHB 1700.7, NASA -STD-6001

Place/Time/Purpose of Delivery:

Provide to the GSFC Project Office 30 days before developer PDR for review, 30 days before developer CDR for approval and 30 days before acceptance for approval.

Preparation Information:

The toxicity rating of all materials on the polymeric and composite materials usage list and the lubrication list that are operated or stowed in the crew compartments will be provided on the Odor and Toxic Offgassing Materials Usage list. The odor and toxic characteristics of each material on the list shall be evaluated.

The materials lists shall contain STS stowage location for the assembled piece of flight hardware and associated odor and toxicity values. MSFC-HDBK-527 gives a partial listing of these values. MSFC also has a resource, the Materials And Processes Technical Information Service (MAPTIS), which is available to help in gathering odor and toxicity ratings. This service is available through computer Telnet applications. The materials lists should also state if a material is not rated, or has not yet been tested.

For unavailable ratings, or for materials that have not been tested, odor and toxicity values should be measured at the NASA White Sands Test Facility (WSTF). Goddard Materials Engineering personnel will be available to arrange this WSTF testing. WSTF can test individual materials up to entire hardware assemblies. Flight materials or assemblies are required for this test.

DID 11-8: Waiver

Title: Waiver	CDRL No.: 11-8

Reference:

Paragraph 11.3.8

Use:

For usage evaluation and approval of a material that has exceeded its shelf life or expiration date.

Related Documents:

None

Place/Time/Purpose of Delivery:

Provide to the GSFC Project Office for approval 30 days prior to the CDR or use.

Preparation Information:

A waiver shall be submitted for approval of uncured polymers that exceeded their expiration date or for flight approval of cured polymers and lubricated mechanism that have a limited shelf life.

For uncured polymers, mechanical and physical properties of polymer or paint samples made from same batch of expired uncured material or test data on identical expired uncured polymer or paint shall be submitted to demonstrate that the cured paint or polymer is acceptable.

For lubricated mechanisms and old polymer products such and o-rings, propellant tank diaphragms, seals dampers and tapes, mechanical and physical property data, test results and heritage performance information shall be submitted to demonstrate the flight acceptability of the hardware.

DID 11-9: Inorganic Materials and Composites Usage List

Title: Inorganic Materials and Composites Usage List	CDRL No.: 11-9
Reference: Paragraph 11.3.9	
Use: For usage evaluation and approval of all metal, ceramic and metal/ceramic composite material applications.	
Related Documents: MSFC-HDBK-527, NHB 1700.7, MSFC-SPEC-522	

Place/Time/Purpose of Delivery:

Provide to the GSFC Project Office 30 days before developer PDR for review, 30 days before developer CDR for approval and 30 days before acceptance for approval.

Preparation Information:

The hardware provider shall provide the information requested on the inorganic materials and composites usage list, the equivalent information on the hardware developer's forms or the equivalent information electronically.

The inorganic materials and composite usage list (1) form requires, as a minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, developer, developer address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, item number, materials identification (2), condition (3), application or usage (4), expected environment (5), stress corrosion cracking table number, MUA number and NDE method. Notes 1 through 5 are listed below:

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.

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

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.

Give details of where on the spacecraft the material shall be used (component) and its function. Example: Electronics box structure in attitude control system, not hermetically sealed.

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:

a. T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV)
b. Storage: up to 1 year at room temperature
c. Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxygen

DID 11-10: Fastener Control Plan

Title: Fastener Control Plan	CDRL No.: 11-10

Reference:

Paragraph 11.3.10

Use:

For evaluation and approval.

Related Documents:

541-PG-8072.1.2, NHB 1700.7, GSFC 731-0005-83, GMI 1700.3

Place/Time/Purpose of Delivery:

Provide with proposal for GSFC review and 30 days before the PDR for approval.

Preparation Information:

The developer's fastener control plan shall address the following for flight hardware threaded fasteners that are used in structural or critical applications:

a. acquisition/supplier control

b. documentation/traceability

c. receiving inspection/testing

DID 11-11: Lubrication Usage List

Title: Lubrication Usage List	CDRL No.:11-11
Reference: Paragraph 11.3.11	
Use: For evaluation and approval of all lubricant usage and applications.	
Related Documents: None	
Place/Time/Purpose of Delivery: Provide to the GSFC Project Office 30 days before developer PDR for review, 30 days before developer CDR for approval and 30 days before acceptance for approval.	

Preparation Information:

The hardware provider shall provide the information requested on the lubricant usage list, the equivalent information on the hardware developer's forms or the equivalent information electronically. The form is in the Mission Assurance Guide.

The lubricant usage list form requires, as the minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, developer, developer address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, item number, component type, size, material (1); component manufacturer and manufacturer identification; proposed lubrication system and amount of lubrication; type and number of wear cycles (2); speed, temperature and atmosphere of operation (3); type and magnitude of loads (4) and other details (5). Notes 1 through 5 are listed below:

1. Ball bearing (BB), Sleeve bearing (SB), Gear (G), Sliding surfaces (SS), Sliding electrical contacts (SEC), Give generic identification of materials used for the component, (Examples: 440C steel, PTFE)
2. Continuous unidirectional rotation (CUR), Continuous oscillation (CO), intermittent rotation (IR), intermittent oscillation (IO), Small angle oscillation (< 30 degrees) SAM, large angle oscillation (> 30 degrees) (LAM), Continuous sliding (CS), Intermittent sliding (IS). Number of wear cycles: 1 to 1E2 (A), 1E2 to 1E4 (B), 1E4 to 1E6 (C), >1E6 (D)
3. Speed: revolution per min. (RPM), oscillation per min. (OPM), variable speed (VS), sliding speed in cm. per min. (CPM) Operational temperature range Atmosphere: vacuum, air, gas sealed or unsealed and pressure
4. Type of loads: Axial, radial, tangential (gear load). Give magnitude of load.
5. For ball bearings, give type and material of ball cage, number of shields, type of ball groove surface finishes. For gears, give surface treatment and hardness. For sleeve bearings, give the bore diameter and width. Provide the torque and torque margins.

DID 11-12: Life Test Plan for Lubricated Mechanisms

Title:	
Life Test Plan for Lubricated Mechanisms	CDRL No.:11-12

Reference:

Paragraphs 11.3.11

Use:

For evaluation and approval of all lubricated mechanisms.

Related Documents

None

Place/Time/Purpose of Delivery:

Provide to the GSFC Project Office 30 days before developer PDR for review, 30 days before developer CDR for approval and 30 days before acceptance for approval.

Preparation Information:

The Life Test Plan for Lubricated Mechanisms shall contain:

a. Table of Contents
b. Description of all lubricated mechanisms, performance functions, summary of subsystem specifications and life requirements.
c. Heritage of identical mechanisms and descriptions of identical applications.
d. Design, drawings and lubrication system utilized by the mechanism.
e. Test plan including vacuum, temperature and vibration test environmental conditions of the test.
f. Criteria for a successful test.
g. Delivery of test hardware to GSFC after a successful test.
h. Final Report.

DID 11-13: Material Process Utilization List

Title: Material Process Utilization List	CDRL No.: 11-13

Reference:

Paragraph 11.3.12

Use:

For usage evaluation and approval of all material processes that are used to fabricate, clean, store, integrate and test the space flight hardware.

Related Documents:

None

Place/Time/Purpose of Delivery:

Provide to the GSFC Project Office 30 days before developer PDR for review, 30 days before developer CDR for approval and 30 days before acceptance for approval. . A copy of any process shall be submitted to the GSFC Project Office upon request.

Preparation Information:

The provider shall provide the information requested on the material process utilization list form, the equivalent information developer's forms or the equivalent information electronically. The form is in the Mission Assurance Guide.

The material process utilization list requires, as a minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, developer, address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, date evaluated, item number, process type (1), developer spec. number (2), Military, ASTM, Federal or other specification number, description of material processed (3) and spacecraft/instrument application (4). Notes 1 through 4 are listed below:

1. Give generic name of the process. Example: anodizing (sulfuric acid)
2. If process is proprietary, please state so.
3. Identify the type and condition of the material subjected to the process. Example: 6061-T6
4. Identify the component or structure for which the materials are being processed. Example: Antenna dish.

All welding and brazing of all flight hardware, including repairs, shall be performed by certified operators in accordance with requirements of the appropriate industry or government standards listed in the Materials Process Utilization List , Fig. 11-6. A copy of the procedure qualification record (PQR) and a current copy of the operator qualification test record shall be provided along with the Materials Process Utilization List.

DID 11-14: Certificate of Raw Material Compliance

Title: Certificate of Raw Material Compliance	CDRL No.: 11-14

Reference:

Paragraph 11.4.5.3

Use:

For information assuring acceptable flaw content, chemical composition and physical properties of raw material.

Related Documents:

None

Place/Time/Purpose of Delivery:

Provide to the GSFC project 15 days after request.

Preparation Information:

The provider shall provide information pertaining to the control of raw material. The developer shall provide sufficient information to ensure that the supplied material meets the specified requirements. The developer shall indicate the spacecraft and subsystem or instrument and part using the material.

The generic and manufacturer's designation (if any) shall be provided for the material including the type of test employed to verify material composition.

The provider shall indicate what tests have been performed to verify physical properties and the applicable standards controlling the testing. For example, the heat treat condition of aluminum alloys may be verified by mechanical testing or hardness and conductivity testing.

The provider shall indicate what nondestructive tests have been performed, the applicable standards controlling the testing, the type of flaw detected and the minimum detectable flaw found as a result of the testing.

DID 12-1: Contamination Control Plan

Title:	CDRL No.:
Contamination Control Plan	12-1

Reference:

Paragraph 12.1

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.

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	4/7/99	New PG number initiated as a result of cancellation of GPG 8730.4. This PG replaces 300-PG-8730.4.2 with no changes other than numbering references to 7120.2 rather than 8730.4.
A	09/09/01	Total revamp of document.
B	06/24/02	Removed single quotation mark from the document title, section 1.4 References. Removed the quotation marks from the document title, section 1.5 Cancellation. Added GIDEP and NASA advisory as requirements to chapter 2.2.7. Added reference to various NASA software standards in Chapter 5, SW Assurance. Removed specific text specific to technical reviews from Chapter 6, GDS Assurance. Removed text specific to ISO QMS from Chapter 6, GDS Assurance. Added text to address flow-down of quality requirements. Updated references to ISO standard to the 2000 version. Added requirement that the manufacturer shall notify GSFC of any changes to a procured part's specification or design in chapter 11.3.1.1. Minor text edits within safety related sections and DIDs (specifically chapter 3.10 and DID 3-8).
C	03/14/03	Rewrite of chapter 3, Safety. Specific edits include but are not limited to adding software safety related text (chapter 3.11, adding System Safety Program Plan related text and associated DID, and removing System Safety Implementation Plan related text and associated DID. Rewrite of chapter 5 Software Assurance. Specific edits include but are not limited to rewrite of entire section to be in alignment with NASA Software Assurance Standard and to specifically and adequately address the software related disciplines that comprise software assurance including software quality assurance, software safety, software reliability, verification and validation, and IV&V. Added DIDs for software reliability plan and software safety plan, as well as NASA and industry related references pertaining to software. Revised text in chapter 11, specifically chapter 11.3.1.1 to address PEMs and chapter 11.6.1.4 to address parts in same lot date code. Added definitions for several missing terms including but not limited to mission assurance, reliability and maintainability.

GODDARD SPACE FLIGHT CENTER

General Environmental Verification Specification (GEVS) for STS and ELV Payloads, Subsystems, and Components, Revision A

GEVS-SE Revision A consists of two sections and eleven appendices as follows:

Section 1 - General information including definitions, safety precautions, administration of the test program, failure criteria, distribution of revisions, testing and space hardware, test facilities, and tolerances.

Section 2 - System and environmental verification program including structural dynamics, pressure profile, mass properties, electromagnetic compatibility, thermal-vacuum, thermal balance, humidity, leakage, contamination control, and end-to-end testing.

Appendices A through L, General information and Structural Dynamic Test Levels

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NOTE: GEVS-SE Revision A is provided in PDF format which requires a separate Acrobat reader which is freely available. A copy of the Acrobat reader may be obtained for IBM-PC, MacIntosh, and Sun workstation from Adobe Systems.

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