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Earth System Explorers Program Mission Assurance Requirements (MAR)

Mission Risk Classification – C

Free Flyer Payload

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and
Space Administration

Earth System Explorers Program

Mission Assurance Requirements

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Preface

This document is an Earth System Explorers signature-controlled document. Changes to this document require prior approval by the Earth System Explorers Configuration Control Board (CCB) Chairperson or designee. Proposed changes shall be submitted in the Earth System Explorers Technical Data Management System via a Signature Control Request (SCoRe) along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

All of the requirements in this document assume the use of the word "shall" unless otherwise stated.

Questions or comments concerning this document should be addressed to:
Earth System Explorers Configuration Management Office
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Change History Log

Revision	Effective Date	Description of Changes (Reference the CCR & CCB/ERB Approval Date)
-	February 15, 2023	Initial baseline review; Approved by CCR#1033

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DOCUMENT ORGANIZATION AND CONVENTIONS

This document establishes a risk-based application of mission assurance requirements for a Class C free flyer payload. It is organized around the following Safety and Mission Assurance (SMA) disciplines/focus areas, each with its own section:

- Section 1 – General SMA Requirements
- Section 2 – Quality Management System
- Section 3 – System Safety
- Section 4 – Reliability
- Section 5 – Software Assurance
- Section 6 - Workmanship
- Section 7 - EEE Parts
- Section 8 – Materials and Processes
- Section 9 – Contamination Control
- Section 10 – Metrology and Calibration
- Section 11 – GIDEP Alerts and Problem Advisories
- Section 12 – End Item Acceptance Data Package

Each discipline/focus area is further decomposed into subsections associated with its individual SMA activities or deliverables (ex. within Section 2.2 "Quality Management System", subsection 2.2.2 flows down the specific requirements for operating a "Material Review Board"). In instances where the risk classification does not warrant the flow down of specific SMA process/product standards, that section or subsection has been identified as "not applicable", and the developer is expected to apply their internal standards, without government oversight.

In this document, a specific requirement is denoted by "shall," a good practice by "should, permission by "may", and an expectation by "will".

The requirements in this document use the following identification convention:

SMA Discipline_Numeric Identifier

Ex. QMS_01

Where the key is as follows:

SMA Discipline	One of the following 3-character mnemonics associated with the corresponding SMA Discipline/Focus Area: • GEN – General SMA Requirements • QMS – Quality Management System • SAF – System Safety • REL - Reliability • SWA – Software Assurance • WOR - Workmanship • EEE - EEE Parts • MAP – Materials and Processes • CON – Contamination Control • MAC – Metrology and Calibration • GID - GIDEP Alerts and Problem Advisories • EIA – End Item Acceptance Data Package

Numeric Identifier	A unique, sequential 2-digit number assigned to each requirement in the discipline/focus area

GENERAL

1.1 Systems Safety and Mission Assurance Program

GEN_01: The developer shall implement a safety and mission assurance program that is consistent with contractual requirements. The mission assurance program shall cover:

- Flight hardware and software that is designed, built, or provided by the developer and its subcontractors or furnished by the government, from project initiation through launch and mission operations
- The ground support equipment that interfaces with flight items to the extent necessary to assure the integrity and safety of flight items
- Ground systems required for spacecraft communication, command and control, health and safety monitoring, and science data processing/distribution.

GEN_02: The developer shall submit a compliance matrix that identifies variance and acceptance rationale for processes, procedures, and standards that are proposed as alternatives to those specified by the contract (DID 1-1). This includes identification of requirements for which relief is requested via the Inherited Item Risk Assessment process (see Section 1.9 "Use of Inherited Products/Items").

1.2 Management

GEN_03: The developer shall designate a manager for assurance activities. The assurance manager shall not be responsible for project costs and schedules other than those pertaining to assurance activities.

GEN_04: The developer shall ensure that the assurance manager has direct access to upper management that is independent of project management, with functional freedom and authority to interact with all elements of the project.

1.3 Requirements Flowdown

GEN_05: The Developer shall ensure flow down of SMA requirements to all suppliers based on the work to be performed and establish a process to verify compliance, with the exception of those approved for relief via the Inherited Item Risk Assessment process (see Section 1.9 "Use of Inherited Products/Items").

GEN_06: The Developer's contract review and purchasing processes shall indicate the method for documenting, communicating and reviewing requirements with sub-tier suppliers to ensure requirements are met.

GEN_07: The Developer shall ensure that quality plans, processes, procedures, hardware and software submitted by the Developer's sub-tier suppliers are compliant with the requirements in this MAR, as applicable.

1.4 Identification of Project-Level Critical Items (PCIs)

GEN_08: The Developer shall identify its critical items for incorporation into the project-level critical items (PCIs) developed in accordance with NASA Procedural Requirement (NPR) 8735.2, Section 4.1.4 "Critical Items and Processes Determination".

GEN_10: Identification of critical items and processes should include the results of system safety and reliability analyses.

1.5 Suspension of Work Activities

GEN_11: The developer shall direct the suspension of any work activity that presents an unsafe work condition to personnel or imminent danger to property.

1.6 Surveillance

GEN_12: The developer shall provide access to quality management system documentation, information systems and work products/artifacts to NASA representatives.

GEN_13: The work activities, operations, and documentation performed by the Contractor and sub-tier contractors, or suppliers shall be subject to evaluation, review, audit, inspection, and survey by NASA representatives at various points over the program/project development lifecycle.

GEN_14: In accordance with Federal Acquisition Regulations 46.103, 46.104, 46.202-2, 46.4, and 46.5, the developer shall grant physical or remote access to NASA representatives to conduct an on-site and/or remote audit, assessment, or inspection upon notice. A 30-day notice will be provided to the supplier/developer prior to the start of an assessment. The supplier/developer shall supply personnel, documents, records, equipment, and an acceptable work area within the developer's facilities to assist with the audit/assessments/inspections.

GEN_15: The developer shall report the status of facility operations and quality metrics to NASA on a quarterly basis. This should include the following data for 1st tier and 2nd tier suppliers of project-defined critical items:

- Quality escapes - Any product released by an internal or external supplier that is subsequently determined to be nonconforming to contract and/or product specification requirements:
- First Pass Yield - A measure of quality in a process that reflects the percentage of product made correctly without any rework or corrective activity.
- Supplier Defect Rate - The supplier defeat rate measures the percentage of materials or product received from suppliers that do not meet required or compliance specifications.
- Internal Audit results

1.7 Government Mandatory Inspection Points (GMIPs)

GEN_16: For cost plus projects, the developer shall provide a plan for proposed GMIPs of project-level critical items, subject to government approval. NPR 8735.2 “Hardware Quality Assurance Program Requirements for Programs and Projects” may be used as a guide. Prior to the start of manufacturing, the developer shall provide work instructions, procedures, drawings, etc. that are required for performing the planned inspections.

1.8 List of Suppliers

GEN_19: The developer shall provide a list of suppliers used for product produced under this contract (DID 1-2).

1.9 Use of Inherited Products/Items

GEN_20: For Inherited Products/Items, defined as those that will be build-to-print, or rebuilt with modification, or are available as COTS, or were previously developed and exist (e.g., spares), the developer may propose to follow any Inherited Items Process approved by NASA.

Use of this process does not relieve the developer from meeting contractual performance and functional requirements for the Inherited Product."

1.10 Protection of Flight Hardware

GEN_21: The Developer shall evaluate the potential for Ground Support Equipment (GSE) to damage flight hardware and use appropriate means to prevent such damage from occurring.

GEN_22: The approach to obviate GSE damage to flight hardware shall be presented prior to the start of testing and at subsequent review milestones.

GEN_23: Prior to performing work on flight hardware, the performing organization shall Identify a list of items, if any, that are sensitive to normal handling environments, such as presence of light, presence of metal objects (magnets), or presence of humidity outside of normal cleanroom and workmanship limits.

GEN_24: The Developer shall hold a meeting on the day work is to be performed, prior to the start of each shift, that includes a discussion of the list of items.

1.11 Risk Management

GEN_25: SMA activities should be tightly linked with the project's Risk Management processes. For example, risks that evolve from reliability analyses that affect overall mission objectives should be managed in the project's risk database when not eliminated or mitigated to noncredible likelihood levels.

2 QUALITY MANAGEMENT SYSTEM

2.1 General

QMS_01: The developer shall have a quality management system that is compliant with the requirements of Society of Automotive Engineers AS9100 Quality Systems - Aerospace - Model for Quality Assurance in Design, Development, Production, Installation and Servicing.

2.2 Supplemental Quality Management System Requirements

Control of Nonconforming Product

QMS_05: The developer shall have a documented closed loop system for identifying, reporting, and correcting product nonconformances. The system shall ensure that the adequacy of corrective action is determined by audit, inspection or test, that objective evidence is collected, and that preventive action is implemented to preclude recurrence.

2.2.1 Material Review Board (MRB)

QMS_07: The Developer shall have a documented process(es) for the establishment and operation of an MRB to process major non-conformances, which are those that (1) affect form, fit, function, (2) require a software change, (3) involve the presence of Foreign Object Damage (FOD), or (4) the developer determines involves elevated risk.

QMS_08: The Developer shall appoint a MRB chairperson who is responsible for implementing the MRB process and for appointing Developer representatives as MRB members.

QMS_10: The MRB process shall include a government representative as a participating member on MRB actions involving major nonconformances.

QMS_12: The government shall be provided notice and applicable documentation 24 hours in advance of scheduled MRB meetings.

QMS_14: The MRB shall use the following disposition actions:

- Scrap — the product is not usable
- Re-work/Re-test — the product will be re-worked/re-tested to conform to requirements (sometimes referred to as “return to print”)
- Return to supplier — the product will be returned to the supplier
- Repair — the product will be repaired
- Use as is — the product will be used as is

2.2.3 Anomaly Reporting and Disposition

QMS_15: The developer shall have a documented process for the establishment and operation of an anomaly review board (ARB) to process (report and disposition) major anomalies, which are those that have resulted in hardware or software test failures and damage or potential damage to hardware (DID 2-1).

QMS_17: Reporting of major anomalies shall begin with the first application of power at the component or board level, flight software acceptance testing and when interfacing with flight hardware, and the first mechanical operation.

QMS_19: The ARB (or equivalent function) shall permit a government representative to be a participating member.

QMS_20: The government shall be provided notice of major anomalies and applicable documentation in advance of scheduled ARB meetings.

QMS_21: Failures that cannot be duplicated, have unknown root cause, or cannot be verified shall be assessed for residual risk, declared as red flag problem failure records (PFRs), and brought to the project risk board for disposition.

2.3 Orbital Debris Assessment Report (ODAR) and End of Mission Plan (EOMP)

QMS_22: The developer shall provide the information necessary for the development of the ODAR and the EOMP deliveries per the content defined in NASA-STD 8719.14 Process for Limiting Orbital Debris (DID 2-2).

3 SYSTEM SAFETY

3.1 General

SAF_01: The developer shall document and implement a system safety program, support the ELV Safety Review Process as defined in Chapter 3 of NPR 8715.7 Payload Safety Program, comply with launch service provider requirements and comply with launch range safety requirements.

SAF_02: The developer shall include the following specific safety requirements in the system safety program:

- The developer shall incorporate three independent inhibits in the design (dual failure tolerant) if a system failure may lead to a catastrophic hazard. A prelaunch catastrophic hazard is a payload-related hazard, condition, or event occurring prior to launch that could result in a fatal injury to personnel or loss of a ground facility. A post-launch catastrophic hazard is a payload-related hazard, condition, or event occurring after launch and up to payload separation that could result in a fatal injury or loss of flight termination system.
- The developer shall incorporate two independent inhibits in the design (single failure tolerant) if a system failure may lead to a critical hazard. A critical hazard is defined as a hazard, condition or event that may cause severe injury or occupational illness or major property damage to facilities.
- The developer shall adhere to specific detailed safety requirements, including compliance verification that must be met for design elements with hazards that cannot be controlled by failure tolerance. The process by which safety is incorporated into these design elements (e.g., structures and pressure vessels) is called "Design for Minimum Risk".

3.2 Mission Related Safety Requirements Documentation

SAF_03: The developer shall implement the launch range safety requirements that are applicable to the launch site. The developer shall implement the most stringent safety requirement in the event there are conflicting requirements. The sections below include the applicable requirements documents for the pertinent launch ranges:

SAF_04: ELV Eastern Test Range or Western Test Range Missions

- NASA-STD 8719.24 (with Annex) NASA Expendable Launch Vehicle Payload Safety Requirements
- KNPR 8715.3 Kennedy Space Center (KSC) Safety Practices Procedural Requirements (applicable at KSC property, KSC-controlled property, and offsite facility areas where KSC has operational responsibility)
- NPR 8715.7 Expendable Launch Vehicle Payload Safety Program
- Launch Site Facility-specific Safety Requirements, as applicable (e.g., Astrotech)

SAF_05: Wallops Flight Facility (WFF) Missions

- NASA-STD 8719.24 (with Annex) NASA Expendable Launch Vehicle Payload Safety Requirements
- GSFC-STD-8009 Range Safety Manual for Goddard/WFF

SAF_06: Japanese Missions

- NASA-STD 8719.24 (with Annex) NASA Expendable Launch Vehicle Payload Safety Requirements, as negotiated with Japan Aerospace Exploration Agency and Goddard SMA Directorate
- JMR 002 Launch Vehicle Payload Safety Requirements
- JERG-1-007 Safety Regulations for Launch Site Operations/Flight Control Operations
- KDP-99105 Safety Guide for H-II/H-IIA Payload Launch Campaign

SAF_07: European Missions

- NASA-STD 8719.24 (with Annex) NASA Expendable Launch Vehicle Payload Safety Requirements, as negotiated by each project with European Space Agency and Goddard SMA Directorate
- ECSS-E-10A Space Engineering – System Engineering
- ECSS-Q-40-02A Space Product Assurance – Hazard Analysis
- ECSS-Q-40 Space Product Assurance: Safety
- CSG-NT-SBU-16687-CNES Payload Safety Handbook
- CNES/P N°2010-1 of December 2010 Operation of the Guiana Space Centre Facilities

SAF_08: Russian Missions

- P32928-103 Requirements for International Partner Cargoes Transported on Russian Progress and Soyuz Vehicles

3.3 System Safety Deliverables

3.3.1 System Safety Program Plan

SAF_10: The developer shall prepare a System Safety Program Plan (SSPP) that describes the tasks and activities of system safety management and engineering required to identify, evaluate, and eliminate or control hazards to the hardware, software, and system design by

reducing the associated risk to an acceptable level throughout the system life cycle, including launch range safety requirements (DID 3-1).

3.3.2 Safety Requirements Compliance Checklist

SAF_11: The developer shall document and implement a Safety Requirements Compliance Checklist to demonstrate that the payload complies with NASA and range safety requirements (DID 3-2).

3.3.3 Hazard Analyses

3.3.3.1 Preliminary Hazard Analysis

SAF_13: The developer shall perform a Preliminary Hazard Analysis (PHA) to obtain an initial risk assessment and to identify safety critical areas of a concept or system. The developer will base the PHA on the best available data, including mishap data from similar systems and other lessons learned.

SAF_14: The developer shall evaluate hazards associated with the proposed design or function for severity, control approach (fault tolerance or design for minimum risk), and operational constraints. The developer shall identify safety provisions and alternatives that are needed to eliminate hazards or reduce their associated risk to an acceptable level.

SAF_15: The developer shall deliver the PHA with <Preliminary ISAR (DID 3-4ISR) or SDP I (DID 3-4SDP).

3.3.3.2 Operations Hazard Analysis (OHA) and Hazard Verification Tracking Log (HVTL)

SAF_16: The developer shall document, implement, and maintain an OHA and a HVTL to demonstrate that hardware operations, test equipment operations, and integration and test (I&T) activities comply with the safety requirements of the facilities where the activities will be performed and that hazards associated with those activities are mitigated to an acceptable level of risk (DID 3-3).

SAF_17: The developer shall update and maintain the Hazard Verification Tracking Log during I&T activities to track open issues.

3.3.3.3. Lifting Device Safety Requirements

A Critical Lift is defined as a lift during which failure/loss of control presents an elevated risk of serious injury, loss of life, or loss of one-of-a-kind articles, or high dollar items, whose loss would have serious programmatic or institutional impact.

SAF_18: The developer shall implement the following safety requirements for lifting devices and equipment (LDE) when performing NASA work at non-NASA facilities:

- Overhead cranes, winches, and wire rope hoists shall have a dual hoist braking system installed per the NASA STD 8719.9 (Lifting Standard), Sections 5.4 and 7.4. Chain hoists typically do not have dual brakes as standard equipment unless included in the manufacturer's design when specifically requested by the user. A single hoist motor holding brake in combination with a Variable Frequency Drive dynamic braking system is an acceptable dual braking system.
- Label and tag LDE the NASA STD 8719.9B, Section 4.9 requirements with no more than its Working Load Limit (WLL) as determined by the original equipment manufacturer (OEM) or its current certified WLL if that value is lower than the OEM rated WLL.
- Perform an initial one-time proof load test per the following NASA STD 8719.9B, Section 4.5 requirements:
  - 1.25X WLL for overhead cranes.
  - 1.25X WLL for mobile aerial platforms that will be used near critical hardware.
  - 1X WLL for mobile cranes and derricks (.95X to 1X is acceptable).
  - 1.25X WLL for below-the-hook lifting devices.
  - Slings (i.e., wire rope, synthetics, chain, etc.,) should only be proof load tested beyond its WLL with OEM approval.
  - 2X WLL for rigging hardware items used for critical lifts (i.e., shackles. hoist rings. turnbuckles, etc.,).
- Perform a 1X WLL load test every four years after the initial proof test on all LDE.
- In addition to visual inspection, perform a post load test nondestructive testing (NDT) inspection (e.g., radiographic, ultra-sonic, magnetic particle, dye penetrant, etc.) on crane hooks and critical welds. A critical weld is one in which a failure would result in a failure of the hardware. The inspections will be performed by an American Society of Non-destructive Testing or equivalently trained inspector.

3.3.3.4 Operating and Support Hazard Analysis

SAF_20: The developer shall perform an Operating and Support Hazard Analysis (O&SHA) to evaluate activities for hazards introduced during testing, transportation, storage, integration, and prelaunch operations at the launch site. The primary purpose is to evaluate the adequacy of procedures used to eliminate, control, or mitigate identified hazards so as to ensure implementation of safety requirements for personnel, procedures, and equipment during activities at the launch site.

SAF_21: The developer shall submit the results of the O&SHA as a part of the <Intermediate & Final ISARs (DID 3-4ISR) or SDP II and SDP III (DID 3-4SDP)>.

3.3.4 Instrument Safety Assessment Report (ISAR)/ Safety Data Package (SDP)

SAF_22: The developer shall generate an ISAR to document the comprehensive evaluation of the risk being assumed prior to the testing or operation of an instrument. The spacecraft developer will use the ISAR as an input to the SDP (DID 3-4SDP).

SAF_23: The developer shall prepare an integrated SDP to document the results of hazard analyses identifying the prelaunch, launch and ascent hazards associated with the flight system, ground support equipment, and their interfaces in hazard reports (DID 3-4).

3.3.5 Verification Tracking Log (VTL)

SAF_24: The developer shall document and implement a VTL that documents a Hazard Control and Verification Tracking process as a closed-loop system that ensures safety compliance has been satisfied per applicable launch range safety requirements.

SAF_25: The developer shall document in the VTL the process of verifying the control of hazards by test, analysis, inspection, similarity to previously qualified hardware, or any combination of these activities.

SAF_26: The developer shall ensure that verifications listed on the hazard reports refer to specific test, analysis, or inspection reports with a summary of the pertinent results.

SAF_27: The developer shall make the results of these tests, analyses, and inspections available for government review.

SAF_28: The VTL shall identify hazard controls that are not verified as closed and shall be delivered with the <final ISAR (DID 3-4ISR) or SDP III (DID 3-4SDP)>.

SAF_29: The developer shall provide regular electronic updates of the VTL until all hazard controls are verified as closed.

3.3.6 Hazardous Procedures for Payload I&T and Pre-launch Processing

SAF_30: The developer shall document the hazardous procedures that will be implemented when integration and test activities and pre-launch activities are performed at processing facilities and the launch site (DID 3-5).

SAF_31: The developer shall ensure that the procedures comply with applicable facility safety requirements.

SAF_32: The developer shall provide safety support for the implementation of hazardous procedures.

3.3.7 N/A

3.3.8 Mishap Reporting and Investigation

SAF_33: The developer shall prepare a Pre-Mishap Plan that describes appropriate mishap and close call notification, reporting, recording, and investigation procedures (DID 3-6).

SAF_34: The developer shall report accidents, test failures, or other mishaps and close calls promptly to NASA.

SAF_35: The developer shall promptly investigate to determine the root cause.

3.3.9 NASA Expendable Launch Vehicle (ELV) Payload Safety Program Forms

SAF_36: The developer shall prepare NASA Expendable Launch Vehicle Payload Safety Forms. The forms are available at URL https://kscsma.ksc.nasa.gov/PayloadSafety/forms.

4 RELIABILITY

4.1 Reliability Program Plan (RPP)

REL_01: The developer shall document and implement an RPP that includes both qualitative and quantitative techniques to support decisions regarding mission success and safety throughout system development (DID 4-1).

REL_03: The developer shall include a detailed approach to the analysis of hardware and software for their contributions to system reliability and mission success

REL_05: The developer should perform reliability analyses concurrent with design and maintain consistency between reliability analyses so that identified problem areas are addressed, and corrective action taken in a timely manner.

4.2 Analysis of Design

4.2.1 FMECA and Critical Items List (CIL)

REL_11: The developer shall perform and maintain Failure Modes and Effects Criticality Analyses (FMECA) that address flight hardware and software and ground support equipment that interfaces with flight systems that are being designed, built, or provided from project initiation through launch and mission operations. The developer shall include likelihood, cause, detection and mitigation, and the effects of each failure mode at the local, subsystem, and system or mission levels, to the interface level for existing systems and to the box or functional level for modified or new systems (DID 4-2).

REL_12: The developer shall prepare and maintain a Critical Items List for items with failure-mode severity categories 1SC (Safety Critical), 1, 1R (Redundant), 1S (Safety), and 2 per table 4.1.

Table 4.1 Severity Categories

	Criticality	Category	Description
SPFs	Critical	1SC	Failure modes that could cause a catastrophic event such as the loss of life, permanently disabling injury to personnel, or facility loss/destruction.
		1	Failure modes that could result in mission loss or minimum mission success criteria not being achievable.
		1S	Failure modes that could prevent detection of or operations during a hazardous condition resulting in 1SC conditions, eliminate a hazard inhibit, or cause severe injury, occupational illness, or major property damage.
		1R	Failure modes of identical or equivalent redundant hardware items that, if all failed, could result in category 1/1SC effects.
		2	Failure modes that could result in loss of one or more mission objectives, including the significant loss of data, functionality, or a significant reduction in life of the mission. Minimum mission success criteria is still achievable.
	Significant	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 full mission objectives and still meet minimum mission.
	Minor	4	Minor Failure modes that could result in insignificant or no loss to mission objectives.

REL_13: The developer shall prepare and maintain a Single Point Failure (SPF) list for modes resulting in category 1 and 1SC severities per table 4.1 and document applicable failure causes, mitigations, and retention rationale.

REL_14: The developer shall identify and assess any known common cause failure modes and their causes for category 1R and 2R items.

REL_15: The developer shall estimate the likelihood score for each failure mode using the appropriate criteria provided by the managing NASA Center or in the developer's standard risk scale. Each likelihood prediction can be based on qualitative assessment and/or failure rate data from other analyses (i.e., system calculations) in order to score each failure mode for the mission duration.

4.2.2 Fault Tree Analysis (FTA)

REL_18: The developer shall perform and maintain qualitative fault tree analyses (FTA) (DID 4-3), as deemed necessary by the Chief Safety & Mission Assurance Officer (CSO) and the Mission Systems Engineer (MSE).

REL_19: The fault tree shall address both hardware and software contributions at a level necessary to identify risks, verify mitigations, and assist in the development of fault management.

REL_20: In the event the developer or the project identifies a major mission risk contributor in the FMECA or FTA, the developer shall quantify (and if necessary, expand) the appropriate FTA or the portions of the FTA necessary for detailed risk assessment, as deemed necessary by the CSO and the MSE.

REL_21: FTA should also be considered for use to check the FMECAs for completeness.

4.2.3 Reliability Calculations

REL_23: The developer shall perform and maintain reliability and ground-system availability calculations using Fault Tree Analyses (FTA), reliability block diagrams, and/or Probabilistic Risk Assessment (DID 4-4) to identify design weaknesses, support design trades, and demonstrate the impact of critical items, as deemed necessary by the CSO and the MSE.

4.3 Limited Life Analysis

REL_25: The developer shall perform a Limited Life Item Analysis (LLA) that identifies components that have a limited useful life inherent to the performance of their respective function and documents and fosters a plan to manage limited life items (DID 4-5).

REL_27: The developer shall prepare a list of limited life items that includes expected life, required life, an assessment of life margin (including servicing and maintenance), and retention rationale for items with an expected life of less than 2x the required life.

REL_29: The risk assessment and mitigations plans shall factor in wear caused by atomic oxygen, solar and trapped radiation, shelf-life, extreme temperatures, thermal cycling, and mechanical wear or fatigue, and include refurbishment and maintenance plans.

Table 4.2 Example Limited Life Item Tracking Log

Limited-Life Item:				
Limiting Characteristic:				
Date	Start (e.g., time)	End (e.g., time)	Total	Remarks

4.4 Parts Stress Analysis

REL_30: The developer shall perform parts stress and derating analyses for electrical, electronic, and electromechanical (EEE) parts in accordance with EEE-INST-002 Instruction for EEE Parts Selection, Screening, Qualification, and Derating (DID 4-6) or developer's own established derating document, unless specifically relieved of this requirement by the Inherited Items Risk Assessment process being used by the developer (See Section 1.9).

REL_32: If alternate derating guidelines are requested to be used, they will be submitted to the Parts Control Board for approval.

4.5 Worst-Case Analysis

REL_35: The developer shall perform worst-case analyses (WCA) for circuit designs that are new or significantly modified and identified as critical through analysis of the design (See Section 4.2) (DID 4-7).

5 SOFTWARE ASSURANCE

5.1 Software Assurance Program

SWA_01: The developer shall establish a software assurance program consisting of a planned and systematic set of activities and disciplines that ensures that software conforms to organizational and project-specific requirements and standards throughout the project lifecycle, where software is defined as:

- Computer programs, procedures, and possibly associated documentation and data pertaining to the operation of a computer system.
- All or a part of the programs, procedures, rules, and associated documentation of an information processing system.
- Program or set of programs used to run a computer.
- All or part of the programs which process or support the processing of digital information.
- Part of a product that is the computer program or the set of computer programs.

Note: The software definition applies to software developed by NASA, software developed for NASA, software maintained by or for NASA, COTS, Government off-the-shelf software, Modified off-the-shelf software, Open Source Software, reused software components, auto-generated code, embedded software, software used on ground support equipment, the software executed on processors embedded in programmable logic devices, legacy, heritage, applications, freeware, shareware, trial or demonstration software, and open-source software components.

SWA_03: The developer shall ensure the independence of software assurance from software engineering.

SWA_04: The developer shall document and implement a Software Assurance Plan and schedule compliant to NASA-STD-8739.8A, NASA Software Assurance and Software Safety Standard (DID 5-1). The plan will include the software assurance processes, procedures, tools and techniques to be used commensurate with the software classification and safety criticality assessment, with additional tailoring in accordance with guidance provided by NASA-STD-8739.8A for each category of software (new, reused, Off-the-shelf, auto-generated code, etc..).

The plan addresses both Software Assurance and Software Safety disciplines. This includes the necessary collaboration with relevant SMA and Engineering stakeholders (i.e., system safety, system reliability, hardware quality, system security, and software engineering), and the process by which traceability is established to their respective analyses and/or requirements.

5.2 Surveillance of Software Development, Maintenance, and Assurance Activities

SWA_09: Consistent with the general requirement for support of government surveillance (see Section 1.8 "Surveillance"), the developer shall provide on-request access to following:

- Software problem reports
- Software documentation (i.e., management plans, assurance plans, configuration management plans, requirements specifications, design documents, test plans, test cases, test procedures, test results, software review results, software engineering and assurance schedule, maintenance plans)
- Source code
- Findings and corrective actions from software process and product audits and assessments

6 WORKMANSHIP

6.1 General

WOR_02: The developer shall implement a workmanship program to assure that electronic packaging technologies, processes, and workmanship meet mission objectives for quality and reliability per the requirements of the following standards:

- NASA-STD-8739.6 Implementation Requirements for NASA Workmanship Standards, excluding sections 8.1, 9.1, and 10.1
- J-STD-001, Requirements for Soldered Electrical And Electronic Assemblies
- IPC-2225 Sectional Design Standard for Organic Multichip Modules (MCM-L) and MCM-L Assemblies
- IPC-6015 Qualification and Performance Specification for Organic Multichip Module (MCM-L) Mounting and Interconnecting Structures

WOR_03: The developer shall comply with one of the following standards for electrical cables and harnesses:

- NASA-STD-8739.4 Crimping, Interconnecting Cables, Harnesses, and Wiring
- IPC/WHMA-A-620-S Requirements and Acceptance for Cable and Wire Harness Assemblies, Space Addendum

6.2 Electrostatic Discharge Control (ESD)

WOR_05: The developer shall prepare and implement an ESD control plan that conforms to the requirements of ANSI/ESD S20.20 "Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)" (DID 6-1).

6.3 Printed Circuit Boards (PCB)

WOR_07: The developer shall comply with one of the following standards for rigid printed circuit boards:

- IPC-6012 Qualification and Performance Specification for Rigid Printed Boards, Class 3 (the latest revision preferred, but older revisions acceptable based on inherited designs or developer standard practices)
- MIL-PRF-55110H Performance Specification: Printed Wiring Board, Rigid, General Specification For
- ECSS-Q-ST-70-10 Qualification of Printed Circuit Boards

WOR_08: The developer shall document and implement a PCB procurement plan (DID 6-2).

WOR_11: The developer should deliver PCB coupon evaluation reports for information only.

Note: 3rd party coupon evaluations are not required.

6.4 Lead-Free Control Measures

WOR_14: The developer shall document and implement a Lead-Free Control Plan (LFCP) (DID 6-5).

WOR_15: The developers shall submit uses of lead-free solder or surface finishes to the NASA project office for approval before use.

7 EEE PARTS

7.1 General

EEE_02: The developer shall document and implement a Parts Control Plan (PCP) per Level 3 requirements of EEE-INST-002 Instruction for EEE Parts Selection, Screening, Qualification, and De-rating or the developer's internal standard (DID 7-1C).

Note: The developer may use as is Class V, S, Q, B, M compliant microcircuits and JANS, JANTXV, and JANTX semiconductors. The developer may use as is automotive or hi-rel COTS parts, which are deemed compliant to level 3 per NASA-STD-8739.10 without any additional screening or qualification tests or inspections. When COTS parts are used, they may be procured from OEMs or OEM-designated distributors only. Any OEM-designated authorized distributor is an acceptable procurement source.

7.2 Parts Control Board

EEE_06: The developer shall establish a Parts Control Board (PCB) that is responsible for the planning, management, and coordination of the selection, application, and procurement requirements of EEE parts.

EEE_09: The developer shall identify the person responsible for directing and managing the EEE parts program and interfacing with government assurance personnel.

Note: there is no intent or expectation to change any parts from a proven heritage design based on the requirements in this document.

7.3 Re-use of EEE Parts

EEE_14: The developer shall require approval of the PCB to re-use EEE parts that have been installed.

7.4 Master EEE Parts List

EEE_15: The developer shall develop and deliver a Master EEE Parts List in accordance with DID 7-2, and maintain it for the duration of the project.

7.5 Radiation

EEE_18: The developer shall provide a plan, for approval, for how radiation will be addressed (DID 7-3).

8 MATERIALS AND PROCESSES

8.1 Materials and Processes (M&P) Selection, Control, and Implementation Plan (MPCIP)

MAP_01: The developer shall prepare and implement a MPCIP (DID 8-1C). NASA-STD-6016 shall be used as a baseline, with developer standard practices acceptable if associated command media are shared with NASA.

8.2 Materials Usage Agreement (MUA)

MAP_04: The developer shall prepare materials usage agreements (DID 8-2).

8.3 Materials Identification and Usage List (MIUL)

MAP_06: The developer shall prepare a materials identification and usage list (DID 8-3).

8.4 Life Test Plan and Final Report for Lubricated Mechanisms

MAP_09: The developer shall prepare and implement a life test plan and final report for lubricated mechanisms (DID 8-4C).

8.5 Additive Manufacturing Control Plan (AMCP)

MAP_11: The developer shall prepare and implement an AMCP for the design and manufacture of Additively Manufactured (AM) Parts (DID 8-5).

8.6 AM Part Production Plan (PPP)

MAP_13: The developer shall prepare a PPP for each AM part (DID 8-6).

9 CONTAMINATION CONTROL

9.1 Contamination Control Plan

CON_01: The developer shall prepare and implement a contamination control program (DID 9-1).

9.2 Material Outgassing

CON_04: The developer shall include information regarding material outgassing (DID 8-3).

CON_05: If an alternate standard to NASA-STD-6016 "STANDARD MATERIALS AND PROCESSES REQUIREMENTS FOR SPACECRAFT " is implemented, materials shall meet requirements of < 1% total mass loss and < 0.1% collected volatile condensable material at 125C under vacuum for twenty-four hours when tested to American Society for Testing and Materials (ASTM) E595 Standard Test Methods for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment.

9.3 Foreign Object Debris Program

CON_07: The developer shall prepare and implement a foreign object debris program (DID 9-2).

10 METROLOGY AND CALIBRATION

10.1 Metrology and Calibration Program

MAC_01: For measurement and test equipment that has documented requirements for metrological accuracy and traceability, the developer shall comply with NASA-STD-8739.12 "Metrology and Calibration", or verify equipment against calibrated instruments or intrinsic standards, using a documented procedure.

Note: The developer may verify torque wrenches against a calibrated torque tester prior to use.

10.2 Use of Calibrated and Non-Calibrated Instruments

MAC_02: The developer shall record the measurements that require accuracy in applicable project build documents (e.g., work order authorizations, job orders, task sheets or test plans), including the article of calibrated equipment used to take the measurement and its calibration end date.

MAC_03: When verification is chosen instead of calibration, the developer shall perform verification within a timeframe that has been demonstrated to provide appropriate levels of reliability, in the same facility, and under the same conditions that will be encountered during the process.

11 GIDEP ALERTS AND PROBLEM ADVISORIES

11.1 Government-Industry Data Exchange Program (GIDEP)

GID_01: The developer shall participate in GIDEP per the GIDEP Operations Manual (Note: this document is available through http://www.gidep.org).

11.2 Alert Disposition

GID_03: The developer shall review the following, hereafter referred to collectively as Alerts, for effects on EEE parts, materials, equipment and software used in NASA products: GIDEP Alerts; GIDEP SAFE-ALERTS; GIDEP Problem Advisories; GIDEP Agency Action Notices; NASA Advisories.

GID_05: When the developer identifies an item in their design, inventory, or assembly that is documented in an Alert, the developer shall disposition the item and Alert through the Material Review Board as a major nonconformance.

11.3 GIDEP Reporting

GID_06: The developer shall prepare and submit failure experience data and safety issue reports per the requirements of GIDEP Operations Manual whenever failed or nonconforming items are discovered that are available to other buyers.

11.4 Review Reporting

GID_07: The developer shall report the status of NASA products that are affected by Alerts (or by significant EEE parts, materials, software, and safety problems) and the actions taken to eliminate or mitigate negative effects at monthly status reviews, parts control board meetings, program milestone reviews and readiness reviews.

12 END ITEM ACCEPTANCE DATA PACKAGE

EIA_01: The developer shall maintain the EIADP throughout the project lifecycle and submit in accordance with (DID 12-1).

Note: Given that the generation of the EIADP is essentially a consolidation of artifacts that should be readily available in a robust CM system, a separate effort for the developer to collect and compile the individual items into a single deliverable is discouraged, as it does not add any substantive value. However, since it only increases cost and does not increase risk, the project may choose to request this deliverable at its own discretion. In addition, the individual items included in the end item acceptance data package may be adjusted.

Appendix A Acronym List

AMCP	Additive Manufacturing Control Plan
AMR	Additive Manufacturing Requirement
ANSI	American National Standards Institute
ARB	Anomaly Review Board
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CCB	Configuration Control Board
CDR	Critical Design Review
CIL	Critical Items List
COTS	Commercial off-the-shelf software
CSO	Chief Safety and Mission Assurance Officer
DID	Data Item Description
EEE	Electrical, Electronic, and Electromechanical
EIA	End Item Acceptance
EIADP	End Item Acceptance Data Package
ELV	Expendable Launch Vehicle
EOMP	End of Mission Plan
ESD	Electrostatic Discharge Control
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes and Effects Criticality Analysis
FOD	Foreign Object Damage
FTA	Fault Tree Analysis
GID	GIDEP Alerts and Problem Advisories
GIDEP	Government-Industry Data Exchange Program
GOTS	Government off-the-shelf software
GPR	Goddard Procedural Requirement
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HVTL	Hazard Verification Tracking Log
I&T	Integration and Test
ISAR	Instrument Safety Assessment Report
ITAR	International Traffic in Arms Regulations
KSC	Kennedy Space Center
LDE	lifting devices and equipment
LFCP	Lead-Free Control Plan
LLA	Limited Life Item Analysis
MAC	Metrology and Calibration
MAP	Materials and Processes
M&P	Materials and Processes
MAPTIS	Materials and Processes Technical Information System

MAR	Mission Assurance Requirements
MCM	Multichip Modules
MIUL	Materials Identification and Usage List
MOSFET	metal–oxide–semiconductor field-effect transistor
MPCIP	M&P Selection, Control, and Implementation Plan
MPE	Material Process Engineer
MPR	Material and Process Requirement
MRB	Material Review Board
MSE	Mission Systems Engineer
MSFC	Marshall Space Flight Center
MUA	Materials Usage Agreement
NASA	National Aeronautics and Space Administration
NPD	NASA Policy Directive
NPR	NASA Procedural Requirement
O&SHA	Operating and Support Hazard Analyses
ODAR	Orbital Debris Assessment Report
OEM	original equipment manufacturer
OHA	Operations Hazard Analysis
OSHA	Occupational Health and Safety Administration
PCB	Printed Circuit Board
PCB	Parts control board
PCP	Parts Control Plan
PDR	Preliminary Design Review
PHA	Preliminary Hazard Analyses
PPP	Part Production Plan
PSR	Pre-Ship Review
QMS	Quality
REL	Reliability
RPP	Reliability Program Plan
SAF	System Safety
SDP	Safety Data Package – STS missions only
SMA	Safety and Mission Assurance
SMA-D	Safety and Mission Assurance Directorate
SPF	Single Point Failure
SRR	System Requirements Review
SSPP	System Safety Program Plan
STD	Standard
SWA	Software Assurance
VTL	Verification Tracking Log
WCA	Worst Case Analysis
WFF	Wallops Flight Facility
WLL	Working Load Limit
WOR	Workmanship

Appendix B Data Item Descriptions

DID #	Title
1-1	Mission Assurance Compliance Matrix
1-2	Supplier List
2-1	Major Anomaly Report
2-2	Orbital Debris Assessment Report (ODAR) and End of Mission Plan (EOMP)
3-1	System Safety Program Plan
3-2	Safety Requirements Compliance Checklist
3-3	Operations Hazard Analysis and Hazard Verification Tracking Log
3-4ISR	Instrument Safety Assessment Report
3-4SDP	Safety Data Package
3-5	Hazardous Procedures for Payload I&T and Pre-Launch Processing
3-6	Pre-Mishap Plan
4-1	Reliability Program Plan
4-2	FMECA and Critical Items List
4-3	Fault Tree Analysis (FTA)
4-4	Reliability Calculations
4-5	Limited Life Items List
4-6	Parts Stress Analysis
4-7	Worst-Case Analysis
5-1	Software Assurance Plan
6-1	ESD Control Plan
6-2	Printed Circuit Board Procurement Plan
6-5	Lead-Free Control Plan
7-1	EEE Parts Control Plan
7-2	Master EEE Parts List
7-3	Radiation Effects Mitigation
8-1	M&P Selection, Control, and Implementation Plan (MPCIP)
8-2	Materials Usage Agreement (MUA)
8-3	Materials Identification and Usage List (MIUL)
8-4C	Life Test Plan and Final Report for Lubricated Mechanisms
8-5	Additive Manufacturing Control Plan (AMCP)
8-6	AM Part Production Plan (PPP)
9-1	Contamination Control Plan
9-2	Foreign Object Debris Program
12-1	End Item Acceptance Data Package

Table 12.1 Data Item Descriptions

Title: Mission Assurance Compliance Matrix	**DID No.:** 1-1
Associated Requirement(s): • GEN_02: The developer shall submit a compliance matrix that identifies variance and acceptance rationale for processes, procedures, and standards that are proposed as alternatives to those specified by the contract (DID 1-1). This includes identification of requirements for which relief is requested via the Inherited Item Risk Assessment process (see Section 1.9 "Use of Inherited Products/Items").	
Reference Documents:	
Due Date/Purpose of Delivery: • Preliminary with proposal (For Information) • Final 15 calendar days after contract award (For Approval)	
Preparation Information: The following will be tailored so as to address requirements for post-launch support, ground data systems, or other project-specific aspects of the contract. The Mission Assurance Compliance Matrix shall address the contractual system safety and mission assurance requirements as applied to: • All flight hardware and software that is designed, built, or provided by the developer and its subcontractors, or furnished by the government, from project initiation through launch and mission operations • The ground system that interfaces with flight equipment to the extent necessary to assure the integrity and safety of flight items • The ground data system	

Title: Supplier List	**DID No.:** 1-2
Associated Requirement(s): • GEN_19: The developer shall provide a list of suppliers used for product produced under this contract (DID 1-2).	
Reference Documents:	
Due Date/Purpose of Delivery: • Initial submission 60 days after contract award (For Information) • Update monthly, as new suppliers are determined (For Information)	
Preparation Information: Provide the following information for suppliers that have been contracted to provide products (down to the component-level): a) Supplier name b) Location(s) c) Cage code(s) d) Product description e) Contract start and end dates (if available) f) Delivery date (if available)	

Title: Major Anomaly Record	**DID No.:** 2-1
Associated Requirement(s): • QMS_15: The developer shall have a documented process for the establishment and operation of an anomaly review board (ARB) to process (report and disposition) major anomalies, which are those that have resulted in hardware or software test failures and damage or potential damage to hardware (DID 2-1).	
Reference Documents:	
Due Date/Purpose of Delivery: • Initial submission 24 hours of occurrence (For Information) • Notice of a change in status 24 hours of occurrence (For Information) • Proposed closure prior to closure (For Approval)	
Preparation Information: Document anomaly details and the record of the anomaly disposition, including the following information: a) Identification of project, system, or sub-system b) Identification of failed item (e.g., assembly, sub-assembly, or part) c) Description of item d) Identification of next higher assembly e) Description of anomaly, including activities leading up to anomaly, if known f) Names and contact information of individuals involved in anomaly g) Date and time of anomaly h) Status of item i) Contact information for personnel who originated the report j) Date of original submission k) Anomaly cause (Upon Closure) l) Corrective actions implemented (Upon Closure) m) Retesting performed and results (Upon Closure) n) Other items affected in the system	

Title: Orbital Debris Assessment Report (ODAR) and End of Mission Plan (EOMP)	**DID No.:** 2-2

Associated Requirement(s):

- QMS_22: The developer shall provide the information necessary for the development of the ODAR and the EOMP deliveries per the content defined in NASA-STD 8719.14 Process for Limiting Orbital Debris (DID 2-2).

Reference Documents:

- NASA-STD-8719.14 Process for Limiting Orbital Debris

Due Date/Purpose of Delivery:

- Preliminary ODAR inputs 15 days prior to mission PDR (For Information)
- Interim ODAR and Draft EOMP inputs 60 days prior to mission Critical Design Review (CDR) (For Information)
- Final/updated ODAR and EOMP inputs 90 days prior to PSR. (For Information)

Preparation Information:

NASA-STD-8719.14 Process for Limiting Orbital Debris Appendix A (ODAR) and Appendix B (EOMP) provide details on what information is required for the Project office to complete these analyses

NOTE: Orbital Debris Assessment Software is available for download from Johnson Space Center at URL: http://sn-callisto.jsc.nasa.gov/mitigate/das/das.html

Title: System Safety Program Plan	**DID No.:** 3-1

Associated Requirement(s):

- SAF_10: The developer shall prepare a SSPP that describes the tasks and activities of system safety management and engineering required to identify, evaluate, and eliminate or control hazards to the hardware, software, and system design by reducing the associated risk to an acceptable level throughout the system life cycle, including launch range safety requirements (DID 3-1).

Reference Documents:

NASA-STD-8719.24 (with Annex), NASA Expendable Launch Vehicle Payload Safety Requirements

Due Date/Purpose of Delivery:

- Preliminary at SRR (For Review)
- Final 45 days prior to PDR (For Approval)
- Updates 30 days prior to implementation (For Review)

Preparation Information:

The developer shall prepare a SSPP that describes the development and implementation of a system safety program that complies with the requirements of NPR 8715.7, the launch service provider, and launch range safety. The developer shall

a) Define the roles and responsibilities of personnel
b) Define the required documentation, applicable requirements documents, and completion schedules for analyses, reviews, and safety packages
c) Address support for Safety Reviews, Safety Working Group Meetings and TIMs
d) Provide for early identification and control of hazards to personnel, facilities, support equipment, and the flight system during product development, including design, fabrication, test, transportation, and ground activities.
e) Address compliance with the launch range safety requirements
f) Include a safety review process that meets the requirements of NPR 8715.7 Expendable Launch Vehicle Payloads Safety Program
g) Address compliance with industrial safety requirements imposed by NASA and the Occupational Health and Safety Administration (OSHA) design and operational needs and contractually imposed mission unique obligations

Title: Safety Requirements Compliance Checklist	**DID No.:** 3-2

Associated Requirement(s):

- SAF_11: The developer shall document and implement a Safety Requirements Compliance Checklist to demonstrate that the payload complies with NASA and range safety requirements (DID 3-2).

Reference Documents:

NASA-STD 8719.24 (with Annex), NASA Expendable Launch Vehicle Payload Safety Requirements

Due Date/Purpose of Delivery:

- Preliminary 45 days prior to SRR (For Approval)
- Final 45 days prior to PDR (For Approval)
- Updates 45 days prior to CDR (For Approval)

Preparation Information:

The developer shall prepare a compliance checklist of all design, test, analysis, and data submittal requirements. The following shall be included:

a) Criteria and requirement.
b) System
c) Indication of compliance, noncompliance, or not applicable
d) Rationale for indications other than compliant
e) Resolution
f) Reference
g) Copies of Range Safety and NASA approved non-compliances, including waivers and equivalent levels of safety certifications

Note: the developer shall submit safety waivers for non-compliant design elements per paragraph 3.3.7.

Title: Operations Hazard Analysis and Hazard Verification Tracking Log	**DID No.:** 3-3

Associated Requirement(s):

- SAF_16: The developer shall document, implement, and maintain an Operations Hazard Analysis (OHA) and a HVTL to demonstrate that hardware operations, test equipment operations, and integration and test (I&T) activities comply with the safety requirements of the facilities where the activities will be performed and that hazards associated with those activities are mitigated to an acceptable level of risk (DID 3-3).

Reference Documents:

Due Date/Purpose of Delivery:

- Submit OHA and HVTL 45 days prior to first use (For Approval)

Note: OHA controls for engineering test units undergoing environmental tests shall be presented in accordance with local safety authorities 45 days prior to test performance.

Preparation Information:

The OHA shall include the following information:

a) Introduction – a summary of the major findings of the analysis and the proposed corrective actions and definitions of special terms, acronyms, and abbreviations; the findings will address the safety requirements of the facilities in which activities will be performed
b) System Description – a description of system hardware and configuration, with a list of subsystem components and schedules for integration and testing
c) Analysis of Hazards
d) List of real or potential hazards to personnel, equipment, and property during I&T processing
e) The following information shall be included for each hazard:
f) System Component/Phase – the phase and component with which the analysis is concerned; e.g., system, subsystem, component, operating/maintenance procedure, or environmental condition.
g) System Description and Hazard Identification, Indication:
h) A description of expected results from operating the component/subsystem or performing the operating/maintenance action
i) A complete description of the actual or potential hazard resulting from normal actions or equipment failures; indicate whether the hazard will cause personnel injury and equipment damage.
j) A description of warning indicators for the operator/crew that includes all means of identifying the hazard to operational/maintenance personnel.
k) A description of the safety hazards of software controlling hardware systems where the hardware effects are safety critical.
l) Effect on System – the detrimental effects of an uncontrolled hazard on the system
m) Risk Assessment.
n) Caution and Warning Notes – a list of warnings, cautions, procedures required in operating and maintenance manuals, training courses, and test plans
o) Status/Remarks – the status of actions to implement hazard controls.
p) References (e.g., test reports, preliminary operating and maintenance manuals, and other hazard analyses)

Title: Instrument Safety Assessment Report	**DID No.:** 3-4ISR

Associated Requirement(s):

- SAF_15: The developer shall deliver the PHA with <Preliminary ISAR (DID 3-4ISR) or SDP I (DID 3-4SDP)>.
- SAF_21: The developer shall submit the results of the O&SHA as a part of the <Intermediate & Final ISARs (DID 3-4ISR) or SDP II and SDP SS (DID 3-4SDP)>.
- SAF_22: The developer shall generate an ISAR to document the comprehensive evaluation of the risk being assumed prior to the testing or operation of an instrument. The spacecraft developer will use the ISAR as an input to the SDP (DID 3-4SDP).
- SAF_28: The VTL shall identify hazard controls that are not verified as closed and shall be delivered with the <final ISAR (DID 3-4ISR) or SDP III (DID 3-4SDP)>.

Reference Documents:

Due Date/Purpose of Delivery:

- Preliminary ISAR 30 days prior to instrument PDR (For Review)
- Intermediate ISAR 30 days prior to instrument CDR (For Review)
- Final ISAR 30 days prior to instrument PSR (For Approval)

Preparation Information:

The ISAR will identify safety features of the hardware, software, and system design as well as procedural, hardware, and software related hazards that may be present in the instrument. This includes specific procedural controls and precautions that should be followed. The ISAR will include the following information:

a) The safety criteria and methodology used to classify and rank hazards, including assumptions upon which the criteria or methodologies were based or derived
b) The results of hazard analyses and tests used to identify hazards in the system including:
c) Those hazards that still have a residual risk and the actions that have been taken to reduce the associated risk to a level contractually specified as acceptable
d) Results of tests conducted to validate safety criteria, requirements, and analyses
e) Hazard reports documenting the results of the hazard analyses to include a list of all significant hazards along with specific safety recommendations or precautions required to ensure safety of personnel, property, or the environment. NOTE: Identify whether or not the risks may be expected under normal or abnormal operating conditions.

The developer will submit with the Final ISAR a signed statement that:

f) Hazards have been closed out through elimination or through risk mitigations that are contractually specified as acceptable
g) Identifies hazards that have not been eliminated or controlled at the time of submission
h) The instrument is ready to test, operate, or proceed to the next phase.

Title: Safety Data Package	**DID No.:** 3-4SDP

Associated Requirement(s):

- SAF_15: The developer shall deliver the PHA with <Preliminary ISAR (DID 3-4ISR) or SDP I (DID 3-4SDP)>.
- SAF_21: The developer shall submit the results of the O&SHA as a part of the <Intermediate & Final ISARs (DID 3-4ISR) or SDP II and SDP III (DID 3-4SDP)>.
- SAF_22: The developer shall generate an ISAR to document the comprehensive evaluation of the risk being assumed prior to the testing or operation of an instrument. The spacecraft developer will use the ISAR as an input to the SDP (DID 3-4SDP).
- SAF_28: The VTL shall identify hazard controls that are not verified as closed and shall be delivered with the <final ISAR (DID 3-4ISR) or SDP III (DID 3-4SDP)>.

Reference Documents:

Due Date/Purpose of Delivery:

- Preliminary ISAR 30 days prior to instrument PDR (For Review)
- Intermediate ISAR 30 days prior to instrument CDR (For Review)
- Final ISAR 30 days prior to instrument PSR (For Approval)

Preparation Information:

1. Introduction. State the purpose of the safety data package.
2. System Description. This Paragraph may be developed by referencing other program documentation such as technical manuals, System Program Plan, System Specification.
3. System Operations.
   a) A description of the procedures for operating, testing, and maintaining the system, including the safety features and controls.
   b) A description of special safety procedures needed to assure safe operations, test and maintenance, including emergency procedures.
   c) A description of anticipated operating environments and specific operator skills.
   d) A description of special facility requirements or personal equipment to support the system.
4. Systems Safety Engineering Assessment. This Paragraph shall include:
   a) A summary of the criteria and methodology for classifying and ranking hazardous conditions.
   b) A description of the analyses and tests performed to identify inherent hazardous conditions, including the software safety analysis
   c) A separate appendix documenting the Hazard Reports by subsystem or major component level with the Hazard Reports being listed in alphanumeric order based on the chosen Hazard Report numbering scheme.
      i. A discussion of the actions taken to eliminate or control these items.
      ii. A discussion of the effects of these controls in terms of fault tolerance, design for minimum risk, and severity level of potential mishaps.
      iii. A discussion of the results of tests conducted to validate safety criteria requirements and analyses, including a reference to the specific test/analysis/inspection reports that provide this verification. These reports shall be made available upon request.
5. Conclusions and Recommendations. This Paragraph shall include:
   a) A list of significant hazards and specific safety controls.
   b) For hazardous materials:
      (1) Material identification as to type, quantity, and hazards.
      (2) Safety precautions and procedures for use, storage, transportation, and disposal.
      (3) A copy of the Material Safety Data sheet (OSHA Form 20 or DD Form 1813).

c) Appropriate radiation forms/analysis.
d) Reference material to include a list of all pertinent references such as Test Reports, Preliminary Operating Manuals and Maintenance Manuals
e) Recommendations applicable to the safe interface of this system with the other system(s).

6. The developer will submit with the SDP III a signed statement that:
   a) Hazards have been closed out through elimination or through risk mitigations that are contractually
      a. specified as acceptable
   b) Identifies hazards that have not been eliminated or controlled at the time of submission
   c) The observatory is ready to test, operate, or proceed to the next phase

Title: Hazardous Procedures for Payload I&T and Pre-Launch Processing	**DID No.:** 3-5
Associated Requirement(s): • SAF_30: The developer shall document the hazardous procedures that will be implemented when integration and test activities and pre-launch activities are performed at processing facilities and the launch site (DID 3-5).	
Reference Documents: • NASA-STD 8719.24 (with Annex), NASA Expendable Launch Vehicle Payload Safety Requirements • KNPR 8715.3 KSC Safety Practices Procedural Requirements (as applicable)	
Due Date/Purpose of Delivery: • I&T hazardous procedures to Project Office 7 days before first use (For Review) • Launch Range Hazardous Procedures 65 days prior to first use (For Review) • Note: Project Office approval of Launch Range Hazardous Procedures is required 10 days after delivery with subsequent Range Safety approval	
Preparation Information: The developer shall document the hazardous procedures and associated safeguards that will be used for integration and test activities and pre-launch activities. The safeguards will comply with the applicable safety requirements for the installation where the activities will be performed.	

Title: Pre-Mishap Plan	**DID No.:** 3-6

Associated Requirement(s):

- SAF_33: The developer shall prepare a Pre-Mishap Plan that describes appropriate mishap and close call notification, reporting, recording, and investigation procedures (DID 3-6).

Reference Documents:

- Sample Pre-Mishap Plan – available upon request

Due Date/Purpose of Delivery:

- Preliminary plan 45 days prior to SSR (For review)
- Final plan 45 days prior to PDR (For Approval)
- Updates 45 days prior to CDR (For Approval)

Preparation Information:

The Pre-Mishap Plan shall identify the processes and procedures to be followed to respond to the occurrence of a mishap or a close call and identify the chain of individuals, including government personnel, to be contacted. The Mishap Plan includes the following information:

a. The developer's policies and plan regarding response to a mishap or close call, to include:

1. Actions to be taken from the occurrence through implementation of corrective actions.
2. Plans for emergency response, notification, evidence preservation, mishap investigation, the mishap investigation report, lessons learned, and corrective actions.
3. Information regarding responsible for duties and tasks involved in the process.

b. The following definitions:

1. Close Call -- An occurrence or a condition of employee concern in which there is no injury or minor injury requiring first aid and no or minor equipment or property damage (less than $20,000) but which possesses a potential to cause a mishap.
2. Incident -- An occurrence of a close call or a mishap.
3. Mishap -- An unplanned occurrence that results in damage to property or personnel injury or illness: damage to developer, government, or customer-owned hardware property or critical products; fatalities, injuries, or illnesses occurring during program operations; environmental releases or spills occurring in the course of program operations.

c. The following definitions regarding the type of mishaps:

1. Type A Mishap -- A mishap resulting in one or more of the following: (1) an occupational injury or illness resulting in a fatality, a permanent total disability, or the hospitalization for inpatient care of 3 or more people within 30 workdays of the mishap; (2) a total direct cost of mission failure and property damage of $2 million or more.
2. Type B Mishap -- A mishap that caused an occupational injury or illness that resulted in a permanent partial disability, the hospitalization for inpatient care of 1-2 people within 30 workdays of the mishap, or a total direct cost of mission failure and property damage of at least $500,000 but less than $2,000,000.
3. Type C Mishap -- A mishap resulting in a nonfatal occupational injury or illness that caused any days away from work, restricted duty, or transfer to another job beyond the day or shift on which it

occurred, or a total direct cost of mission failure and property damage of at least $50,000 but less than $500,000.

4. Type D Mishap -- A mishap that caused any nonfatal OSHA recordable occupational injury and/or illness that does not meet the definition of a Type C mishap, or a total direct cost of mission failure and property damage of at least $20,000 but less than $50,000.

d. Contact information for Project Office personnel.

e. Notification schedule and mishap response process timeline (notification in no more than 24 hours).

f. Note: The following are not reportable as mishaps but may be reportable as failures or anomalies:

1. Property Damage:
2. Items normally covered under Failure Reporting
3. Malfunction or failure of component parts or equipment due to normal wear and tear where the malfunction is the only damage, and the only action is to replace or repair the equipment.
4. Anticipated damage to equipment or property was incurred during testing or manufacturing.
5. Property damage from vandalism, arson, sabotage or acts of God.

Title: Reliability Program Plan	**DID No.:** 4-1

Associated Requirement(s):

- REL_01: The developer shall document and implement an RPP that includes both qualitative and quantitative techniques to support decisions regarding mission success and safety throughout system development (DID 4-1).

Reference Documents:

- NPD 8720.1, NASA Reliability and Maintainability (R&M) Program Policy
- NASA-STD-8729.1, Planning, Developing and Managing an Effective Reliability and Maintainability (R&M) Program.
- NPR 8705.4 Risk Classification for NASA Payloads

Due Date/Purpose of Delivery:

- Methodology 30 days prior to SRR (For Review)
- Initial report 30 days prior to PDR (For Review)
- Final report 30 days prior to CDR and subsequent milestone reviews (For Review)
- Revisions 30 days after updates/changes (For Review)

Preparation Information:

The Reliability Program Plan shall explain how the developer intends to implement and comply with MAR Reliability analysis requirements. The explanation shall include the following:

a) The organizational responsibilities and functions for each task to be performed as part of the program.
b) The point of contact for implementing and generating the necessary documents for each requirement.
c) A list of subsystems and components for which trend analysis will be performed, including the parameters to be monitored.
d) The execution and management plan for each task, including schedule.
e) Documentation, methods, scope, level of detail, and reporting specific to each task in the plan and for each element if there are differences.
f) Alternate/additional methodologies (non-analysis, e.g., qual testing, modeling, inheritance assessment) for supporting analyses and addressing requirements.

Title: FMECA and Critical Items List	**DID No.:** 4-2

Associated Requirement(s):

- REL_11: The developer shall perform and maintain Failure Modes and Effects Criticality Analyses (FMECA) that address flight hardware and software and ground support equipment that interfaces with flight systems that are being designed, built, or provided from project initiation through launch and mission operations. The developer shall include likelihood, cause, detection and mitigation, and the effects of each failure mode at the local, subsystem, and system or mission levels, to the interface level for existing systems and to the box or functional level for modified or new systems (DID 4-2).

Reference Documents:

- NPR 8705.4 Risk Classification for NASA Payloads
- GPR 7120.4D Risk Management

Due Date/Purpose of Delivery:

- Preliminary FMEA/FMECA and CIL 30 days before PDR (For Review)
- Updated FMEA/FMECA and CIL 30 days prior to CDR and each subsequent milestone review leading up to Launch Readiness Review (For Review)

Preparation Information:

The FMECA Report shall explain the approach of the analysis, methodologies, assumptions, results, conclusions, and recommendations.

a) Objectives
b) Level of the analysis
c) Ground rules
d) Functional description
e) Functional block diagrams
f) Reliability block diagrams to illustrate any redundancies
g) Equipment analyzed
h) Data sources used
i) Problems identified
j) Corrective actions
k) Work sheets identifying, item functions failure modes, causes, severity category, consequence category, and effects at the item, next higher level, and mission level, detection methods, and mitigating provisions.
l) Critical Items List (CIL) for severity categories 1SC, 1, 1R, 1S, and 2, including item identification, cross-reference to FMECA line items, and retention rationale. Appropriate retention rationale may include design features, historical performance, acceptance testing, manufacturing product assurance, corrective action recommendation/elimination of undesirable failure modes, proper design controls, and failure detection methods. The rationale also will contain data that describes operational constraints caused by occurrence of the failure and any measures that can be taken to restore the function on orbit where known.
m) Single Point Failure (SPF) list for failure modes resulting in category 1 and 1SC severities per table 4.1

Title: Fault Tree Analysis (FTA)	DID No.: 4-3
MAR Paragraph: 4.2.2	

Use:

Used to assess mission failure from the top-level perspective. Undesired top-level states are identified, and combinations of lower-level events are considered to derive credible failure scenarios. The technique provides a methodical approach to identify events or environments that can adversely affect mission success and provides an informed basis for assessing system risks.

Reference Documents

- NASA Fault Tree Handbook with Aerospace Applications (http://www.hq.nasa.gov/office/codeq/doctree/fthb.pdf)
- NPR 8705.4 Risk Classification for NASA Payloads
- NPR 8715.3 NASA General Safety Program Requirements

Place/Time/Purpose of Delivery:

- Submit preliminary FTA report no later than thirty (30) days prior to PDR for review
- Submit final FTA report no later than thirty (30) days prior to CDR for review
- Submit revisions to the FTA report no later than thirty (30) days after identification of updates or changes for review

Preparation Information:

The mission FTA Reports shall contain:

- Analysis ground rules including definitions of undesirable end states
- References to documents and data used
- Fault tree diagrams
- Results and conclusions

Title: Reliability Calculations	**DID No.:** 4-4
Associated Requirement(s): • REL_23: The developer shall perform and maintain reliability and ground-system availability calculations using Fault Tree Analyses (FTA), reliability block diagrams, and/or Probabilistic Risk Assessment (DID 4-4) to identify design weaknesses, support design trades, and demonstrate the impact of critical items, as deemed necessary by the CSO and the MSE.	
Reference Documents: • NASA/SP-2009-569 Bayesian Inference for NASA Probabilistic Risk and Reliability Analysis • NASA Fault Tree Handbook with Aerospace Applications	
Due Date/Purpose of Delivery: • Methodology 30 days prior to SRR (For Review) • Initial report 30 days prior to PDR (For Review) • Final report 30 days prior to CDR and subsequent milestone reviews (For Review) • Revisions 30 days after updates/changes (For Review)	
Preparation Information: The reliability/availability calculations reports shall include the following: a) The methodology and results of comparative reliability assessments including mathematical models b) Reliability block diagrams and/or fault tree diagrams c) Failure rates d) Mean time to repair (ground systems) e) Maintenance man hours/hours (ground systems) f) Failure definitions / definitions of undesirable end states g) References to documents and data used h) Trade-offs considered i) Assumptions j) Any other pertinent information used in the assessment process k) Results and conclusions	

Title: Limited Life Items List	**DID No.:** 4-5
Associated Requirement(s): • REL_25: The developer shall perform a Limited LLA that identifies components that have a limited useful life inherent to the performance of their respective function and documents and fosters a plan to manage limited life items (DID 4-5).	
Reference Documents:	
Due Date/Purpose of Delivery: • 30 days prior to PDR (For Review) • Updates 30 days of changes (For Review)	
Preparation Information: The developer shall prepare and maintain a list of limited life items and their predicted impact on mission operations. The list shall include expected life, required life, duty cycle, and rationale for selecting and using the items for which the expected life is less than twice the required life.	

Title: Parts Stress Analysis	**DID No.:** 4-6
Associated Requirement(s): • REL_30: The developer shall perform parts stress and derating analyses for electrical, electronic, and electromechanical (EEE) parts in accordance with EEE-INST-002 Instruction for EEE Parts Selection, Screening, Qualification, and Derating (DID 4-6), unless specifically relieved of this requirement by the Inherited Items Risk Assessment process (See Section 1.9). •	
Reference Documents: EEE-INST-002 Instruction for EEE Parts Selection, Screening, Qualification, and Derating	
Due Date/Purpose of Delivery: • 30 days prior to CDR (For Approval) • Revisions 30 days after identification (For Approval)	
Preparation Information: The Parts Stress Analysis Report shall contain analysis worksheets that include: a) Identification of derating standard used b) Part identification (traceable to circuit diagrams) c) Rated stress d) Applied stress (consider all significant operating parameter stresses at the extremes of anticipated environments) e) Ratio of applied-to-rated stress	

Title: Worst-Case Analysis	**DID No.:** 4-7
Associated Requirement(s): • REL_34: For new or significantly modified designs, the developer shall perform WCA (DID 4-7) • REL_35: The developer shall perform WCA for circuit designs that are new or significantly modified and identified as critical through analysis of the design (See Section 4.2) (DID 4-7).	
Reference Documents:	
Due Date/Purpose of Delivery: • 30 days prior to CDR (For Review) • Revisions 30 days after identification (For Review)	
Preparation Information: The Worst-Case Analysis Report shall include the following: a) Identification of worst-case conditions considered for each component. b) Consideration of critical parameters at maximum and minimum limits. c) The effect of environmental stresses on the operational parameters being evaluated.	

Title: Software Assurance Plan	**DID No.:** 5-1

Associated Requirement(s):

- SWA_04: The developer shall document and implement a Software Assurance Plan and schedule compliant to NASA-STD-8739.8A, NASA Software Assurance and Software Safety Standard (DID 5-1). The plan will include the software assurance processes, procedures, tools and techniques to be used commensurate with the software classification and safety criticality assessment, with additional tailoring in accordance with guidance provided by NASA-STD-8739.8A for each category of software (new, reused, Off-the-shelf, auto-generated code, etc..).

Reference Documents:

- NASA-STD-8739.8, NASA Software Assurance and Software Safety Standard
- NPR 7150.2, NASA Software Engineering Requirements

Due Date/Purpose of Delivery:

- Preliminary plan 30 days prior to SRR (For Information)
- Final plan 15 days prior to PDR (For Information)
- Updates 30 days prior to implementation (For Information)

Preparation Information:

The Software Assurance Plan shall address the following:

a) Purpose and Scope
b) Assurance Activities, Tools and Techniques by discipline:
    1. Software Quality (process and product)
    2. Software Safety
    3. Software Reliability
    4. Software Verification and Validation
    5. Independent Verification and Validation (if applicable)
c) Software Assurance Program Metrics
d) Problem Reporting and Corrective Action
e) Assurance records, collection, maintenance, and retention
f) Risk Management
g) NASA-STD-8739.8 Compliance Matrix

Title: ESD Control Plan	**DID No.:** 6-1
Associated Requirement(s): • WOR_05: The developer shall prepare and implement an ESD control plan that conforms to the requirements of ANSI/ESD S20.20 "Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)" (DID 6-1).	
Reference Documents: • ANSI/ESD S20.20-2014, Protection of Electrical and Electronic Parts, Assemblies And Equipment (Excluding Electrically Initiated Explosive Devices)	
Due Date/Purpose of Delivery: • 30 days prior to PDR (For Information)	
Preparation Information: The ESD Control Plan shall be prepared and implemented to comply with ANSI/ESD S20.20 requirements and the ESD sensitivity of the product being developed.	

Title: Printed Circuit Board Procurement Plan	**DID No.:** 6-2

Associated Requirement(s):

- WOR_8: The developer shall document and implement a PCB procurement plan (DID 6-2).

Reference Documents:

- IPC-2221 Generic Standard on Printed Board Design
- IPC-601X

Due Date/Purpose of Delivery:

- Preliminary information 30 days prior to CDR (For Approval)
- Changes 14 days prior to manufacturing (For Approval)

Preparation Information:

For all printed boards to be used in mission hardware, the procurement plan shall contain:

a) Name of next higher-level assembly (box or subsystem)
b) Printed board assembly name
c) Part number
d) Indication as being a new or heritage design
e) Description of design complexity, to include:
f) Number of layers
g) Overall board thickness
h) Most complex via stack-up
i) Use of micro-vias
j) Use of via-in-pad
k) Line width and spacing
l) Maximum voltage in application
m) Base material (IPC-4101 designation or trade name)
n) Applicable printed board design standard
o) Applicable printed board performance standard
p) Fabrication notes or procurement specifications
q) Note of any waiver or deviation affecting printed board requirements or acceptability
r) Printed board supplier(s) or candidates
s) Quantity required for flight build
t) Minimum quantity required for spares

The procurement information will ensure that test coupons are fabricated for each design in a quantity sufficient to meet testing requirements per IPC-2221 Generic Standard on Printed Board Design and satisfy supplier acceptance testing per IPC-601X.

Title: Lead-Free Control Plan	**DID No.:** 6-5
Associated Requirement(s): • WOR_14: The developer shall document and implement a LFCP (DID 6-5).	
Reference Documents:	
Due Date/Purpose of Delivery: • 60 days after contract award (For Information)	
Preparation Information: The Lead-Free Control Plan (LFCP) shall meet the requirements of GEIA-STD-0005-1 and GEIA-STD-0005-2 for tin-based solders and surface finishes that are less than 3% lead by weight and comply with the Level 2C requirements set. Note: The LFCP requires prior MRB approval for uses of tin-based lead-free solder or surface finishes and whisker mitigation methods.	

Title: EEE Parts Control Plan	**DID No.:** 7-1

Associated Requirement(s):

- The developer shall document and implement a Parts Control Plan (PCP) per Level 3 requirements of EEE-INST-002 Instruction for EEE Parts Selection, Screening, Qualification, and De-rating or the developer's internal standard (DID 7-1C).

Reference Documents:

- EEE-INST-002 Instructions for EEE Parts Selection, Screening, Qualification, and Derating
- S-311-M-70 Specification for Destructive Physical Analysis
- AS5553 Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition

Due Date/Purpose of Delivery:

- 30 days after contract award (For Information)

Preparation Information:

The PCP shall address the following:

a) Parts control program organization and management
b) EEE Parts control per EEE-INST-002 Instructions for EEE Parts Selection, Screening, Qualification, and Derating
c) Shelf-life control plan
d) Supplier and manufacturer surveillance
e) Procedures regarding application specific integrated circuits, gate arrays, system-on-chip, and custom integrated circuits
f) Incoming inspection and test
g) Sparing policies
h) Destructive physical analysis per S-311-M-70 Specification for Destructive Physical Analysis
i) Defective parts controls program.
j) Handling, preservation, and packing
k) Contamination control
l) Alternate quality conformance inspection and small lot sampling
m) Traceability and lot control
n) Failure analysis
o) Counterfeit parts control plan per AS5553 Counterfeit Electronic Parts, Avoidance, Detection, Mitigation, and Disposition
p) Radiation hardness assurance program or approach that addresses total ionizing dose; displacement damage (total non-ionizing dose); destructive and non-destructive single-event effects; single-event effect rates; proton hardness/tolerance
q) Parts Control Board Operations
r) Organization and membership
s) Meeting schedule and notices
t) Distribution of meeting agenda, notes, and minutes
u) Review and approval responsibilities and processes
v) Documentation and records

Title: Master EEE Parts List	**DID No.:** 7-2

Associated Requirement(s):

- EEE_15: The developer shall develop and deliver a Master EEE Parts List in accordance with DID 7-2 and maintain it for the duration of the project.

Reference Documents:

Due Date/Purpose of Delivery:

- EEE parts to the Parts Control Board prior to inclusion (For Approval)
- Updates prior to inclusion (For Approval)

Preparation Information: "The developer shall maintain the Master EEE Parts List Information in a searchable electronic format. The G Project Parts Engineer shall have access to the list.

The Developer shall generate and maintain a Master Parts List with the minimum information listed below for the various stages throughout the project's lifecycle:

a) For EEE parts that are identified for potential flight use, the list shall include the following information:
   1. Flight component identity to the circuit board level
   2. Complete part number (i.e. Defense Supply Center Columbus part number, Specification Control Drawing part number, with all suffixes)
   3. Manufacturer's Generic Part number
   4. Manufacturer (not distributor)
   5. Part Description (please include meaningful detail)
   6. Federal Supply Class
   7. Procurement Specification
   8. Comments and clarifications, as appropriate
   9. Estimated quantity required (for procurement forecasting)

b) For EEE parts that are approved for flight use the list shall include the following information:
Procurement Part Number
   1. Flight Part Number (if different from the procurement part number)
   2. Package Style/Designation
   3. Radiation effects mitigation approach to cover all categories of radiation (e.g., radiation test data, prior flight usage, circuit design, shielding, etc)
   4. PCB Status
   5. PCB Approval Date
   6. PCB Required Testing/Evaluations

c) For EEE parts that are approved for as-designed use the list shall include the following information:
   1. Assembly Name/Number
   2. Next Level of Assembly
   3. Need Quantity
   4. Reference Designator(s)
   5. Item number (if applicable)

d) For EEE parts in flight hardware the list shall include the following information:
   1. Assembly serial number
   2. Item revision
   3. Next Level of Assembly serial number
   4. Lot/Date/Batch/Heat/Manufacturing Code, as applicable
   5. Manufacturer's Cage Code (specific plant location when relevant)

6. Distributor/supplier, if applicable
7. Part number
8. Part serial number (if applicable)

Title: Radiation Effects Mitigation	**DID No.:** 7-3

Associated Requirement(s):

- EEE_18: The developer shall provide a plan, for approval, for how radiation will be addressed (DID 7-3).

Reference Documents:

Due Date/Purpose of Delivery:

- Submission 60 days after contract award (For Approval)

Preparation Information: Provide the overall plan for mitigating the effects of radiation, including one or more of the following approaches, as applicable:

1. Avoidance: dormancy of sensitive electronic elements in high stress regions such as SAA or Van Allen Belts
2. Rad Hard By Design : Proven rad-hard by design approach, applied to circuits and/or parts
3. Traditional parts-centric: Use of Radiation Hardness Assurance parts with radiation-tolerant design to accommodate high stress region operation
4. Modern parts-centric: Use of familiar sensitive parts[1] along with proven circuit designs in comparable environment
5. Radiation-tolerant design: Use radiation-tolerant circuit design techniques including features such as metal–oxide–semiconductor field-effect transistor (MOSFET) protection and overcurrent detection with reset capability, resettable processors, EDAC, derating beyond EEE-INST-002 recommendations, etc.
6. Risk-based approach combining past on-orbit experiences in similar stressing environments.
7. System fault-tolerance (including redundancy): This may include new, unproven approaches, with backup proven systems.

[1]Sensitive parts include memory, processors, complementary metal-oxide semiconductor devices, MOSFETs, etc.

Title: M&P Selection, Control, and Implementation Plan (MPCIP)	**DID No.:** 8-1

Associated Requirement(s):

- MAP_01: The developer shall prepare and implement a Materials and Processes (M&P) Selection, Control, and Implementation Plan (MPCIP) (DID 8-1). NASA-STD-6016 shall be used as a baseline, with developer standard practices acceptable if associated command media are shared with NASA.

Reference Documents:

- NASA-STD-6016C Standard Materials and Processes Requirements for Spacecraft
- NASA-STD-8739.14 NASA Fastener Procurement, Receiving Inspection, and Storage Practices for NASA Mission Hardware
- 541-PG-8072.1.2 Goddard Space Flight Center (Goddard) Fastener Integrity Requirements

Due Date/Purpose of Delivery:

- 14 days prior to SRR (For Information)
- 30 days prior to Mission PDR (For Approval)
- 30 days prior to CDR (For Approval)

Preparation Information:

For each Material and Process Requirement (MPR) in NASA-STD-6016C, Section 4, with the additions and prescribed changes below, the developer shall prepare and implement an MPCIP that states the MPR, identifies the degree of conformance under the subheading "Degree of Conformance," and identifies the method of implementation under the subheading "Method of Implementation."

The use of well-established developer practices is encouraged to meet the intent of MPRs, and may be referenced by the MPCIP, provided documentation of these practices is made available for review remotely by the Goddard Material Process Engineer (MPE) (in accordance with electronic access requirements specified in Section 1. 5 “Surveillance”). Tailoring of NASA-STD-6016C requirements by the MPCIP is also permitted, pending review and approval by Goddard. Upon approval, the MPCIP becomes the M&P implementation document used for verification (see NASA-STD-6016C, Section 4.1.1)

When NASA-STD-6016 is the employed standard, the MPCIP shall address the following additions and prescribed changes to NASA-STD-6016C requirements:

a) The developer shall meet the applicable launch site requirements documented in Section 3.2 of this MAR.
b) In addition to the requirements of NASA-STD-6016C, Section 4.2.3.6, the developer shall provide the vacuum bake out schedule for materials that fail outgassing requirements within the MIUL (See DID 8-2) or provide a separate MUA (see DID 8-3).
c) The additive manufacturing plan, per NASA-STD-6016C, Section 4.2.4.11, shall be in accordance with Section 8.5 of this MAR and delivered separately (DID 8-5).
d) The contamination control plan, per NASA-STD-6016C, Section 4.2.6.7, shall be in accordance with Section 9.1 of this MAR and delivered separately (DID 9-1)
e) The MPCIP shall include the developer fastener management and control policy per NASA-STD-8739.14 or 541-PG-8072.1.2, including degree of conformance. The use of well-established developer practices are encouraged, provided documentation of these practices are made available for review electronically by the Goddard MPE.

Notes:

- For NASA-STD-6016C, Section 4.1.5., the developer may use GFSC forms or any equivalent electronic format in lieu of the MAPTIS format with approval from the Goddard MPE.

• The developer may use the Goddard outgassing database (URL http://outgassing.nasa.gov) in addition to MAPTIS (URL http://maptis.nasa.gov)."
Title: Materials Usage Agreement (MUA) **DID No.:** 8-2
Associated Requirement(s): • MAP_04: The developer shall prepare materials usage agreements (DID 8-2).
Reference Documents: • NASA-STD-6016C Standard Materials and Processes Requirements for Spacecraft • MSFC-STD-3029A Guidelines for The Selection Of Metallic Materials For Stress Corrosion Cracking Resistance In Sodium Chloride Environment
Due Date/Purpose of Delivery: • 30 days prior to CDR (For Approval) • After CDR, submit new or revised MUAs, 30 days after their identification (For Approval)
Preparation Information: The MUA documentation approach, per NASA-STD-6016C, Section 4.1.6, or developer standard practices, shall be defined in the Materials and Processes Selection, Control, and Implementation Plan (see DID 8-1). The MUA package shall include the technical information required to justify the application. MUAs for stress corrosion shall include a Stress Corrosion Cracking Evaluation Form per MSFC-STD-3029A (see NASA-STD-6016C) and a stress analysis or per developer standard practices.

Title: Materials Identification and Usage List (MIUL)	**DID No.:** 8-3

Associated Requirement(s):

- MAP_06: The developer shall prepare a materials identification and usage list (DID 8-3).
- CON_4: The developer shall include information regarding material outgassing (DID 8-3).

Reference Documents:

Due Date/Purpose of Delivery:

- 30 days prior to PDR (For review)
- 30 days prior to CDR (For Approval)
- Updates 30 days after identification (For Approval)
- As-Built MIUL 30 days prior to PSR (For Approval)

Preparation Information:

The MIUL documentation approach, per NASA-STD-6016C, Section 4.1.5, shall be defined in the Materials and Processes Selection, Control, and Implementation Plan (DID 8-1).

Additions and Prescribed Changes to NASA-STD-6016C MIUL requirements:

a) The MIUL shall identify all unique materials and processes used in the construction of the deliverable hardware.
b) With approval from the Goddard MPE, for NASA-STD-6016C, Section 4.1.5, the developer may use GFSC forms or the developer's equivalent forms in lieu of the MAPTIS format.
c) The MIUL shall include Thermal Vacuum Stability data, when appropriate, per NASA-STD-6016C, Section 4.2.3.6.
d) The MIUL shall include the vacuum bake-out schedule for materials that fail outgassing requirements or provide a separate MUA (see DID 8-2).
e) The developer may use the Goddard outgassing database (URL http://outgassing.nasa.gov) in addition to MAPTIS (URL http://maptis.nasa.gov).
f) The MIUL shall document, when appropriate, compliance to MSFC-STD-3029A
g) The MIUL shall clearly identify all materials that do not meet the requirements of NASA-STD-6016C and require an MUA per Section 8.2 and DID-8-2 of this MAR.
h) - The MIUL shall include soldering flux and solvents used for cleaning flight electronic assemblies, other than isopropyl alcohol or deionized water.

Title: Life Test Plan and Final Report for Lubricated Mechanisms	**DID No.:** 8-4

Associated Requirement(s):

- MAP_09: The developer shall prepare and implement a life test plan and final report for lubricated mechanisms (DID 8-4C).

Reference Documents:

- NASA-STD-6016C Standard Materials and Processes Requirement for Spacecraft
- NASA-TM-86556 Lubrication Handbook for the Space Industry (Part A: Solid Lubricants, Part B: Liquid Lubricants)
- NASA/CR-2005-213424 Lubrication for Space Applications

Due Date/Purpose of Delivery:

- 30 days prior to PDR (For Approval)
- 30 days after acceptance test completion (For Information)

Preparation Information:

The developer shall prepare and implement a Life Test Plan to qualify all lubricated mechanisms either by life testing or heritage with an identical mechanism used in an identical application. The developer shall perform a lubricant loss analysis for all mechanisms to show that the design meets a 10X margin.

The Plan shall contain:

a. Table of Contents
b. Description of lubricated mechanisms, performance functions, summary of subsystem specification, and life requirements.
c. Heritage of identical mechanisms and descriptions of identical applications.
d. Design, drawings, and lubrication system used by the mechanism.
e. Test plan, including vacuum, temperature, and vibration test environmental conditions.
f. Criteria for a successful test.

NASA-STD-6016C, Section 4.2.3.4, NASA-TM-86556, and NASA/CR-2005-213424 should be used as guides when developing the Plan

Alternatively, the developer shall provide detailed justification for NOT conducting life tests and/or lubricant loss analyses.

Title: Additive Manufacturing Control Plan (AMCP)	**DID No.:** 8-5

Associated Requirement(s):

- MAP_11: The developer shall prepare and implement an Additive Manufacturing Control Plan (AMCP) for the design and manufacture of Additively Manufactured (AM) Parts (DID 8-5).

Reference Documents:

- NASA-STD-6030 Additive Manufacturing Requirements for Spaceflight Systems
- NASA-STD-6016C Standard Materials and Processes Requirement for Spacecraft

Due Date/Purpose of Delivery:

- 14 days prior to SRR (For Information)
- 30 days prior to Mission PDR (For Approval)
- 30 days prior to CDR (For Approval)

Preparation Information:

For each Additive Manufacturing Requirement (AMR) in NASA-STD-6030, Sections 4 through 8, with the additions and prescribed changes below, the developer shall prepare and implement an AMCP that states the AMR, identifies the degree of conformance under the subheading "Degree of Conformance," and identifies the method of implementation under the subheading "Method of Implementation."

The use of well-established developer practices is encouraged to meet the intent of AMRs, and may be referenced by the AMCP, provided documentation of these practices is made available for review remotely by the Goddard MPE (in accordance with electronic access requirements specified in Section 1. 5 "Surveillance"). Tailoring of NASA-STD-6030 requirements by the AMCP is permitted, pending review and approval by Goddard. Upon approval, the AMCP becomes the AM implementation document used for verification (see Section 4.2.1.c of NASA-STD-6030)

Additions and Prescribed Changes to NASA-STD-6030:

- Technologies not included in NASA-STD-6030, Section 1.4.2, Table 1, will be considered pending review and approval by the Goddard MPE
- A Mission Critical Part is specified by the project-defined critical items list.
- Exempt Parts, per NASA-STD-6030, Section 4.3.1.4, are not allowed.

Title: AM Part Production Plan (PPP)	**DID No.:** 8-6
Associated Requirement(s): • MAP_13: The developer shall prepare a PPP for each AM part (DID 8-6).	
Reference Documents: • NASA-STD-6030 Additive Manufacturing Requirements for Spaceflight Systems	
Due Date/Purpose of Delivery: • Draft: 30 days prior to CDR (For Information) • Final: 30 days prior to an Additive Manufacturing Readiness Review (as defined by the AMCP) (For Approval)	
Preparation Information: The PPP shall document the part-specific information required by NASA-STD-6030, Section 7 Note: Not all AMR's in NASA-STD-6030, Section 7, apply to Class C parts. The primary purpose of the PPP for Class C parts is to document the rationale for the Class C designation.	

Title: Contamination Control Plan	**DID No.:** 9-1

Associated Requirement(s):

- CON_01: The developer shall prepare and implement a contamination control program (DID 9-1).

Reference Documents:

- GSFC-STD-7000 General Environmental Verification Standard
- GSFC-STD-1000 Rules for the Design, Development, Verification, and Operation of Flight Systems
- ASTM E595 Standard Test Methods for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment
- Outgassing Data for Selecting Spacecraft Materials (URL: http://outgassing.nasa.gov/)

Due Date/Purpose of Delivery:

- 30 days before PDR (For Review)
- 30 days before the CDR (For Approval)
- Final thermal vacuum bakeout results provided within 30 days of completion (For Review)
- Contamination certificate of compliance with End Item Acceptance Data Package (DID 12-1) (For Review)

Preparation Information:

The developer shall provide material properties data; design features; test data; system tolerance of degraded performance; methods to prevent degradation. The items below shall be addressed in the plan:

a) Beginning of life and end of life requirements for contamination sensitive surfaces or subsystems
b) Methods and procedures used to measure and maintain the levels of cleanliness required during each of the various phases of the item's lifetime (e.g., protective covers, environmental constraints, purges, cleaning/monitoring procedures)
c) Materials
d) Outgassing as a function of temperature and time.
e) Nature of outgassing chemistry.
f) Areas, weight, location, view factors of critical surfaces.
g) Venting: size, location and relation to external surfaces.
h) Thermal vacuum test contamination monitoring plan, to include vacuum test data, Quartz Crystal Microbalance (QCM) location and temperature, pressure data, system temperature profile, and shroud temperature.
i) On-orbit spacecraft and instrument performance as affected by contamination deposits.
j) Contamination effect monitor
k) Methods to prevent and recover from contamination in orbit
l) Evaluation of on-orbit degradation
m) Photopolymerization of outgassing products on critical surfaces
n) Atomic oxygen erosion and re-deposition
o) Analysis of contamination impact on the satellite on orbit performance
p) In orbit contamination impact from other sources such as space station and adjacent instruments
q) Ground/Test support equipment controls to prevent contamination of flight item(s)
r) Facility controls and processes to maintain hardware integrity (protection and avoidance)
s) Transportation/shipping controls and processes to maintain hardware integrity (protection and avoidance)
t) Training
u) Data package on test results for materials and as-built product

Title: Foreign Object Debris Program	**DID No.:** 9-2
Associated Requirement(s): • CON_7: The developer shall prepare and implement a foreign object debris program (DID 9-2).	
Reference Documents: • Nas412 Foreign Object Damage (FOD) Prevention Guidance Document	
Due Date/Purpose of Delivery: • Submit 30 days before PDR (For Review)	
Preparation Information: The plan will address the preservation of product with respect to foreign object debris prevention per the requirements of NAS 412 Foreign Object Damage/Foreign Object Debris (FOD) Prevention.	

Title: End Item Acceptance Data Package	**DID No.:** 12-1

Associated Requirement(s):

- EIA_1: The developer shall submit an end item acceptance data package (DID 12-1).
- EEE_17: The developer shall submit the Master EEE Parts List as part of the End Item Data Package (see DID 12-1).

Reference Documents:

Due Date/Purpose of Delivery:

- 30 days prior to PSR (For Approval)
- Final 30 days prior to end item delivery (For Approval)
- Updates 30 days after identification (For Approval)

Preparation Information:

The developer prepares the End Item Acceptance Data Package as part of design development and implementation such that it is completed prior to delivery. The following items shall be included (as specified by requirement):

a) The deliverable item name, serial number, part number, and classification status (e.g., flight, non-flight, ground support, etc.).
b) Appropriate approval signatures (e.g., developer's quality representative, product design lead, government Representative, etc.)
c) List of shortages or open items at the time of acceptance with supporting rationale.
d) As-built serialization
e) As-built configuration
f) In-process Work Orders (available for review at developers--not a deliverable)
g) Final assembly and test Work Order
h) Major MRB actions
i) Major anomaly reports
j) Acceptance testing procedures and report(s), including environmental testing
k) Trend data
l) Anomaly/problem failure reports with root cause and corrective action dispositions
m) Master EEE parts list
n) As-built materials list
o) Chronological history, including:
p) Total operating hours and failure-free hours of operation
q) Total number of mechanical cycles and remaining cycle life
r) Limited life items, including data regarding the life used and remaining
s) As-built final assembly drawings
t) PCB coupon results
u) Photographic documentation of hardware (pre- and post-conformal coating for printed wiring assemblies, box or unit, subsystem, system, harness, structure, etc.)
v) Waivers
w) Certificate of Compliance which is signed by management

Note: Given that the generation of the EIADP is essentially a consolidation of artifacts that should be readily available in a robust CM system, a separate effort for the developer to collect and compile the individual items into a single deliverable is discouraged, as it does not add any substantive value. However, since it only increases cost and does not increase risk, the project may choose to request this deliverable at its own discretion. In addition, the individual items included in the end item acceptance data package may be adjusted.