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SOLAR
X-Ray Irradiance Sensor (XRIS)
Mission Assurance Requirements (MAR)

SWO Reviewed – Not Subject to Export Control

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National Oceanic and Atmospheric Administration (NOAA)
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National Aeronautics and Space Administration (NASA)

SOLAR X-Ray Irradiance Sensor (XRIS) Mission Assurance Requirements (MAR)
Signature/Approval Page

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Preface

This document is under Space weather Observations at L1 to Advance Readiness (SOLAR) configuration management (CM)-controlled document. Changes to this document require prior approval and shall be submitted in the SOLAR project Technical Data Management System (TDMS) via a Configuration Control Request (CCR) or Signature Control Request (SCoRe), along with supportive material justifying the proposed change. Changes to this document will be made via complete revision.

All of the requirements within this document assume the use of the work “shall” unless otherwise stated.

Questions or comments concerning this document should be addressed to:

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Change History Log

Revision	Effective Date	Description of Changes (Reference the CCR & CCB/ERB Approval Date)
Revision RFI	05/31/2024	Baseline release for RFI released following the approval of SOLAR-CCR-0081
Revision -	04/09/2025	Baseline release following the approval of SOLAR-CCR-0124
Revision A	09/15/2025	Update following the approval of SOLAR-CCR-0143
Revision B	03/13/2026	Update following the approval of SOLAR-CCR-0184

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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 or 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 or focus area is further decomposed into subsections associated with its individual SMA activities or deliverables, e.g., 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

The key to the requirement identification 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

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Note: The contents of this Mission Assurance Requirements (MAR) document are the result of tailoring from a master set of requirements. Consequently, there may be instances where jumps or gaps occur in the numbering sequence of requirement IDs and DIDs. Due to the tailoring, there may also be sections that are not applicable, and have thus been marked "RESERVED." This is done intentionally to preserve the organization of the document and to facilitate tracking of data from implementation of requirements.

Requirements that have an associated Contract Data Requirements List (CDRL) item are denoted with the CDRL item number of MA x-y, where MA indicates a Mission Assurance CDRL item, x is the section referenced in this MAR document, and y is a sequential item number.

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1 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

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 (CDRL MA 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 all 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 Flow down

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 and information on discrepancy reports is communicated.

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 and adequately communicated, 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 NPR 8735.2, Section 4.1.4 "Critical Items and Processes Determination".

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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 or artifacts to National Aeronautics and Space Administration (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 or project development lifecycle.

GEN_14: In accordance with Federal Acquisition Regulations (FAR) 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 or developer prior to the start of an audit or assessment. The supplier or developer shall supply personnel, documents, records, equipment, and an acceptable work area within the developer's facilities to assist with the audit, assessments, or 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 firm fixed price projects, the developer shall provide a proposed GMIP plan, which will be used by the government in determining the final GMIPs that will be conducted. NASA Procedural Requirements (NPR) 8735.2 "Hardware Quality Assurance Program Requirements for Programs and Projects" may be used as a guide.

Typical GMIPs include:

a. Inspect Circuit Card Assemblies (CCAs), harnesses, connectors, etc. prior to staking/conformal coating process (solder, crimps, handling, and overall workmanship).

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b. Inspect CCAs for proper staking and conformal coating.
c. Pre-Cap inspection of Hybrid Components
d. Perform a pre-closure inspection of flight components (e.g., box, subsystem, structure) prior to the start of acceptance testing for configuration verifications and general mechanical and electrical workmanship.
e. Inspect flight harnesses for compliance to NASA-STD-8739.4
f. Review of purchase orders and statements of work on components/subsystem elements for proper requirements flow-down
g. Packaging, packing, shipping, and storage of flight products pre-shipment, and receiving of Government Furnished Equipment (GFE).
h. Witness and verify fastener torquing involving flight hardware.
i. Witness and inspect mates and de-mates of all flight connectors.
j. Verify test setups.
k. Witness and inspect any additional items or processes identified by the Government as areas of concern due to perceived risk.

GEN_19: 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_20: The developer shall track suppliers used for product produced under this contract.

1.9 Use of Inherited Products/Items

GEN_21: For Inherited Products/Items, defined as those that will be build-to-print (BTP), or rebuilt with modification, or are available as commercial-off-the-shelf (COTS), or were previously developed and exist (e.g., spares), the developer may propose to follow the processes documented in GPR 8730.5 “Safety and Mission Assurance Acceptance of Inherited and Build-to-Print Products”.

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_22: 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_23: The approach to obviate GSE damage to flight hardware shall be presented prior to the start of testing and at subsequent review milestones.

GEN_24: 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_25: 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 from GEN_24.

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1.11 Risk Management

GEN_26: 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.

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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 (SAE) AS9100 Quality Systems – Aerospace – Model for Quality Assurance in Design, Development, Production, Installation and Servicing.

2.2 Supplemental Quality Management System Requirements

2.2.1 Control of Nonconforming Product

QMS_04: The developer shall have a documented closed loop system for identifying, reporting, and correcting product nonconformances that shall include sub-tier supplier discrepancy reports. 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.

2.2.2 Material Review Board (MRB)

QMS_06: 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 affect form, fit, function, require a software change, involve the presence of Foreign Object Debris (FOD), affect the reliability, or safety of the end item, where a contractual requirement is violated, or those that the Government or developer determines involve elevated risk.

QMS_07: The Developer shall appoint a MRB chairperson who is responsible for implementing the MRB process and for appointing Developer representatives as MRB members.

QMS_09: The MRB process shall include a government representative as a participating member on MRB actions involving major nonconformances.

QMS_11: The government shall be provided notice and applicable documentation 24 hours in advance of scheduled MRB meetings.

QMS_12: The Developer shall inform the Government of MRB actions (CDRL MA 2-2).

QMS_13: 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_14: 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

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hardware, require a software change, affect safety or where there is a violation of a Government requirement.

QMS_16: 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 (CDRL MA 2-1).

Note: This is input to the Observatory ODAR and EOMP, and not the report and plan themselves which the Project will provide.

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3 SYSTEM SAFETY

3.1 General

SAF_01: The developer shall document and implement a system safety program, support the Expendable Launch Vehicle (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 ensure 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 ensure 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 selected 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 likely launch range (Requirements to be provided if another range is selected):

SAF_04: ELV Eastern Test Range (ETR) or Western Test Range (WTR) Missions:

- NASA-STD 8719.24 (with Annex) NASA Expendable Launch Vehicle Payload Safety Requirements
- KNPR 8715.3 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)

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3.3 System Safety Deliverables

3.3.1 System Safety Plan

SAF_10: The developer shall prepare a System Safety Plan (SSP) 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 (CDRL MA 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 (CDRL MA 3-2).

3.3.3 Instrument Safety Assessment Report (ISAR)

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 (CDRL MA 3-4). The spacecraft developer will use the ISAR as an input to the Safety Data Package (SDP).

3.3.4 Hazard Analyses

3.3.4.1 Preliminary Hazard Analysis

SAF_15: 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 PHA is based on the best available data, including mishap data from similar systems and other lessons learned.

SAF_16: 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_17: The developer shall deliver the PHA with a Preliminary ISAR (CDRL MA 3-4).

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

SAF_18: The developer shall perform hazard analysis to ensure 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.

SAF_19: The developer shall update and maintain the Hazard Verification Tracking Log during I&T activities to track open issues.

3.3.4.3 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

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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 3-4).

3.3.5 Verification Tracking Log (VTL)

SAF_22: 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_23: 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_24: 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_25: The developer shall make the results of the tests, analyses, and inspections from SAF_24 available for government review.

SAF_26: The VTL shall identify hazard controls that are not verified as closed and shall be delivered with the final ISAR (CDRL MA 3-4).

SAF_27: 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_28: 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.

SAF_29: The developer shall ensure that the hazardous procedures comply with applicable facility safety requirements.

SAF_30: The developer shall provide safety support for the implementation of hazardous procedures.

3.3.7 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_31: The developer shall implement the following safety requirements for Lifting Devices and Equipment (LDE) when performing NASA work at non-NASA facilities:

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- 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 (VFD) dynamic braking system is an acceptable dual braking system.
- Label and tag LDE per 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 (BTH) 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 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 (ASNT) or equivalently trained inspector."

3.3.8 Mishap Reporting and Investigation

SAF_32: The developer shall have a plan that describes appropriate mishap and close call notification, reporting, recording, and investigation procedures.

SAF_33: The developer shall report accidents, test failures, or other mishaps and close calls promptly (within 24 hours) to NASA.

SAF_34: The developer shall promptly investigate test failures, or other mishaps and close calls to determine the root cause of the mishap/close call.

3.3.9 NASA ELV Payload Safety Program Forms

SAF_35: The developer shall prepare NASA Expendable Launch Vehicle Payload Safety Forms. The forms are available at URL https://kscsma.ksc.nasa.gov/PayloadSafety/forms.

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4 RELIABILITY

4.1 Reliability Program

REL_05: The developer should perform reliability analyses concurrent with design 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. Components and systems designated as inherited items shall be analyzed at the interface level. All others shall be analyzed at the box or functional level. (CDRL MA 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.
SPFs	Critical	1	Failure modes that could result in mission loss or minimum mission success criteria not being achievable.
	Critical	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.
	Critical	1R	Failure modes of identical or equivalent redundant hardware items that, if all failed, could result in category 1/1SC effects.
	Critical	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 are still achievable.
	Significant	2R	Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed.
	Significant	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.

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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. This shall be included and maintained in CDRL MA 4-2.

REL_15: The developer shall estimate the likelihood score for each failure mode from 1-5 using the appropriate criteria from GPR 7120.4 (shown in Table 4.2) or another scale approved by GSFC Reliability. Each likelihood estimation can be based on qualitative assessment and/or failure rate data from other analyses (e.g., system calculations) in order to score each failure mode for the mission duration. This should be included and maintained in CDRL MA 4-2.

Table 4.2 Likelihood Rankings

Likelihood	Safety (Estimated likelihood of safety event occurrence)	Technical (Estimated likelihood of not meeting performance requirements)	Cost/Schedule (Estimated likelihood of not meeting cost or schedule commitment)
5 Very High	($P_{SE} > 10^{-1}$)	($P_T > 50\%$)	($P_{CS} > 75\%$)
4 High	($10^{-2} < P_{SE} \leq 10^{-1}$)	($25\% < P_T \leq 50\%$)	($50\% < P_{CS} \leq 75\%$)
3 Moderate	($10^{-3} < P_{SE} \leq 10^{-2}$)	($15\% < P_T \leq 25\%$)	($25\% < P_{CS} \leq 50\%$)
2 Low	($10^{-5} < P_{SE} \leq 10^{-3}$)	($2\% < P_T \leq 15\%$)	($10\% < P_{CS} \leq 25\%$)
1 Very Low	($10^{-6} < P_{SE} \leq 10^{-5}$)	($0.1\% < P_T \leq 2\%$)	($2\% < P_{CS} \leq 10\%$)

REL_16: The developer shall identify the consequence for each failure mode using the appropriate criteria from GPR 7120.4 (shown in Table 4.3). This should be included and maintained in CDRL MA 4-2).

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Table 4.3 Consequence Rankings

Consequence Categories					
Risk	**1 Very Low**	**2 Low**	**3 Moderate**	**4 High**	**5 Very High**
Safety	Negligible or not impact	Could cause the need for only minor first aid treatment	May cause minor injury or occupational illness or minor property damage	May cause severe injury or occupational illness or major property damage.	May cause death or permanently disabling injury or destruction of property.
Technical	No impact to full mission success criteria	Minor impact to full mission success criteria	Moderate impact to full mission success criteria. Minimum mission success criteria is achievable with margin	Major impact to full mission success criteria. Minimum mission success criteria is achievable	Minimum mission success criteria is not achievable
Schedule	Negligible or no schedule impact	Minor impact to schedule milestones; accommodates within reserves; no impact to critical path	Impact to schedule milestones; accommodates within reserves; moderate impact to critical path	Major impact to schedule milestones; major impact to critical path	Cannot meet schedule and program milestones
Cost	<2% increase over allocated and negligible impact on reserve	Between 2% and 5% increase over allocated and can handle with reserve	Between 5% and 7% increase over allocated and cannot handle with reserve	Between 7% and 10% increase over allocated, and/or exceeds proper reserves	>10% increase over allocated, and/or can't handle with reserves

4.2.2 Fault Tree Analysis (FTA)

REL_17: The developer shall perform qualitative fault tree analyses (FTA), as deemed necessary by the contractor.

REL_18: Fault trees 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_19: 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_20: FTA should also be considered for use to check the FMECAs for completeness.

4.2.3 Reliability Calculations

REL_21: The developer shall perform and maintain reliability and availability calculations using Fault Tree Analyses (FTA), reliability block diagrams, and/or Probabilistic Risk Assessment (PRA) to identify design weaknesses, support design trades, and demonstrate the impact of critical items, as deemed necessary by the contractor.

4.3 Limited Life Analysis

REL_22: The developer shall perform and maintain Limited Life Item Analysis (LLA) that includes expected life, required life, and an assessment of life margin (including servicing and maintenance); provides retention rationale for items with an expected life of less than 2x the required life and fosters a plan to manage limited life items (CDRL MA 4-5).

REL_25: The risk assessment and mitigations plans shall be included in the LLA for items not meeting the 2X life requirement and shall factor in wear caused by atomic oxygen, solar and

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trapped radiation, shelf-life, extreme temperatures, thermal cycling, write/erase cycles and mechanical wear or fatigue, and include refurbishment and maintenance plans.

4.4 Parts Stress Analysis

REL_26: The developer shall perform parts stress and derating analyses for electrical, electronic, and electromechanical (EEE) parts in accordance with GSFC EEE-INST-002 Instruction for EEE Parts Selection, Screening, Qualification, and Derating (CDRL MA 4-6) or the developer's own established standard, unless specifically relieved of this requirement by the GSFC Inherited Items Risk Assessment process (See Section 1.9).

REL_28: If alternate derating guidelines are requested to be used, they shall be submitted to the Parts Control Board and GSFC Reliability Engineering for approval.

4.5 Worst-Case Analysis

REL_30: The developer shall perform Worst-Case Analyses (WCA) for circuit designs that are new or significantly modified or are being used in an environment not covered by the existing analysis and identified as critical through analysis of the design (See Section 4.2) (CDRL MA 4-7).

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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, GOTS, MOTS, OSS, 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-8739.8B, NASA Software Assurance and Software Safety Standard (CDRL MA 5-1).

The plan includes 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-8739.8B 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_08: Consistent with the general requirement for support of government surveillance (see Section 1.6 "Surveillance"), the developer shall provide on-request access to following:

- Software problem reports

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- 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, and maintenance plans)
- Source code
- Findings and corrective actions from software process and product audits and assessments

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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
- GSFC-STD-6001 Ceramic Column Grid Array Design and Manufacturing Rules for Flight Hardware
- 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_04: 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 Requirements and Acceptance for Cable and Wire Harness Assemblies

6.2 Electrostatic Discharge Control (ESD)

WOR_06: 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)" or contractor equivalent.

6.3 Printed Circuit Boards (PCB)

WOR_08: 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_09: In cases in which high-density interconnect (HDI) components (e.g., reconfigurable FPGAs, high-density SRAMs, etc.) or board population are present, the developer should consult with the GSFC Project and GSFC MPCB CRAE for a specification strategy to avoid extensive rebuilds or the incorporation of risky features solely in order to meet the spec. This consultation may result in deviations from the specifications above with no waiver required.

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WOR_12: For non-conforming coupons, the evaluation report shall be delivered to the GSFC MPCB CRAE for a risk assessment. If the CRAE's risk assessment determines that there is no elevated risk, no waiver is required and the CSO will determine the disposition of the board.

6.4 Lead-Free Control Measures

WOR_17: The developers shall submit uses of lead-free solder or surface finishes to the NASA project office for approval before use.

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7 EEE PARTS

7.1 General

EEE_02: The developer shall document and implement a Parts Control Plan (PCP) per Level 3 instructions of GSFC EEE-INST-002 Instruction for EEE Parts Selection, Screening, Qualification, and De-rating (CDRL MA 7-1).

Note: The developer may use as is Class V, S, Q, B, M compliant microcircuits; JANS, JANTXV, and JANTX semiconductors without any further approval.

Note: The developer may use as is automotive or hi-rel commercial off the shelf (COTS) parts, compliant to level 3 per NASA-STD-8739.10 without any additional screening or qualification tests without any further approval.

7.2 Parts Control Board

EEE_07: 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_10: The developer shall identify the person responsible for directing and managing the EEE parts program and interfacing with government assurance personnel.

EEE_13: The developer shall include the GSFC Parts Engineer and the Parts and Radiation Assurance Engineer (PRAE) as participating members of the PCB.

7.3 Re-use of EEE Parts

EEE_15: The developer shall require approval of the PCB to re-use EEE parts that have been installed.

7.4 Master EEE Parts List

EEE_16: The developer shall develop and deliver a Master EEE Parts List in accordance with CDRL MA 7-2 and maintain it for the duration of the project.

7.5 Radiation Effects Mitigation

EEE_19: The developer shall provide a plan, for approval, for how radiation will be addressed (CDRL MA 7-3).
EEE_20: The developer shall provide a radiation and shielding analysis to ensure that all instrument parts will be compatible with the expected space radiation environment for the required mission life and to determine whether the instrument radiation shielding is adequate to protect the instrument electrical and optical parts from excessive degradation due to radiation (CDRL MA 7-4).

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8 MATERIALS AND PROCESSES

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

MAP_01: The developer shall implement a Materials and Processes (M&P) Selection, Control, and Implementation Plan (MPCIP). 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 Identification and Usage List (MIUL)

MAP_04: The developer shall prepare a materials identification and usage list (CDRL MA 8-3).

8.3 Life Test Plan for Lubricated Mechanisms

MAP_05: The developer shall implement a life test plan for lubricated mechanisms.

8.4 Additive Manufacturing Control Plan (AMCP)

MAP_06: The developer shall implement an Additive Manufacturing Control Plan (AMCP) for the design and manufacture of Additively Manufactured (AM) if AM parts will be used.

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9 CONTAMINATION CONTROL

9.1 Contamination Control Plan

CON_01: The developer shall implement a contamination control program.

9.2 Material Outgassing

CON_03: The developer shall include in CDRL MA 8-3 (MIUL) information regarding material outgassing.

CON_04: 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 (TML) and < 0.1% collected volatile condensable material (CVCM) at 125C under vacuum for twenty-four hours when tested to 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_05: The developer shall implement a foreign object debris program.

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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 (WOAs), 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.

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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. (CDRL MA 11-2).

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. (CDRL MA 11-1)

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12 END ITEM ACCEPTANCE DATA PACKAGE

EIA_01: The developer shall maintain the End Item Acceptance Data Package (EIADP) throughout the project lifecycle and submit in accordance with (CDRL MA 12-1).

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Appendix A Acronym List

AMCP	Additive Manufacturing Control Plan
ANSI	American National Standards Institute
ARB	Anomaly Review Board
ASNT	American Society for Nondestructive Testing
CCB	Configuration Control Board
CCR	Configuration Change Request
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CIL	Critical Items List
COTS	Commercial off-the-shelf software
CRAE	Commodity Risk Assessment Engineer
CSO	Chief Safety and Mission Assurance Officer
DID	Data Item Description
EEE	Electrical, Electronic, and Electromechanical
ELV	Expendable Launch Vehicle
EOMP	End of Mission Plan
ESD	Electrostatic Discharge Control
FAR	Federal Acquisition Requirements
FMECA	Failure Modes and Effects Criticality Analysis
FOD	Foreign Object Debris
FTA	Fault Tree Analysis
GIDEP	Government-Industry Data Exchange Program
GOTS	Government off-the-shelf software
GPR	Goddard Procedural Requirement
GSFC	Goddard Space Flight Center
HVTL	Hazard Verification Tracking Log
I&T	Integration and Test
ISAR	Instrument Safety Assessment Report
LFCP	Lead-Free Control Plan
MA	Mission Assurance
M&P	Materials and Processes
MOTS	Modified off-the-shelf software
MRB	Material Review Board
MUA	Materials Usage Agreement
MIUL	Materials Identification and Usage List
NASA	National Aeronautics and Space Administration
NPR	NASA Procedural Requirement
O&SHA	Operating and Support Hazard Analyses

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ODAR	Orbital Debris Assessment Report
OHA	Operations Hazard Analysis
PCB	Printed Circuit Board
PCB	Parts Control Board
PCP	Parts Control Plan
PHA	Preliminary Hazard Analyses
SAE	Society of Automotive Engineers
SDP	Safety Data Package
SMA	Safety and Mission Assurance
SMA-D	Safety and Mission Assurance Directorate
SOLAR	Space weather Observations at L1 to Advance Readiness
SSP	System Safety Plan
STD	Standard
VTL	Verification Tracking Log
WCA	Worst Case Analysis
WOA	Work Order Authorization
XRIS	X-Ray Irradiance Sensor

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