



Subject: Product Assurance Requirements

Responsible Office: Safety and Mission Assurance Office

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PREFACE

P.1 Purpose

- a. This Langley Procedural Requirement (LPR) sets forth the implementation requirements for the National Aeronautics and Space Administration's (NASA's) Langley Research Center (LaRC) policy, procedures, and practices relative to product assurance.
- b. All HQ Safety & Mission Assurance (SMA) requirements are ensured by the SMA Director for tenant NASA program/projects through application of the requirements within this document and as negotiated with the tenant program/project. Office of Safety and Mission Assurance (OSMA) (including MAB personnel) are independent of program/project management.
- c. The Mission Assurance Branch (MAB), Safety and Mission Assurance Office (SMAO), are the LaRC contact for product assurance (PA) requirements. MAB is responsible for the issuance, distribution, and control of this LPR. Revisions will be reviewed with affected organizations and documented on a Transmittal Notice.
- d. This LPR comprises the LaRC Mission Assurance Program (MAP). Compliance with the requirements of the LaRC MAP is essential to ensure the successful accomplishment of LaRC's mission in an efficient and cost effective manner. It is the responsibility of each member of the staff to work together to achieve this goal.

P.2 Applicability

- a. The requirements of this LPR are applicable to all LaRC projects which produce, launch and/or operate flight hardware and/or software. The scope or coverage includes all exploration projects, atmospheric science instruments, satellites and missions, International Space Station payloads and experiments, and planetary science payloads missions. SMAO requirements must also be met on risk reduction flights; flight experiments or technology demonstrations; flights of opportunity that are sub-orbital; involve sounding rockets; un-crewed aerospace vehicles; drop models; and major Unmanned Aerial Vehicle (UAV) operations as determined by management. Technology Readiness Level (TRL) 6 or higher projects and/or experiments are subject to SMAO review and requirements.
- b. This includes products developed, fabricated, or integrated at LaRC and other NASA Centers, procured from contractors, or obtained from academic or other institutions.
- c. Excluded are efforts involving TRL level 5 or lower research and development, wind tunnel models and aircraft experiments. Wind tunnel models safety and quality assurance requirements are specified in LPR 1710.15, Wind-Tunnel Model Systems Criteria. Flight experiments in aircraft are required to follow LPR 1710.16,

Aviation Operations and Safety Manual, and LMS-CP-5580, Airworthiness and Safety Review Board (ASRB).

P.3 Authority

- a. NPD 7120.4, NASA Engineering and Program/Project Management Policy
- b. NPD 8700.1, NASA Policy for Safety and Mission Success
- c. NPR 7120.5, NASA Space Flight Program and Project Management Requirements
- d. NPR 7120.8, NASA Research & Technology Program and Project Management Requirements
- e. Langley Policy Directive (LAPD) 5300.1, Program/Product Assurance
- f. NASA Federal Acquisition Requirement (FAR) Supplement (Paragraph 18-42.202-70).

P.4 Applicable Documents

- a. NASA FAR Supplement: 48 C.F.R., Chapter 18
- b. NPD 8730.2C, NASA Parts Policy (Revalidated 12/6/13)
- c. NPD 8730.5, NASA Quality Assurance Program Policy
- d. NPR 2810.1, Security of Information Technology
- e. NPR 7120.5, NASA Space Flight Program and Project Management Requirements
- f. NPR 8000.4, Risk Management Procedural Requirements
- g. NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping
- h. NPR 8705.2, Human-Rating Requirements for Space Flight Systems
- i. NPR 8705.4, Risk Classification for NASA Payloads
- j. NPR 8705.5, Technical Probabilistic Risk Assessment (PRA) Procedures for Safety and Mission Success for NASA Programs and Projects
- k. NPR 8705.6, Safety and Mission Assurance (SMA) Audits, Reviews, and Assessments
- l. NPR 8715.3, NASA General Safety Program Requirements
- m. NPR 8715.6, Limiting Orbital Debris
- n. NPR 8735.2, Management of Government Quality Assurance Functions for NASA Contracts
- o. NPR 8735.1, Procedures for Exchanging Parts, Materials, and Safety

- Problem Data Utilizing the Government-Industry Data Exchange Program and NASA Advisories
- p. NPR 8735.2, Management of Government Quality Assurance Functions for NASA Contracts
 - q. LAPD 1000.1, Langley Management System (LMS) Policy Manual
 - r. LAPD 4520.1, Langley Research Center (LaRC) Requirements for Safety-Critical Product Testing
 - s. LAPD 5330.3, Langley Research Center (LaRC) Standards for the Acquisition of Threaded Fasteners (Bolts)
 - t. LPR 1710.3, Chemical Hygiene Plan
 - u. LPR 1710.4, Personnel Protection – Clothing and Equipment
 - v. LPR 1710.5, Ionizing Radiation
 - w. LPR 1710.6, Electrical Safety
 - x. LPR 1710.7, Handling and Use of Explosives
 - y. LPR 1710.8, Non-Ionizing Radiation
 - z. LPR 1710.10, Langley Research Center Energy Control Program (Lockout/Tag out)
 - aa. LPR 1710.11, Fire Protection Program
 - bb. LPR-1710.12, Potentially Hazardous Materials-Hazard Communications Standards
 - cc. LPR 1710.17, Respiratory Protection Program
 - dd. LPR 1710.40, Langley Research Center Pressure Systems Handbook
 - ee. LPR 1740.2, Facility Safety Requirements
 - ff. LPR 1740.5, Procedures for Cleaning of Systems and Equipment for Oxygen Service
 - gg. LPR 1740.6, Personnel Safety Certification
 - hh. LPR 1740.7, Process Systems Certification Program
 - ii. LPR 1710.41, Langley Research Center Standard for the Evaluation of Socket and Branch Connection Welds
 - jj. LPR 1820.2, Ergonomics Program
 - kk. LPR 2710.1, Langley Research Center Noise Control and Hearing Conversation Program
 - ll. LPR 5310.1, Foreign Object Damage (FOD) Prevention Program
 - mm. LPR 7100.10, Protection of Human Research Subjects
 - nn. LPR 7150.2, LaRC Software Engineering Requirements

- oo. LPR 8717.1, Job Hazard Analysis Program
- pp. LPR 8739, Workmanship Standards Certification Program
- qq. LPR 8739.21, Langley Research Center (LaRC) Procedures and Guidelines for Electrostatic Discharge (ESD) Control of ESD-Sensitive (ESDS) Devices Program
- rr. LMS-CP-0506, Selection, Use and Control of Inspection, Measuring, and Test Equipment (IM&TE)
- ss. LMS-CP-4505, Purchase Requisition (PR) Initiation/Modification/Cancellation and Supporting Documentation
- tt. LMS-CP-4520.5, Receipt Inspection for Safety-Critical Products
- uu. LMS-CP-4520.6, Receipt Inspection for Fastener, Insert, and Nut Products
- vv. LMS-CP-4703, Review of Purchase Requests by the Safety and Mission Assurance Office (SMAO)
- ww. LMS-CP-4706, Monitoring and Reporting of Materials Analysis and Quality Assurance Testing Results Performed by the Materials Analysis and Quality Assurance Lab
- xx. LMS-CP-4750, Develop Product Assurance Plans
- yy. LMS-CP-4751, Response to Requests for Mission Assurance Support in Proposal or Contract Development
- zz. LMS-CP-4754, Quality Assurance (QA) for Software Development and Acquisition
- aaa. LMS-CP-4756, Handling, Preservation, Storage, and Shipping of Flight Hardware and Ground Support Equipment
- bbb. LMS-CP-4759, Acquisition of Hazardous Materials
- ccc. LMS-CP-4760, Reporting Injuries, Illnesses, and Compensation Claims
- ddd. LMS-CP-4892, Bonded Storage
- eee. LMS-CP-5507, Reporting and Disposition of Nonconforming Aerospace Hardware Items and Products
- fff. LMS-CP-5523, SOW Review Procedure
- ggg. LMS-CP-5640, Requesting, Performing, and Closing Fabrication Requests
- hhh. LMS-CP-7122.5, Critical and Complex Work Designation
- iii. LMS-CP-7150.3, Class A, B, and All Safety Critical Software
- jjj. LMS-CP-7150.4, Class C Software
- kkk. LMS-CP-7150.5, Class D Software
- lll. LMS-CP-7150.6, Class E Software
- mmm. LMS-CP-7151, Obtaining Waivers for Langley Management System (LMS)

Requirements

- nnn. LMS-CP-8621, Reporting, Investigating, and Recordkeeping for Mishaps, Close Calls, and Previously Unidentified Serious Workplace Hazards
- ooo. LMS-CP-8705.2, Safety and Mission Assurance (SMA) Programmatic Risk and Quality Assurance Assessments
- ppp. LMS-OP-5146, Purchase Request Quality Assurance Review
- qqq. LMS-OP-5515, Electric, Electronic, Electromechanical (EEE) Parts Assurance
- rrr. NASA-STD-6008, NASA Fastener Procurement, Receiving Inspection, and Storage Practices for Spaceflight Hardware
- sss. NASA-STD-6016, Standard Materials and Process Requirements for Spacecraft
- ttt. NASA-STD 8709.20, Management of Safety and Mission Assurance Technical Authority (SMA TA) Requirements
- uuu. NASA-STD-8719.9, Standard for Lifting Devices and Equipment
- vvv. NASA-STD 8719.14, Procedures for Limiting Orbital Debris
- www. NASA-STD-8729.1, Planning, Developing and Managing an Effective Reliability and Maintainability (R&M) Program
- xxx. NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies
- yyy. NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring
- zzz. NASA-STD-8739.5, Fiber Optics Terminations, Cable Assemblies, and installation
- aaaa. NF 1430, Letter of Contract Administration Delegation, General
- bbbb. NF 1544, Problem Impact Statement—Parts, Materials, and Safety
- cccc. LF 45, Data Requirements Description
- dddd. LF 45A, Data Requirements Description, Continued
- eeee. LF 47, Documents Requirements List (DRL)
- ffff. LF 52, Shipping/Transfer Document
- gggg. LF 132, Record of Weight
- hhhh. LF 133, Fabrication Work Request
- iiii. LF 136, Fabrication Inspection and Operations Sheet
- jjjj. LF 138, Time/Cycle Log
- kkkk. LF 142, Quality Status Stamp Request/Receipt/Return
- llll. LF 143, Nonconformance Report (Web-based form)
- mmmm. LF 144, Connector Log

nnnn. LF 147, Contractor Deviation/Waiver Request
oooo. LF 150, Bonded Stores Inventory Log (Horizontal)
pppp. LF 150, Bonded Stores Inventory Log (Vertical)
qqqq. LF 154, Configuration Record
rrrr. LF 155, Assembly History Record
ssss. LF 170, Nonstandard Part Approval Request (NSPAR)
tttt. LF 177, Bonded Stores Receipt and Requisition Record
uuuu. LF 183, Hardware Identification Log
vvvv. LF 184, Identification Card
www. LF 188, Contract/Purchase Order /Solicitation Quality Assurance Requirements Form
xxxx. LF 191, Bonded Stores Audit Checklist
yyyy. LF 192, Record Form
zzzz. LF 248, Materials Analysis and Quality Assurance Laboratory (MAQAL) Work Request
aaaaa. LF 285, MAQA Lab Material Release (portrait) NOTE: Internal form for use exclusively in the Material Analysis and Quality Assurance (MAQA) Lab
bbbbb. LF 285L, MAQA Lab Material Release (landscape) NOTE: Internal form for use exclusively in the Material Analysis and Quality Assurance (MAQA) Lab
ccccc. LF 290, Fastener Work Request – MAQAL
dddd. LF 320, Cleanroom Audit Checklist
eeee. LF 285R, MAQA Lab Material Release (reference only) NOTE: Internal form for use exclusively in the Material Analysis and Quality Assurance (MAQA) Lab
ffff. LF 358, Candidate Critical Lift Checklist
ggggg. LF 387, Logbook Audit Checklist
hhhhh. LF 450 Quality Status Stamp Yearly Inventory
iiii. LF 527, Supplier Risk Assessment Evaluation Form
jjjj. LF 532, Receipt and Inspection Report (R & IR) Flight Hardware
kkkkk. JSC Form 542, Payload Hazard Report
llll. JSC Form 1230, Flight Payload Standardized Hazard Control Report
mmmm. Constellation Systems Supportability Strategy (SS), which is part of the NASA, Constellation Systems Document 0000028493
nnnnn. AFI 91-202, U.S. Air Force Mishap Prevention Program

- ooooo. AFSPCMAN 91-710, U.S. Air Force Range Safety User Requirements Manual, Vol. 7
- ppppp. ANSI/ESD S20.20, Protection of Electrical and Electronics Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
- qqqqq. CxP 70038, Constellation Program Hazard Analyses Methodology
- rrrrr. Defense (DoD) Form 250, Material Inspection and Receiving Report
- sssss. EWR 127-1, Eastern and Western Range Safety Requirements
- ttttt. Federal Standard 209, Clean Room and Work Station Requirements, Controlled Environment
- uuuuu. FED-STD-209D, Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones
- vvvvv. GEVG-LaRC/SED, General Environmental Verification Guidelines for STS and ELV Payloads, Subsystems and Components
- wwwww. IEST-STD-CC1246D, Product Cleanliness Levels and Contamination Control Program
- xxxxx. JSC 26943, Guidelines for the Preparation of Payload Flight Safety Data Packages and Hazard Reports
- yyyyy. JSC-SN-C-0005, Space Shuttle Contamination Control Requirements
- zzzzz. J-STD-001ES, Joint Industry Standard, Space Applications Electronic Hardware Addendum to J-STD-001E, Requirements for Soldered Electrical and Electronic Assemblies
- aaaaa. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook
- bbbbb. MIL-STD-882, System Safety
- ccccc. MSFC-HDBK-527/JSC 09604, Materials Selection List for Space Hardware Systems
- dddddd. NSTS 1700.7, Safety Policy and Requirements for Payloads Using the Space Transportation System
- eeeeee. NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements

P.5 Measurement/Verification

Compliance with this LPR will be tracked by product assurance plans.

P.6 Cancellation

LPR 5300.1 K, Program/Product Assistance, dated July 25, 2011.

/s/ Cathy H. Mangum, Center Associate Director, July 23, 2015

Distribution

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Chapter 1: Introduction

1.1 General

This document identifies the LaRC internal PA requirements and activities to produce, launch, and operate flight project products (as defined in the P.2 Applicability section) designed, fabricated, and/or managed at LaRC or to procure a contractor for providing these products and/or services.

- 1.1.1 This includes flight, proto-type, proto-flight and qualification hardware, software, firmware, and critical ground support equipment (GSE).
- 1.1.2 The requirements and activities identified herein, form the basis for the development of project unique Product Assurance Plans (PAPs).
- 1.1.3 LaRC is primarily involved with project level support rather than program level. Understandably, all requirements flowed down to LaRC PAPs are developed at the project level and below. This results in the absence of LaRC Program level requirements (derived from NASA Headquarters' NPD/NPR Program requirements), as they are not applicable and have been tailored out of this Product Assurance Plan Requirements document.

1.2 Mission Success Criteria

- 1.2.1 The sponsoring LaRC organization and the principal investigator, if applicable, shall establish Mission Success Criteria (MSC) for each project.
- 1.2.2 The MSC shall document the mission science requirements, required data products, and a numerical Reliability Goal (RG) for a specified mission duration as per program requirements, which if satisfied, will deem the mission to be successful.

1.3 Implementation

Project PA activities will comply with the requirements of this LPR and are initiated as follows:

- a. The Project Implementation Office shall initiate MAB involvement in the preparation of internal Project product assurance requirements and/or Statement of Work (SOW) for contracted activities.
- b. MAB shall assign a Product Assurance Manager (PAM) to assist the project in establishing the MSC.
- c. Project personnel shall meet with the PAM to scope the PA activities as required by this document and to achieve the specified MSC.
- d. The PAM, in conjunction with project personnel, shall develop a PAP for PA

activities performed internal to LaRC in accordance with the applicable requirements of this document.

- e. For contracted PA activities, the PAM, in conjunction with project personnel, via the Office of Procurement (OP) coordination, shall establish PA requirements for inclusion in the project SOW and Request for Proposal (RFP).
 - (1) The RFP may require the submittal of PAP elements with the contractor proposal that satisfies the PA requirements outlined by this document.
 - (2) A contractor developed PAP shall be required as a government approved deliverable following contract award.
- f. The Head of MAB and the Project Manager (PM) will review and approve the PAP and/or RFP PA requirements.

CHAPTER 2: PRODUCT ASSURANCE PLANS

2.1 General

2.1.1 All LaRC flight projects (as defined in the P.2 Applicability section), regardless of cost or where managed, shall have a PAP developed in accordance with LMS-CP 4750.

2.1.1.1 Project offices shall ensure that sufficient funding is available for PAP development and implementation.

2.2 Content

2.2.1 The PAP shall identify the applicable requirements of this document necessary to achieve the specified MSC and as required by other NASA or Program Office documents.

2.2.1.1 An organizational chart shall be included, which identifies individuals responsible for the specified product assurance deliverables and support activities. A sample PAP outline is provided in Appendix B.

2.2.2 Key Characteristics

2.2.2.1 These are features of a material, process, or part whose variation has a significant influence on product fit, performance, service life, or manufacturability.

2.2.2.2 In order to meet the MSC for a given project, the end product shall have either specified or derived key characteristics that must be met in order to provide satisfactory performance.

2.2.2.3 Key characteristics, when applicable, are identified as part of the design and development outputs and require all pertinent data to allow the product to be identified, manufactured, inspected, used and maintained as defined.

2.2.2.4 The PAP shall identify key characteristics (in keeping with the applicability of the design outputs) at the system/product level, and identify those quality assurance activities for monitoring and control.

2.2.2.5 Key characteristics are used in determining the overall quality assurance approach and ensuring the lower level work processes incorporate the necessary standards, inspections, and tests.

2.3 Approval

2.3.1 All PAPs shall be approved by the Head, MAB, and the LaRC PM.

- 2.3.2 In addition, the following steps are applicable to PAPs developed by contractors in response to a LaRC RFP, whether competed or sole sourced:
- a. The MAB evaluates the proposed PAP as to its adequacy for assuring the desired MSC and other required product assurance elements are achievable.
 - b. The selected contractor's proposed PAP, with negotiated additions, modifications, and subsequent revisions shall be approved by the MAB.
 - c. The contractor shall submit an approved PAP at the Preliminary Design Review (PDR) and an updated, if required, PAP 30 days prior to the Critical Design Review (CDR) for MAB approval.
 - d. Upon MAB approval, the contractor PAP is base-lined and placed under the project configuration control system.

2.4 Changes

- 2.4.1 All changes to an approved PAP shall be subject to the Project's configuration management process.
- 2.4.2 PAPs shall be promptly updated to include all approved changes.

2.5 PAP Deviations/Waivers

- 2.5.1 Deviations to the PA requirements in this document shall be implemented during the development of the PAP and documented within the Project PAP.
- 2.5.2 Deviations from internal LaRC processes/requirements shall be approved by the signatories of the PAP and the only documentation required shall be an explanation of the deviation in the PAP.
- 2.5.3 Deviations/waivers from NASA SMA NPDs, NPRs, NASA Standards, etc., with the exception of personnel safety requirements, that have been delegated to the Centers as prescribed in NASA-STD 8709.20 shall be approved by the Center OUMs for Flight Project Directorate and Safety & Mission Assurance Office and the Center's Chief Engineer.
- 2.5.4 Deviations/waivers for personnel safety requirements that have been delegated to the Center as prescribed in NASA-STD 8709.20 shall be approved as specified in 2.5.3, but also require the Center Director's approval.
- 2.5.5 Deviations/Waivers from NASA SMA requirements that have not been delegated to the Center shall follow the requirements as specified in NASA-STD 8709.20.

- 2.5.6 Waivers for specific hardware/software that are documented in a Non-Conformance Report as specified in section 7.9 are not required to be documented in the PAP.

2.6 Audits and Assessment

- 2.6.1 All PA activities identified in an approved PAP shall be subject to audits or reviews by the MAB or its designee or program/project and follow LMS-CP-8705.2.
- 2.6.1.1 These audits or reviews ensure compliance with identified PA requirements and ascertain that personnel performing PA activities have the required training and skills for the successful completion of their tasks, as applicable.
- 2.6.1.2 All identified deficiencies shall be promptly corrected by the responsible organization.
- 2.6.2 The MAB or its designee shall have the authority to stop ongoing work, prevent work from commencing on any LaRC activity, or request the Contracting Officer Representative (COR) to stop work on any contractor activity assessed to be noncompliant with an approved PAP.
- 2.6.3 NASA Safety Center (NSC) Quality Audit, Assessment, and Review (QAAR) led SMA assessments, as designated by HQ in NPR 8705.6B, shall implement the following:
- a. Be supported by Center Management, Center SMA, Project Management and personnel (including contractors) as scoped in the scheduled assessment activities.
 - b. Be assigned a SMA Point-of-Contact (POC) for the assessment and provided applicable resource support for scoped areas of review.
 - c. Be provided all necessary review materials including, but not limited to, Center documents; Program/Project documents, organizational charts; contracts; results of other relevant audits, reviews, or assessments that may have previously verified compliance with requirements; and Center internal SMA audits and assessments to facilitate the planning and execution of the SMA audit and assessment.
 - d. Be provided with support for the audit or assessment plan by providing the logistic and resource support required for successful execution of and response to the SMA audit and assessment (e.g. planning and schedule coordination, and workspace and information technology support).
 - e. Be provided with a Corrective Action Plan (CAP) addressing resolution of all Center SMA audit noncompliances to the NSC.

- f. Be provided with annual status of the CAP (to the NSC) until all Center SMA audit noncompliances have been closed.

2.7 Responsibilities

2.7.1 The MAB is responsible for:

- a. Preparing and maintaining the PAP for in-house projects.
- b. Submitting in-house PAPs for project approval.
- c. Establishing PA requirements for the SOW on flight projects performed by contractors.
- d. Reviewing contractors' PAPs.
- e. Approving in-house PAPs.
- f. Conducting audits or reviews to assure correct implementation of PAPs for in-house and contracted projects.

2.7.2. The PM is responsible for:

- a. Approving PAPs.
- b. Managing implementation of the PAP.

CHAPTER 3: ACQUISITION QUALITY ASSURANCE

3.1 Acquisition Quality Assurance Scope and Requirements

1.1.1 General Information and Definitions

3.1.1.1 Sections 3.1 through 3.4 identify requirements and procedures to ensure suppliers, contractors, and subcontractors deliver products and services which comply with LaRC Product Assurance (PA) requirements.

3.1.1.2 The following functional entities shall be cognizant of the general information and definitions specified in Sections 3.1.1, 3.2.1, 3.3.1 and 3.4.1.

- a. Mission Assurance Branch, Quality Assurance Specialists (MAB/QAS).
- b. Engineers.
- c. Technicians.
- d. Procurement.
- e. Product Assurance Manager (PAM).
- f. PM.

3.1.1.3 Quality Management Systems (QMS) requirements are specified in NPD 8730.5.

3.1.1.4 The following QMS requirements documents, or other quality assurance (QA) requirements are required in contract specifications, SOWs, RFPs, and Task-Order documents, based on the type of contractor work being performed, when procuring flight hardware:

- a. AS9100 is applicable to contractor work that is both critical and complex, as defined in 3.1.1.6 and 3.1.1.7.
- b. AS9100 or ISO 9001, or the inspection and test quality system requirements of AS9003, are applicable to contractor work that is critical, but not complex, as defined in 3.1.1.6.
- c. AS9100 or ISO 9001 is applicable to contractor work that is complex, but not critical, as defined in 3.1.1.7.
- d. AS9100, ISO 9001, AS9003, or in accordance with test and inspection requirements specified in the procurement document is applicable to contractor work that is neither critical nor complex, as defined in 3.1.1.8.

- 3.1.1.5 *Quality characteristics*: Quality characteristics are defined as features of hardware that are required to meet design specifications.
- 3.1.1.6 *Critical work*: Critical work is any hardware task that, if performed incorrectly or in violation of prescribed requirements, could result in loss of human life; serious personal injury; loss of a Class A, B, or C payload (see NPR 8705.4); loss of a Category 1 or Category 2 mission (see NPR 7120.5); or loss of a mission resource valued at greater than \$2M.
- 3.1.1.7 *Complex work*: Complex work involves either:
- a. The design, manufacture, fabrication, assembly, testing, integration, maintenance, or repair of machinery, equipment, subsystems, systems, or platforms; or
 - b. the manufacture/fabrication of parts or assemblies which have quality characteristics not wholly visible in the end item and for which conformance can only be established progressively through precise measurements, tests, and controls applied.
- 3.1.1.8 *Work that is neither critical nor complex*: Work that is neither critical nor complex is defined as work that includes manufacture of “build to print” piece parts or performance of a discrete manufacturing/test operation such as plating, heat treating, non-destructive testing, or laboratory testing for chemical composition or mechanical properties.
- 3.1.1.9 *Type I or Major nonconformance*: A Type I or Major nonconformance is defined as a nonconformance that adversely affects the safety, reliability, durability, performance, interchangeability, or weight requirements of a contract. A Type I or Major nonconformance requires approval by both the contractor’s Material Review Board (MRB) and the LaRC project’s designated representative.
- 3.1.1.10 *Type II or Minor nonconformance*: A Type II or Minor nonconformance is a nonconformance other than that specified as a Type I or Major nonconformance. A Type II or Minor nonconformance requires approval by the contractor according to the contractor’s nonconformance and MRB process and will not require approval from the LaRC project’s designated representative.

3.2 Acquisitions

3.2.1 General Information

- 3.2.1.1 To ensure compliance with the applicable requirements in this Section, the PM shall designate the project’s critical/complex classification, as specified in LMS-CP-7122.5.
- 3.2.1.2 Hardware and/or software products and services (e.g., design, development,

manufacture, test, operations, maintenance, refurbishment, sustainment, and disposal) for applicable flight projects, which are defined in P.2 of this document, are acquired by purchase orders and contracts. Purchase requests are necessary to initiate procurement actions.

3.2.1.3 The definitions of “critical,” “complex,” and “neither critical nor complex,” are specified in the following:

- a. Paragraphs 3.1.1.6 through 3.1.1.8.
- b. LMS-CP-7122.5
- c. NPD 8730.5

3.2.1.4 Purchase request (PR) requirements are specified in Sections 3.2.2-3.2.5.

3.2.1.5 Contract specifications, SOWs, RFPs and Task-Order document requirements are specified in 3.2.6.1 through 3.2.6.10.

3.2.2 Purchase Requests

3.2.2.1 Engineers shall comply with the requirements of LMS-CP-4703 when originating a PR for the acquisition of flight hardware or for the development of flight software.

3.2.2.2 Engineers that originate PRs shall mark “critical and complex” PRs as “Quality Sensitive,” as specified in the following:

- a. Paragraph 3.2.1.1.
- b. LMS-CP-4505

3.2.2.3 Engineers shall consider including the following QA requirements when preparing PRs, as applicable:

- a. Engineering design and required industrial consensus standards as of 2014 can be found at <https://standards.nasa.gov/documents/nasa>. (See NASA Developed Standards tab in the link above.)
- b. Non-destructive testing as specified in the applicable engineering design, industrial consensus standards or NASA NPRs, Standards, Handbooks, or Guidelines.
- c. Pressure or structural proof load tests, as specified in the applicable engineering design, industrial consensus standards or NASA NPRs, Standards, Handbooks, or Guidelines.
- d. Other performance testing, as specified in the applicable engineering

design, industrial consensus standards or NASA NPRs, Standards, Handbooks, or Guidelines.

- e. Documentation of compliance with standards (e.g., Certificate of Conformance).
 - f. Test reports.
 - g. Documentation for compliance with safety requirements.
 - h. Test coupons or other samples for testing upon receipt.
 - i. Lot date codes for fasteners, EEE parts, or other items manufactured in lots or for items with limited life considerations.
 - j. Inspection points as required by NASA workmanship standards, or as determined by criticality of a manufacturing operation or process that cannot be verified in the finished product.
 - k. Dimensional verification.
 - l. Packaging considerations (e.g., ESD packaging), as specified in Section 7.18.4.
 - m. Shipping (e.g., sensitive to shock or vibration), as specified in Section 7.18.5.
 - n. Other requirements, as applicable.
- 3.2.2.4 Engineers shall be solely responsible for stipulating QA requirements, as specified in 3.2.2.3, in PRs for projects classified as other than “critical and complex.”
- 3.2.3 Acquisition of Fasteners and Safety Critical Items**
- 3.2.3.1 Engineers shall select fastener products for application in spaceflight hardware, as specified in LAPD 5330.3.
 - 3.2.3.2 Engineers or technicians shall purchase fastener products for application in spaceflight hardware, as specified in the following documents:
 - a. LAPD 5330.3
 - b. NASA-STD-6008
 - 3.2.3.3 Engineers or technicians shall determine the total number of fasteners to order by consulting note 8 of LMS-CP-4520.6, which includes the additional fasteners needed for destructive testing.

3.2.3.4 Engineers or technicians shall send all fastener and safety-critical products, as defined in LAPD 4520.1, to the Materials Analysis and Quality Assurance Laboratory (MAQAL) upon delivery for receipt inspection and QA testing.

3.2.4 Acquisition of Hazardous Materials

3.2.4.1 Procurement, engineering, and technicians shall purchase hazardous materials, as specified in LMS-CP-4759.

3.2.5. Quality Assurance System Acquisition Requirements

3.2.5.1. The PAM shall review "Quality Sensitive" PRs to determine if the QA requirements, as specified in 3.2.2.3, are included as applicable.

3.2.5.2 The PAM shall review PRs to ensure, that at a minimum, the following items have been included as appropriate:

- a. PA requirements, as applicable, specified elsewhere in this document.
- b. Delegation of QA provisions to other Government agencies, as specified in Section 3.3.
- c. Department of Defense (DoD) Form 250, Material Inspection and Receiving Report.
- d. Information to supplier for packaging and shipping instructions, as specified in sections 7.18.4 and 7.18.5.
- e. Pre-award QA survey, based on the results of LF 527, as specified in LMS-CP-8705.2.
- f. Inspection/acceptance testing requirements (including acceptance/rejection criteria), as specified in the applicable engineering design, industrial consensus standards or NASA NPRs, Standards, Handbooks, or Guidelines.
- g. Safety considerations.
- i. Government source inspection based on the results of LF 527, as specified in LMS-CP-8705.2.
- j. PA evaluation of the proposed subcontractor's quality management system based on the results of LF 527 as specified in LMS-CP-8705.2.
- k. The appropriate QMS or test and inspection requirements, as specified in 3.1.4.

3.2.5.2.1 If the test and inspection requirements, as specified in 3.1.4(d), are applicable

to contractor work, the PAM shall verify the following procurement documents include deliverables evidencing the contractor's tests and inspection results:

- a. Contracts specifications
- b. SOWs
- c. RFPs
- d. Task Order documents

3.2.5.2.2 The PAM shall determine the inspection requirements, as specified in 3.2.5.2(f), based on their assessment of the consequences of a potential noncompliant hardware failure, using the following criteria:

- a. Noncompliance cannot result in loss of life or loss of mission: Use statistically-based sampling plans or 100 percent inspections, as applicable.
- b. Noncompliance can result in loss of life or loss of mission: Perform Government Mandatory Inspection Points (GMIP) to ensure 100 percent compliance with safety/mission critical attributes (i.e., hardware characteristics, manufacturing process requirements, operating conditions, and functional performance criteria).

3.2.5.3 The PAM shall resolve any discrepancies or omissions as a result of implementing the requirements specified in 3.2.5.1, 3.5.2.2 and 3.5.2.2.1, with the responsible engineer.

3.2.5.4 The PAM shall document all QA provisions on LF 188.

3.2.5.5 The PAM shall attach the LF188 electronically through the SAP Core Financial system, as specified in LMS-OP-5146.

3.2.5.6 The PAM shall approve all "Quality Sensitive" PRs in the SAP Core Financial system.

3.2.5.7 The Office of Procurement (OP) shall verify "Quality Sensitive" purchase orders have been approved by the PAM.

3.2.6 Contract Specifications, SOWs, RFPs, and Task-Order Documents

3.2.6.1 The OP shall forward a copy of the following for development of flight hardware and/or software to the MAB:

- a. Proposed Contract Specifications
- b. SOWs

- c. RFPs
 - d. Task-Order Documents
- 3.2.6.2 The PAM, in conjunction with engineering, shall prepare the Product Assurance Requirements (PAR) for inclusion in the following:
- a. Any proposed contract specification
 - b. SOW
 - c. RFP
 - d. Task Order document
- 3.2.6.3 After reviewing the work, the PAM shall verify the PAR is adequate for inclusion in the following:
- a. Any proposed contract specification
 - b. SOW
 - c. RFP
 - d. Task Order document
- 3.2.6.4 The PAM shall base the PAR upon the requirements of this document.
- 3.2.6.5 The PAM shall review all documents specified in 3.2.6.3 to ensure the following elements are included and/or result in:
- a. Compliance to PA requirements.
 - b. Reference to mandatory QA elements of the Federal Acquisition Regulations (FAR), including the NASA FAR Supplement.
 - c. The appropriate Quality System Requirements, as specified in NPR 8735.2 (Chapters 1 and 2), based on the critical/complex classification as determined in 3.1.1.6 through 3.1.1.8.
 - d. Delivering conforming product, as specified in NPR 8735.2 (Chapters 1 and 2).
 - e. LaRC participation in the contractor's Materials Review Board (MRB), as applicable.
- 3.2.6.6 The PAM shall review all documents specified in 3.2.6.3 to determine if a PA evaluation of proposed suppliers is required, as specified in LMS-CP-8705.2.

- 3.2.6.7 Procurement shall include the PAR as part of the contract or Task-Order document negotiated between the contractor and LaRC.
- 3.2.6.8 The PAM shall develop a Program/Project Quality Assurance Surveillance Plan (PQASP) for flight projects, as specified in Chapter 3 of NPR 8735.2.
- 3.2.6.9 The PAM shall tailor the content of the PQASP according to the risk posture of the Project, using the results from the applicable Supplier Risk Assessment Evaluation Form LF 527, as specified in LMS-CP-8705.2.
- 3.2.6.10 The PAM shall determine the inspection requirements for the PQASP, based on their assessment of the consequences of a potential noncompliant hardware failure, using the following criteria:
 - a. Noncompliance cannot result in loss of life or loss of mission: Use statistically-based sampling plans or 100 percent inspections, as applicable.
 - b. Noncompliance can result in loss of life or loss of mission: Perform Government Mandatory Inspection Points (GMIP) to ensure 100 percent compliance with safety/mission critical attributes (i.e., hardware characteristics, manufacturing process requirements, operating conditions, and functional performance criteria).
- 3.2.7 Documents Requirements List (DRL) and Documents Requirements Data (DRD)**
 - 3.2.7.1 The PAM shall develop a Documents Requirements List (DRL), using NASA LF 47, Documents Requirements List (DRL), to identify the required PA documentation to be submitted to the LaRC CO during the contract period for procurements requiring deliverables.
 - 3.2.7.2 The PAM shall review the DRL to ensure it contains the minimum following elements:
 - a. Name of required document
 - b. Reference paragraph in the PAR's section of the Contract Specifications, SOWs, RFPs, and Task Order documents
 - c. Submittal frequency
 - d. Updating frequency
 - e. Distribution
 - f. LaRC action required
 - 3.2.7.3 The PAM shall prepare all PA-related LF 45s, as applicable.

- 3.2.7.4 The PAM shall review all PA-related DRDs to ensure the DRDs contain, at a minimum, the following elements:
- a. Title
 - b. Number
 - c. Use of the deliverable
 - d. Applicable documents
 - e. Reference documents
 - f. Preparation information
 - g. Format requirements
- 3.2.7.5 The PAM shall transmit PA requirements, including the DRL and DRDs, if applicable, for all contract specifications, SOWs, RFPs, and Task Order documents to the OP through electronic mail.
- 3.2.7.6 The OP shall include the PA requirements received from the PAM in the appropriate procurement documents.
- 3.2.7.7 The OP shall verify the following procurement documents have been approved by the PAM:
- a. Contract specifications
 - b. SOWS
 - c. RFPs
 - d. Task Order documents
- 3.2.7.8 The OP shall include the PAM in proposal evaluations.
- 3.2.7.9 The OP shall include the PAM in source evaluations.
- 3.2.7.10 The OP shall include the PAM in contract technical negotiations.
- 3.2.7.11 The OP shall delegate PA functions that are specified by the PAM to other Government agencies, as specified in Section 3.3.
- 3.2.7.12 The PAM shall support the OP requirements, as specified in 3.2.7.7 through 3.2.7.11, as appropriate.

3.3 Delegation of Quality Functions

3.3.1 General Information and Definitions

3.3.1.1 This Section contains the requirements for both determining the need and the process for the delegation of the PA function to other government agencies, or another NASA installation, for the purpose of the oversight of an off-site contractor.

3.3.1.2 Designated Agency (DA): A Designated Agency (DA) is defined as any government agency other than NASA.

3.3.2 Delegation Criteria

3.3.2.1 The PAM shall determine if the need for delegation of a PA function to another agency at contractor facilities is warranted by consideration of the following criteria:

- a. Inspection of flight hardware at any point, other than the provider's location, would require uneconomical disassembly or destructive testing of the deliverables to ensure compliance.
- b. Considerable loss of time or funds would result from the manufacture of unacceptable hardware or from the delay in making necessary corrections.
- c. Considerable loss of time or funds would result from the shipment of unacceptable hardware or from the delay in making necessary corrections.
- d. Special instruments, gages, or facilities required for inspection or testing are available at the provider's location, but are not readily available to the LaRC organization responsible for acceptance.
- e. Government inspection of flight hardware, other than at the provider's location, would destroy or require the replacement of costly special packing or packaging.
- f. Quality control of flight hardware requires verification of process controls that are critical to the product, and can be accomplished only at the contractor's facility.
- g. Deliverables requiring inspection of flight hardware that is being shipped to locations other than LaRC.
- h. Inspection of flight hardware that needs to be accomplished at the contractor's facility to determine product compliance and acceptance, and is not required to be repeated after delivery and installation.
- i. Testing of flight hardware that needs to be accomplished at the contractor's

facility to determine product compliance and acceptance, and is not required to be repeated after delivery and installation.

- j. High MAB workload or unavailability of MAB personnel.

3.3.3 Implementation of Delegation

3.3.3.1 The PAM shall ensure the following elements are considered when preparing a Letter of Delegation (LoD):

- a. Procedure approvals
- b. Bonded stores
- c. Configuration management
- d. Contamination control
- e. Engineering models
- f. Fabrication control
- g. Failure reporting and corrective action
- h. Parts and materials
- i. Processes
- j. Receiving inspection
- k. Software QA
- l. Software testing
- m. Supplier audits
- n. Hardware testing
- o. Inspection
- p. Training
- q. Certification

3.3.3.2 The PAM shall include a DA representative serving as a member of the contractor's MRB in the LoD, if the following criteria are met:

- a. An MRB is authorized in the contract.

- b. The contract specifies that a government representative is a member of the contractor's MRB.
 - c. It is in the best interest of the project.
 - d. The DA representative is resident at the contractor's facility.
 - e. The DA representative is only authorized to approve or disapprove Type II or Minor nonconformance dispositions, as defined in 3.1.1.9 and 3.1.1.10.
- 3.3.3.3 The PAM shall document the delegated QA requirements in NF 1430B, Appendix B.
- 3.3.3.4 The PAM shall forward the NF 1430B, Appendix B, to the OP.
- 3.3.3.5 The OP shall prepare an LoD NF 1430.
- 3.3.3.6 The OP shall verify the LoD does not revoke LaRC's ultimate responsibility, including LaRC's right to intercede.
- 3.3.3.7 The OP shall provide a copy of the issued LoD to the Head of the MAB, including the following:
- a. NF 1430
 - b. NPR 8735.2B
- 3.3.3.8 The PAM shall contact the DA to initiate a meeting for the purpose of discussing the scope of the contract and the delegation assignments after assignment of the LOD to the DA.
- 3.3.3.9 The PAM shall approve the DA QA Plan, if a QA Plan is required by the LoD.
- 3.3.3.10 The PAM shall participate with the DA to finalize the following delegation requirements:
- a. Delegated QA instructions
 - b. Staffing estimates
 - c. The DA QA plan
 - d. Types of reports
 - e. Submittal frequency of reports to the MAB
 - f. Delegations for major subcontracts, as appropriate
- 3.3.3.11 The PAM shall monitor the implementation of the LoD during the contract

duration to ensure the following:

- a. The QA delegation is being accomplished
- b. Adequate, capable manpower is being provided
- c. The required reports are being submitted
- d. The proper records are maintained
- e. The contractor implements the contract PA requirements

3.3.3.12 If a DA is selected, as specified in 3.3.3.2, the PAM shall verify that the DA provides a representative to serve on the MRB.

3.3.4 Delegation to Other NASA Installations

3.3.4.1 The PAM shall assess whether it is advantageous or necessary to delegate directly to another NASA installation using the following criteria:

- a. To support tests or launches being performed at another NASA facility.
- b. Technical expertise to perform delegated functions is not readily available from the Center that would normally perform these functions.
- c. It is in the best interest of the Government.

3.3.4.2 The PAM shall determine if a QA Plan or other QA elements, as specified in 3.3.3.10 (a) through 3.3.3.10 (f), are required when delegating work to other NASA installations, depending upon the extent of the inspections required.

3.3.4.3 The PAM shall document the delegation requirements either by email, or other documentation, which is mutually agreed to between the Centers.

3.3.4.4 The PAM shall insert the appropriate language in the delegation requirements such that the delegation is administered in a manner that does not affect the contractual relationship between the following:

- a. The contractor and LaRC
- b. The contractor and subcontractor

3.3.4.5 The PAM shall monitor the delegation to other NASA installations in the same manner as a delegation to another agency (see paragraphs 3.3.3.1 through 3.3.3.12).

3.4 Contract Deviations and Waivers

3.4.1 General Information

- 3.4.1.1 The definitions of Deviations and Waivers are captured in Sections 5.3.1 (a) and 5.3.1 (b) of this document.
- 3.4.1.2 The OP shall provide for utilization of Deviation and Waiver Request (DWR) in LaRC contracts associated with flight products and services.

3.4.2 Implementation of the Deviation and Waivers Process

- 3.4.2.1 The PM shall include in the appropriate project documents, the specific process for obtaining external customer approval when required.
- 3.4.2.2 The PAM shall prepare the a DRD, as specified in section 3.2.7, if the following documents contain a DWR requirement:
 - a. Contract specification
 - b. SOWs
 - c. RFPs
 - d. Task Orders
- 3.4.2.3 The Contracting Officer (CO) shall receive DWRs on LF 147 from the contractor.
- 3.4.2.4 The CO shall submit DRWs on LF 147 to the PM.
- 3.4.2.5 The PM shall make a determination as to whether or not the deviation or waiver requested requires Center approval, as specified in LMS-CP-7151, and/or external customer approval first.
- 3.4.2.6 The PM shall obtain evaluations from the appropriate project support personnel on matters relating to the DWR.
- 3.4.2.7 The PAM shall obtain comments from the cognizant, delegated Government QA representative on DWRs, if applicable.
- 3.4.2.8 The PAM shall provide recommendations for approval/disapproval on DWRs to the PM, when the DWR is related to PA requirements.
- 3.4.2.9 The PM shall approve or disapprove each DWR.
- 3.4.2.10 The COR shall provide the PM's approval or disapproval DWR recommendations to the CO.
- 3.4.2.11 The CO shall provide notification of approval/disapproval to the contractor of all DWRs.

- 3.4.2.12 The CO shall implement contract modifications for approved DWRs, if required.
- 3.4.2.13 The CO shall notify the disposition of the DWRs to the delegated government agencies at the contractor's plants, provided that a LoD is in effect.

CHAPTER 4: RISK MANAGEMENT (RM)

4.1 General

This chapter identifies the RM requirements and tools necessary to evaluate and provide RM for LaRC Programs and Projects.

4.1.1 RM Concept

- 4.1.1.1 Risk is characterized by the combination of the probability that a program or project will experience an undesired event (some examples include a cost overrun, schedule slippage, safety mishap, health problem, malicious activities, environmental impact, failure to achieve a needed scientific or technological breakthrough or mission success criteria) and the consequences, impact, or severity of the undesired event, were it to occur.
- 4.1.1.2 RM is a process wherein the Program/Project Team is responsible for identifying, analyzing, planning, tracking, controlling, and communicating effectively the risks (and the steps being taken to handle them) both within the team and with management and stakeholders. As depicted in Figure 4.1, RM is a continuous, iterative process to manage risk in order to achieve mission success. RM is a key element and an integral part of normal program/project management and engineering processes.

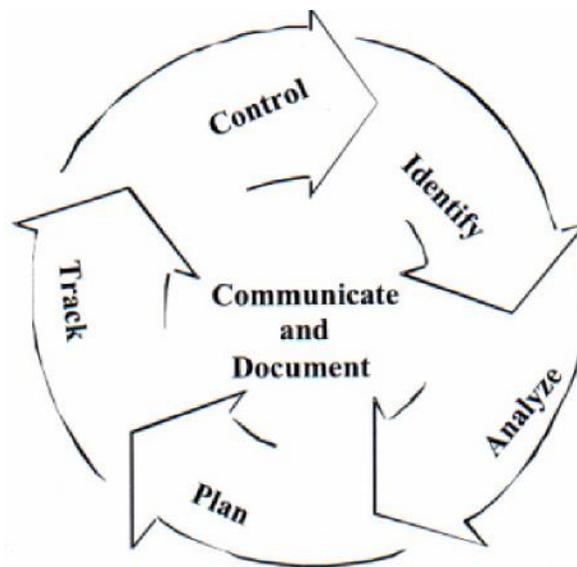


Figure 1 – Risk Management Cycle

4.1.2 RM Requirements

- 4.1.2.1 NPR 8000.4 and NPR 7120.5 provide the basic RM requirements that are applicable to all LaRC programs and projects.

4.1.2.2.1 In addition to the RM requirements contained within NPR 7120.5, other RM and RM-related requirements shall be included within applicable regulations and other directives. Examples include:

- a. NASA FAR Supplement, 48 C.F.R. Chapter 18, which includes requirements for RM within the context of acquisition planning, selecting sources, choosing contract type, structuring award fee incentives, administering contracts, and conducting contractor surveillance.
- b. NPR 2810.1 includes requirements for the identification and assessment of threats and vulnerabilities in order to pinpoint those areas that are most likely to be at risk should someone exploit a system or network vulnerability with the sole purpose of doing harm.
- c. NPR 8705.2 includes requirements related to risks associated with humans involved in or exposed to space flight activities.
- d. NPR 8715.3 includes requirements related to safety risks.
- e. As appropriate, requirements from other sources such as these are referenced within this document.

4.1.3 RM Responsibilities

4.1.3.1 The PMs shall be responsible for the following:

- a. Applying a continuous RM process within the program/project throughout its life cycle.
- b. Documenting and approving the process within a Risk Management Plan.
- c. Documenting and managing risks throughout the program/project's life cycle.
- d. Approving the formal acceptance/closure of all program/project risks.
- e. Providing program risk status, especially concerning primary risks, to the Center Management Council (CMC) or other applicable management council.
- f. Providing project risk status, especially concerning primary risks, to the PM, Center Director, CMC, or other applicable management council.

- 4.1.3.2 The CMC or other identified management council shall be responsible for the following:
- a. Evaluating the program/project's risk status and ensuring that the formal acceptance/ closure of program/project risks is consistent with NASA's goals and requirements.
 - b. Concurrence on the acceptance of all primary risks.
- 4.1.3.3 The MAB is responsible for providing ongoing RM consultation, facilitation, and training to program/project organizations.

4.2 Overview of the RM Process at LaRC

- 4.2.1 RM begins early in program/project formulation and continues in a disciplined manner throughout all program/project life cycle phases.
- 4.2.2 A long-range view of the program/project and its mission success criteria, and open communication among all members of the program/project team (including stakeholders), are essential elements for successful RM.
- 4.2.3 Although different organizations refer to RM elements by different names, RM processes used for years by various organizations contain virtually the same essential core ingredients.

***Note:** For example, the IT security process as described in NPR 2810.1 considers threats (equivalent to undesirable events as used in the definition of risk in NPR 8000.4 and NPR 7120.5), vulnerability (equivalent to likelihood (see NPR 8000.4, Appendix A)), and impact (as defined in NPR 8000.4) as the key elements in identifying risk.*

- 4.2.4 The RM process identified in Figure 4.1 contains the basic elements of the IT security process.

4.2.5 Documenting and Communicating Risk

- 4.2.5.1 Effective RM requires open, clear, and ongoing communication within the program/project team.
- 4.2.5.2 The RM documentation process ensures that RM policies are established, understood, implemented, and maintained, and that a formal audit trail is developed to establish the origin of, and rationale for, all risk-related decisions.
- 4.2.5.1 RM documentation shall be readily accessible to the entire team (e.g., in an automated form, and under configuration control).

4.2.6 LaRC Program/Project Plan

- 4.2.6.1 The Program/Project Plan shall include a summary of the basic RM planning for the program/project.
- 4.2.6.2 The implementation of the basic strategy/philosophy for program/project RM described in the Program/Project shall be further detailed within the Risk Management Plan.
- 4.2.6.3 The acceptable risk level for the program/project shall be defined and documented including a summary of the primary risks for the program/project in the Program/Project Plan.

4.2.7 Risk Management Plan

- 4.2.7.1 Every program/project shall have a Risk Management Plan, as specified in NPR 7120.5.
- 4.2.7.2 This stand-alone plan, Risk Management Plan shall be:
 - a. Approved by the PM during the Formulation phase.
 - b. An integral element of the program/project documentation.
 - c. Placed under formal configuration control.
 - d. Reviewed and updated as necessary when a change in program phase occurs or when significant changes in success criteria, program architecture, or design occur.
- 4.2.7.5 Risk Management Plan Content
 - 4.2.7.5.1 The Risk Management Plan shall be program/project specific, configuration controlled, and include the elements suggested in NPR 8000.4.
 - 4.2.7.5.2 The NASA Safety Center Knowledge Now (NSCKN) Web site <https://nsckn.nasa.gov/ConceptSearch/knSearch.aspx?q1=%22risk+management%22> contains RM plans that can be used to guide the development of new project RM plans. In addition, there is a large amount of information regarding risk found in requirement documentation, presentations and project RM plans.
- 4.2.7.6 Statement of Risk (SoR) is a clear, concise, and complete statement of the risk.
 - 4.2.7.6.1 In general, the SoR shall be written in a condition-consequence format (given a condition, there is a possibility that a consequence will occur).

4.2.7.6.2 The SoR can be supported by additional information if required to place the risk in context or explain the assumptions associated with the risk.

4.2.7.6.3 If supporting information is required, the SoR shall be clearly linked to that information and where it is maintained.

4.2.7.7 Risk List

4.2.7.7.1 Every program/project shall have a risk list.

4.2.7.7.2 The risk list is the listing of all identified risks in priority order from highest to lowest risk, together with the information that is needed to manage each risk and document its evolution over the course of the project.

4.2.7.7.3 Risk prioritization shall be performed by the project team and consolidated and approved by the PM. Further instruction on this process can be found in NPR 8000.4.

4.2.7.7.4 The risk list shall be updated as changes (including changes in assumptions) occur.

4.2.7.7.5 Extracts from the list shall be presented at project meetings, reviews, and milestones as required by the RM Plan.

Note: Programs/projects may also find it beneficial to use the classification of risks to create subsets of the risk list in addition to the complete risk list so that working or functional groups may focus on specific areas of risk (for example, tracking all of the environmental risks or the security risks or technical risks together).

4.2.7.7.6 The Risk List shall be widely accessible to all members of the Program/Project team.

4.2.8 Risk Mitigation Plans

4.2.8.1 Risk Mitigation Plans describe actions to mitigate identified risks, as well as risk measures, indicators, and trigger levels used in the tracking of the risks and the effectiveness of their mitigation actions.

4.2.8.2 Risk Mitigation Plans shall include the cost and schedule information required to implement the plan.

4.2.8.3 The program/project shall determine the format for the Risk Mitigation Plans (which could range from simple action items for relatively simple mitigations to formal task plans for more complex mitigations) consistent with other program/project planning documentation.

4.2.9 Risk Acceptance Records

- 4.2.9.1 Risk Acceptance Records shall document program/project acceptance of risk (and, if a primary risk, LaRC CMC concurrence).
- 4.2.9.2 The program/project shall determine the format of these records consistent with other program/project documentation (e.g., program/project configuration management processes and documentation could be used to document acceptance of risk).
- 4.2.9.3 Risk Acceptance Records shall include the risk acceptance rationale, as well as the appropriate signatures for approval, including revalidations as required.

4.2.10 Risk Trends

- 4.2.10.1 Risk trends shall consist of displays (graphical, tabular, or textual) showing changes to risk indicators over time (i.e., decreasing, staying the same, or increasing).
- 4.2.10.2 Risk trends shall be updated frequently on a schedule documented in the RM Plan, so that the program/project team will have adequate time to react to adverse trends.
- 4.2.10.3 Risk trend documentation shall also be consistent with other program/project metrics information.

4.2.11 Risk Profile

- 4.2.11.1 Beginning early in a project, the PM shall make a qualitative or quantitative projection of overall expected risk trend (technical risks, as well as programmatic risks) over the life of the program/project (showing major milestones).
- 4.2.11.2 A risk profile shall be constructed (see NPR 8000.4).
- 4.2.11.3 Initially, the projected risk profile (that part that lies in the future) shall be annotated to explain significant, but expected, changes in risk.
- 4.2.11.4 Over the life of a program/project, the risk profile shall be updated regularly, as documented in the RM Plan, to reflect actual changes in risk.
- 4.2.11.5 Explanations for these changes shall be annotated on the profile for briefing at major milestone meetings.

4.2.12 Risk Communication

- 4.2.12.1 Early in a program/project, the PM shall develop a risk communication strategy.
- 4.2.12.2 The risk communication strategy shall address how risk will be openly and clearly communicated within the program/project team; with management, stakeholders, appropriate functional offices, other government entities; and the public, throughout the life cycle of the program/project.
- 4.2.12.3 Consideration should be given to establishing a program/project RM database to provide an easily accessible way to store program/project risk information and thereby aid every step of the RM process. This would also provide a risk record archive, making tracking and analyzing risk, past methods, and results available for all to view.

CHAPTER 5: DESIGN ASSURANCE

5.1 General

This chapter identifies Reliability, Maintainability, Availability, and Supportability (RMAS), and Probabilistic Risk Assessment requirements that are a key part in providing design assurance.

5.1.1 Analyses and assessments shall be scheduled and completed concurrently with the design effort such that the design will reflect analysis conclusions and recommendations.

5.1.1.1 Each analysis/assessment shall be performed and coordinated with Program/Project design personnel beginning during the early phases of design.

5.1.1.2 As more definitive information becomes available, computations shall be performed iteratively to ensure design requirements meet or exceed the Program/Project goals.

5.1.1.3 The results of the analyses and assessments are expected to have a positive impact, and improvement in the designs and the feedback presented to the design teams and Program/Project management may result in changes to the design.

5.1.2 Support provided by the LaRC MAB shall include performing RMAS and probabilistic risk assessments in accordance with NASA directives, requirements, policy and guidelines as instituted by Program(s)/Project(s) in order to provide the proper level of design assurance. These include but are not limited to:

- a. NASA-STD-8729.1
- b. NPR 8705.5
- c. NPR 8705.4
- d. NPR 8735.1
- e. "Constellation Systems Supportability Strategy (SS)," which is part of the "NASA, Constellation Systems Document 0000028493."
- f. CxP 70043, Failure Modes and Effects Analysis and Critical Items List (FMEA/CIL) Methodology.
- g. 0000028543, Reliability, Maintainability, and Supportability Requirements Document.

- h. Ensure that R&M data is available for use as heritage data to support the formulation of R&M goals and requirements, quantitative and qualitative reliability analysis, and other R&M engineering activities as part of current, follow-on, or new programs and projects, both at the local Center, and other Centers.

5.1.3 Flight projects shall utilize NPR 8705.4.

5.1.3.1 NPR 8705.4 establishes baseline criteria that enable a user to define the risk classification level for NASA payloads on human-rated or nonhuman-rated launch systems or carrier vehicles, the design and test philosophy, and the common assurance practices applicable to each level.

5.1.3.2 The establishment of the risk level early in the program/project provides the basis for program and PMs to develop and implement appropriate mission assurance and RM strategies and requirements and to effectively communicate the acceptable level of risk.

5.1.3.3 PMs shall:

- a. Implement and ensure that reliability, maintainability, availability, and supportability (RMAS) requirements, including design and operational performance requirements (qualitative and quantitative) are planned, established, allocated, implemented and coordinated.
- b. Assess compliance with upper level RMAS requirements, including the identification of areas for improvement, in a timely and continuous manner.
- c. Identify and pursue opportunities for collaboration between projects.
- d. Ensure RMAS data and experience are maintained, shared across projects, used to assess system performance throughout system lifecycle, and available as historical data for future RMAS requirement development across NASA.
- e. Ensure compatibility is sustained among system design, RMAS planning, and logistics support activity.

5.2 Design Reviews

5.2.1 General

The MAB shall work in conjunction with Program/Project design personnel to implement a design assurance program which interacts with all product assurance elements to ensure the design meets established requirements.

5.2.1.1 The implementation of a design assurance program shall be initiated during the conceptual design phase and may include the review of and concurrence with design specifications, drawings, and procedures prior to release.

- 5.2.1.2 The design review schedule shall be specified in the PAP or Project Plan as appropriate.
- 5.2.1.3 The following sequential set of design reviews is typical for LaRC flight projects:
 - a. Systems Requirements Review (SRR)
 - b. Conceptual Design Review (CoDR)
 - c. Project Requirements Review (PRR)
 - d. Preliminary Design Review (PDR)
 - e. Critical Design Review (CDR)
 - f. Safety and Mission Success Review (SMSR)
 - g. Other formal reviews as established by the Program/Project
- 5.2.1.4 The PAM shall support the project in preparation for and present the status of all appropriate product assurance activities at all design reviews.
- 5.2.1.5 Safety and Mission Success Review (SMSR) is a review held to prepare Agency safety and engineering management to participate in program final readiness reviews preceding flights or launches, including experimental/test launch vehicles, or other reviews as determined by the Chief, Safety and Mission Assurance.
 - 5.2.1.5.1 The SMSR shall provide the knowledge, visibility, and understanding necessary for senior safety and engineering management to either concur or non-concur in program decisions to proceed with a launch or significant flight activity. The complete details and requirements for a SMSR are in NPR 8705.6.
 - 5.2.1.5.2 SMSR records shall be prepared and retained onsite; then destroyed six years after mission completion by the office that conducted the SMSR (Headquarters or delegated Center SMA TA).
 - 5.2.1.5.3 Center Directors shall provide the logistic and resource support required for successful execution of NASA Headquarters-led and NASA Center-led SMSR activities.
 - 5.2.1.5.4 Center SMA Directors and Center Engineering Directors shall:
 - a. Participate in the NASA Headquarters-led SMSR process for each program/project applicable to their Center.

- b. Direct the implementation of a Center-led SMSR process for reviews chaired below the Mission Directorate level in which the Center SMA Organization is asked to concur/non-concur. NASA Center-led SMSRs are led by Center safety management as the delegated SMA TA.
- c. Coordinate with program/project management and Center procurement organizations to ensure that contracts provide for contractor support of NASA Headquarters-led and Center-led SMSR activities.
- d. Complete SMSR actions within the assigned timeframe.

5.2.1.5.5 The delegated SMA TA shall:

- a. Chair each Center-led SMSR.
- b. Conduct a poll of selected SMSR participants at the conclusion of the Center-led SMSR for a recommendation to proceed.
- c. Ensure that the basic elements of a Center-led SMSR, at a minimum, address the NASA Headquarters-led SMSR elements and, to the extent possible, parallel NASA Headquarters-led SMSR residual risk reporting formats.
- d. Complete SMSR actions within the assigned timeframe.

5.2.1.5.6 SMA Managers (including Chief Safety and Mission Assurance Officers (CSOs)) and engineering managers reporting (matrix or direct) to the program/project manager shall:

- a. Help to identify all independent organizations which have assessed portions of the program or project. This activity is aided by developing a Mission Assurance Process Map and a Mission Assurance Process Matrix.
- b. Provide material input for inclusion in SMSRs.
- c. Compile the program/project SMSR material, including the program's assessment of residual safety and mission success risk related to the upcoming milestone, identifying risk consequence and likelihood with supporting rationale and uncertainty associated with estimated likelihood.
- d. Coordinate the presentation of the Center and program/project SMSR material with the Chief, Safety and Mission Assurance.
- e. Coordinate within the program/project and support NASA Headquarters-led and Center-led SMSR preparation meetings, as required.
- f. Participate in SMSR polling.
- g. Complete SMSR action items within the assigned timeframe

5.2.2 Responsibilities

5.2.2.1 The PM shall:

- a. Determine the design reviews to be conducted for the project.
- b. Conduct each design review.

5.2.2.2 The PAM shall:

- a. Ensure design reviews are conducted.
- b. Present the status of the Product Assurance activities at each design review.

5.3 Deviations and Waivers

5.3.1 For purposes of this document, the following definitions apply:

- a. Deviation: authorizes departure from a particular requirement that does not strictly apply. A deviation involves the approval of alternate means that meet the intent of the requirement or formal acceptance of increased risk due to the fact that the requirement is not satisfied.
- b. Waiver: authorizes departure from a specific requirement and is requested during the implementation of a project or operation. A waiver involves approval of an increase in risk, due to the fact that the requirement is not satisfied and has been documented and accepted by the appropriate authority.

Note: Deviations may be approved as part of tailoring (i.e., a process that occurs early in the planning stages of a project and involves documenting and formally approving project requirements).

5.3.2 The projects shall define in the appropriate project plan/documentation the process for reviewing and approving deviations and waivers.

5.3.2.1 The process shall include sufficient detail so as to determine when Center/Customer notification and approval is required before final project acceptance of the deviation and/or waiver.

5.3.2.2 LF 147 shall be used for contract deviations and waivers. Deviations/waivers resulting from in-house non-compliance failure reports are additionally discussed in Section 7.9.

5.4 Reliability

5.4.1 Fault Tree Analysis (FTA)

- 5.4.1.1 FTA may be performed on systems, subsystems, and equipment. FTA can be used in both qualitative and quantitative assessments.
- 5.4.1.2 The FTA will provide a systematic and deductive methodology for defining a single specific undesirable event and determining all possible failures that could cause that event to occur.
- 5.4.1.3 The FTA shall be utilized during the initial design phase as an evaluation tool for driving the preliminary design.
- 5.4.1.4 Upon completion of fabrication, the results of the FTA may be utilized as a troubleshooting tool. Different FTA tools are available for use and include Sapphire, Quantitative Risk Assessment System (QRAS), and Galileo/ASSAP.

5.4.2 Failure Modes and Effects Analysis

- 5.4.2.1 A Failure Modes and Effects Analysis (FMEA) may be performed to systematically document and assess all equipment/component failure modes, mechanisms/causes, and their failure effects at various indenture levels.
- 5.4.2.2 The FMEA process is typically governed by program requirements (e.g., 0000028494, Constellation Program Requirements for Preparation of Hardware Failure Modes and Effects Analysis and Critical Items List).
- 5.4.2.3 The FMEA shall be used for the following:
 - a. Identify single failure points.
 - b. Determine needs for redundancy, fail-safe design features, and/or derating.
 - c. Identify system interface problems.
 - d. Support safety and hazard analyses.
 - e. Identify quality inspection points.
 - f. Determine allowable use time or cycles.
 - g. Determine assembly, inspection, and test procedures.

5.4.2.4 Approach

- 5.4.2.4.1 The FMEA is initiated during the conceptual or preliminary design phase and updated as design changes are incorporated.
- 5.4.2.4.2 The level of indenture to be analyzed is determined by Program/Project requirements and is supported by design engineers, system specifications, drawings, and operational and environmental profiles.
- 5.4.2.4.3 In the process of conducting a FMEA, each hardware item is analyzed for every credible failure mode and the “worst case” effects are determined and documented.
- 5.4.2.4.4 The process of performing the FMEA includes the following:
 - a. Describing the system and its performance requirements.
 - b. Specifying the assumptions and ground rules to be used in the analysis.
 - c. Developing block diagrams or other simple models of the system.
 - d. Developing the analysis worksheet for every identified failure mode.
 - e. Recommending and evaluating corrective actions and design improvements.
 - f. Summarizing the analysis in report form.
- 5.4.2.4.5 The FMEA is based upon single component failures and provides concise statements of the failure mode and its effects. The following basic failure modes shall be imposed at the lowest level of definition:
 - a. Premature operation
 - b. Failure to operate at prescribed time
 - c. Failure to cease operation at prescribed time
 - d. Failure during operation
 - e. Degraded operation
- 5.4.2.4.6 The effects of a single point of failure shall be determined at the next level of definition.
- 5.4.2.4.7 Although a redundant element is considered to terminate the failure effect on the system, the failure mode and effect on the subsystem shall be identified.
- 5.4.2.4.8 Analysis results and pending actions shall be presented during the PDR and updated for the CDR and Flight Readiness Review (FRR).

5.4.2.5 Criticality Category

5.4.2.5.1 Criticality numbers based upon "Failure effect on" entries are as follows:

- a. 1: Single failure which could result in loss of life or vehicle.
- b. 1 R#: Redundant hardware item(s), all of which if failed, could cause loss of life or vehicle. A number trailing the "R" is used to indicate the number of redundant paths or strings (e.g., 1 R3 – represents a triple redundant item).
- c. 1S: Safety or hazard monitoring hardware items that could cause the system to fail to detect, combat, or operate when needed during a hazardous condition, potentially resulting in loss of life or vehicle.
- d. 2: Single failure which could result in severe injury, major property damage, or a loss of mission.
- e. 2R#: Redundant hardware item(s), all of which if failed, could cause loss of mission.
- f. 3: Single failure that could result in minor injury, minor property damage, a significant mission delay, or mission degradation (i.e., some mission goals not achieved).
- g. 4: All others.

5.4.2.6 Disposition and Justification.

5.4.2.6.1 Single failure points shall be eliminated by the removal or redesign of the component or mitigated by graceful degradation or redundancy, unless allowed by Project requirements.

5.4.2.6.2 The determination and acceptance of a probability of failure will be accomplished by examining the history of the component when used previously in a similar application and/or sufficiently testing the component during the development phase of the effort.

5.4.2.7 Critical Items List (CIL)

5.4.2.7.1 A CIL will be derived from the FMEA process and shall identify the rationale or justification for retaining critical items.

5.4.2.7.2 The CIL shall be maintained current and presented at each design and readiness review.

5.4.2.7.3 Utilizing the FMEA, the following classification of failure modes, as a minimum, shall be entered in the CIL:

- a. All functional criticality category 1 and 2 items.
- b. All functional criticality 1 R items where the first failure could result in loss of mission or the next failure of any redundant item could cause loss of crew/vehicle.
- c. All functional criticality category 1 R and 2R items that fail one or more redundancy screens.

5.4.2.7.3 The CIL shall contain the following information, sequenced as indicated:

- a. A concise statement of the purpose of the report.
- b. A description of the major systems contained in the CIL with general information as to what type of data is contained in the CIL.
- c. The rationale or justification for retaining critical items.
- d. A critical hardware list which provides a listing of:
 - 1) Line replaceable unit (LRU) part numbers
 - 2) Reference designators
 - 3) LRU nomenclature
 - 4) LRU highest level criticality
 - 5) Lower indenture level part numbers identified by the FMEA
 - 6) Failure mode number
 - 7) Quantity of items in the subsystem
 - 8) Criticality for each FMEA number
- e. Individual pages describing the actual analysis results.

5.4.2.8 Responsibilities

5.4.2.8.1 The Project personnel shall:

- a. Perform FMEA/CIL
- b. Report results at appropriate design reviews

5.4.2.8.2 The MAB personnel shall:

- a. Provide guidance on performing FMEA/CILs
- b. Review FMEA/CILs
- c. Perform independent FMEA/CILs upon request

5.4.2.8.3 The PM shall:

- a. Implement and ensure that RMAS requirements, including design and operational performance requirements (qualitative and quantitative) are planned, established, allocated, implemented and coordinated.
- b. Assess compliance with upper-level RMAS requirements, including the identification of areas for improvement, in a timely and continuous manner.
- c. Identify and pursue opportunities for collaboration between projects.
- d. Ensure RMAS data and experience are maintained, shared across projects, used to assess system performance throughout system lifecycle, and available as historical data.
- e. Ensure compatibility is sustained among system design, RMA planning, and logistics support activity.
- f. Approve FMEA/CILs.

5.4.3 RMAS Predictions

- 5.4.3.1 RMAS predictions may be performed by MAB personnel as part of design assurance to support (through quantitative analysis) trade studies, Probabilistic Risk Assessment and quantitative FTAs.
- 5.4.3.2 Point estimates (MIL-HDBK-217F Notice 2) are acceptable for initial studies and trades, but uncertainty in these values needs to be understood and developed as the design matures.
 - 5.4.3.2.1 Point estimates can be accomplished through utilizing heritage data, manufacturer testing, and design engineering testing (including component and integrated level testing).
 - 5.4.3.2.2 Bayesian techniques can be used to update initial predictions (this methodology is described in various literatures).
 - 5.4.3.2.3 Software tools (e.g., Relex or Item) can aid in the prediction process, but in order to be accurate, specific component information must be obtained from manufacturer data sheets and interfacing with Electrical, Electronic, and Electromechanical (EEE) Parts engineers and design engineers (e.g., electrical and mechanical).
- 5.4.3.3 The NASA Parts Selection List (NPSL) Website (<http://nepp.nasa.gov/npsl/>) has been developed to serve as a parts selection tool for design engineers and

parts engineers supporting NASA flight programs. This Website provides a detailed listing of EEE part types that the NASA EEE Parts Assurance Group (NEPAG) recommends for NASA flight projects based on evaluations, risk assessments, and quality levels.

5.4.3.3.1 In general, the parts listed in the NPSL:

- a. Have established procurement specifications.
- b. Have available source(s) of supply.
- c. Are capable of meeting a wide range of application needs.
- d. Have been assessed for quality, reliability, and risk and found to meet the criteria for listing.
- e. Provides easily assessable information for design engineers.

5.4.3.4 Duty Cycles shall be incorporated into the analysis to properly account for use cycles or operational, as well as dormancy periods.

5.4.4 Derating Analysis

5.4.4.1 Derating analysis may be performed using information provided by design engineers, EEE parts engineers, and the MAB.

5.4.4.2 This design assurance incorporates component minimum and maximum parameters (e.g., voltage and current) along with component operating values to identify margin within the design throughout their life.

5.4.4.3 This analysis is typically performed by LaRC design engineers with design team (including EEE parts and MAB).

5.4.5 Worst Case Analysis (WCA)

5.4.5.1 Worst Case Analysis may be performed in order to evaluate circuit performance assuming part parameter variations associated with extreme conditions—long life, temperature, radiation, shock, etc.

5.4.5.2 WCA ensures that all circuits will perform within specifications over a given lifetime while experiencing the worst possible variations of electrical piece parts and environments.

5.4.5.3 WCA shall be performed on critical flight equipment (i.e., identified in a FMEA/CIL).

5.4.5.4 WCA is typically performed by LaRC design engineers and other design team personnel (e.g., EEE parts and MAB).

5.5 Maintainability and Availability

5.5.1 Where applicable (e.g., Human flight reusable designs), maintainability and availability assessments shall be performed by the MAB with input from design engineering and other Program/Project disciplines as a part of design assurance.

5.5.2 Maintainability assessments shall be used to estimate mean-time-to repair for various components of a system, as well as provide review of the components for crucial maintainability criteria such as:

- a. Accessibility
- b. Interchangeability
- c. Failure detection
- d. Failure isolation
- e. Special tools and diagnostics
- f. Spares

5.5.3 Information developed as part of the maintainability assessments shall be utilized in other analyses (e.g., FMEA/CIL, Availability) as required.

5.5.4 Availability assessments shall incorporate information developed in both reliability and maintainability analyses to assess the availability (e.g., inherent or operational) of the product under development.

5.6 Supportability

5.6.1 Cost and logistics trade studies and analysis, where required, shall be executed and coordinated by system design engineering.

5.6.2 MAB shall provide system design engineering with relevant analysis information (e.g., Reliability and Maintainability estimates of Mean-Time-Between-Failure or Mean-Time-to-Repair) to support such studies and analysis.

5.7 Probabilistic Risk Assessment (PRA)

5.7.1 Probability Risk Assessment is a technique used to assess Program/Project risk by asking three basic questions:

- a. What can go wrong?

- b. How likely is it?
- c. What are the consequences?

5.7.2 The PRA quantifies undesired scenarios identified using RM practices.

5.7.2.1 The process integrates a collection of models based on systems and design engineering, probability theory, reliability engineering, safety engineering, operations engineering, planned product users, physical and biological sciences, and decision theory.

5.7.3 PRA Process

5.7.3.1 The process and techniques provided in the NPR 8705.5, shall be used for conducting PRAs. NPR 8705.5 cites references that provide more detailed information concerning the PRA process.

5.7.3.2 As a guideline, the following table illustrates various types of Programs/Projects and the scope of PRA that is required.

5.7.3.3 The PRA process is found in the following Table 5.1 and includes:

- a. Objective definition
- b. System familiarization
- c. Identification of initiating events
- d. Scenario modeling
- e. Failure modeling
- f. Quantification
- g. Uncertainty analysis
- h. Sensitivity analysis
- i. Importance ranking
- j. Data analysis

CONSEQUENCE CATEGORY	CRITERIA / SPECIFICS		NASA PROGRAM/PROJECT (Classes and/or Examples)	PRA SCOPE
Human Safety and Health	Public Safety	Planetary Protection Program Requirement	Mars Sample Return Missions	F
		White House Approval (PD/NSC-25)	Nuclear Payloads (e.g., Cassini, Ulysses, Mars 2003)	F
		Space Missions with Flight Termination Systems	Launch Vehicles	F
	Human Space Flight	International Space Station	F	
		Space Shuttle	F	
		Human Space Experiments	F	
		Project Constellation	F	
Mission Success (for non-human rated missions)	High Strategic Importance / High Value Strategic	Mars Program	F	
		High Schedule Criticality	Launch Window (e.g., planetary missions)	F
	All Other Missions	Earth Science Missions (e.g., EOS, QUICKSCAT, specific payloads)	L/S	
		Space Science Missions (e.g., SIM, HESSI, specific payloads)	L/S	
		Technology Demonstration/Validation (e.g., EO-1, Deep Space 1)	L/S	
		Medium to Low Cost Projects	L/S	

Table 1 – Criteria for Selecting the Scope of a Probabilistic Risk Assessment (PRA)

F is Full Scope PRA
L/S is Limited Scope PRA

5.8 Parts and Material Alerts

5.8.1 General

The Government-Industry Data Exchange Program (GIDEP), the NASA Alert Reporting System (NARS), and the NASA Lessons Learned Information System (LLIS) databases shall be reviewed for quality, application, and safety problems associated with parts and materials used by the project. Any problems encountered by the project shall be documented and reported in accordance with the GIDEP, NARS, and LLIS.

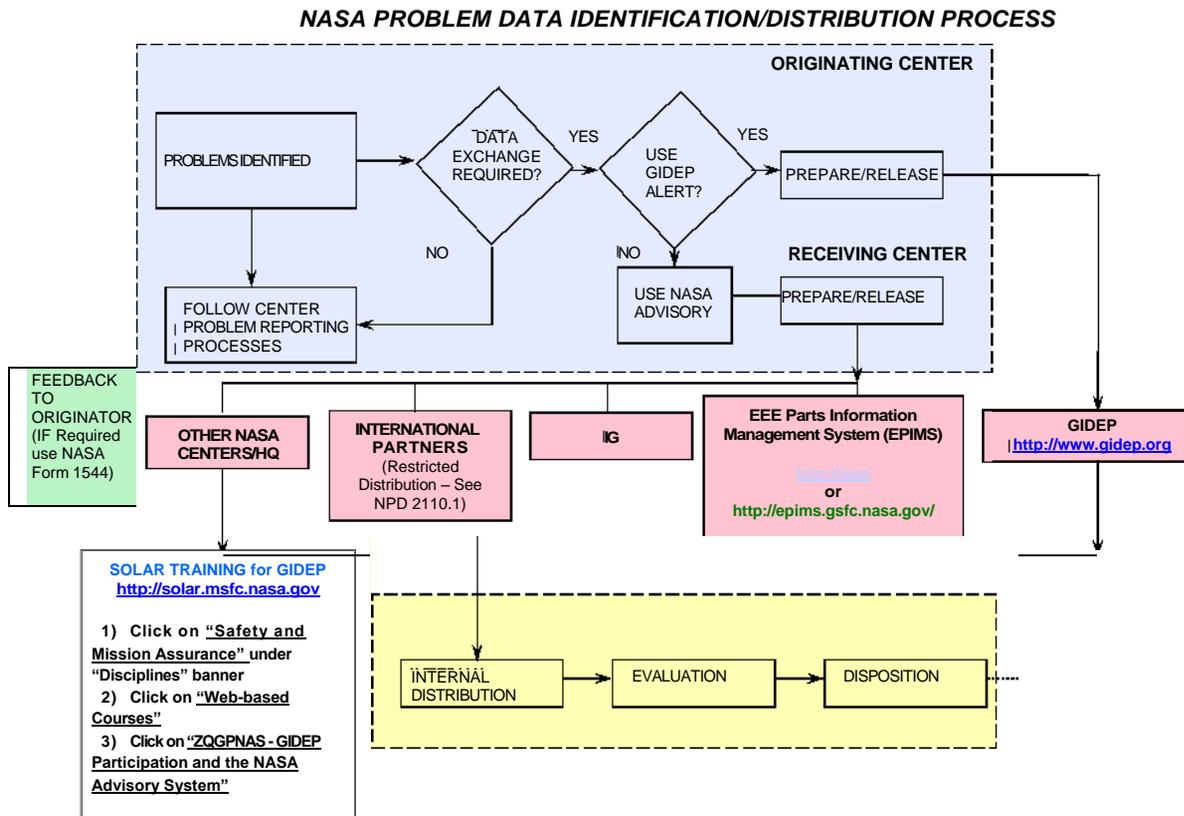


Figure 2 – NASA Problem Data Identification/Distribution Process

5.8.2 Responsibilities

- 5.8.2.1 The Safety and Mission Assurance Office shall appoint a GIDEP Coordinator to serve as the Center's representative for the preparation and evaluation of the various GIDEP and Alert types, as the Center's point of contact with GIDEP, and as the Center's authority for issuing and disseminating GIDEP Alert types and NASA Advisories.
- 5.8.2.2 The NASA GIDEP process, as described in NPR 8735.1, "Procedures For Exchanging Parts, Materials, and Safety Problem Data Utilizing the Government-Industry Data Exchange Program and NASA Advisories," shall be implemented at LaRC.
- 5.8.2.3 The LaRC GIDEP representative shall:
- a. Receive, review, and distribute within 24 hours of receipt GIDEP Alerts, GIDEP Safe-Alerts, GIDEP Problem Advisories and GIDEP Agency Action Notices, and NASA Advisories to the cognizant LaRC program/project, Product Assurance Managers (PAMs), Organizational Heads, Systems Engineers, EEE Parts Engineers, and Facility Safety personnel for review and disposition of impact per NPR 8735.1.
 - b. Before release from LaRC, review all LaRC generated GIDEP Safe-Alerts, GIDEP Problem Advisories and GIDEP Agency Action Notices, and NASA Advisories per NPR 8735.1.
 - c. Sign and release GIDEP Alerts, GIDEP Safe-Alerts, GIDEP Problem Advisories and GIDEP Agency Action Notices, and NASA Advisories for LaRC per NPR 8735.1.
 - d. Submit LaRC GIDEP Utilization report to GIDEP at the end of each fiscal year per NPR 8735.1.
 - e. Utilize NASA Form 1544, "Problem Impact Statement - Parts, Materials, and Safety," as appropriate per NPR 8735.1.
 - f. Maintain and update yearly, or as needed, a list of cognizant representatives responsible for receiving and responding to GIDEP Alerts, GIDEP Safe-Alerts, GIDEP Problem Advisories and GIDEP Agency Action Notices, and NASA Advisories.
- 5.8.2.4 The PAM shall:
- a. Review and coordinate applicable GIDEP Alerts, GIDEP Safe-Alerts, GIDEP Problem Advisories and GIDEP Agency Action Notices, and NASA

Advisories with designers to identify and assess the use of suspect parts and materials.

b. Document problems found and forward to the LaRC GIDEP representative.

c. Review supplier procurement history.

d. Determine if contractor participation in GIDEP is appropriate based on the type of procurement, acquisition phase, contract cost, and criticality of equipment.

5.8.2.5 The Organizational Heads/Systems Engineers/EEE Parts Engineers/Facility Safety personnel shall:

a. Review applicable GIDEP Alerts, GIDEP Safe-Alerts, GIDEP Problem Advisories and GIDEP Agency Action Notices, and NASA Advisories with designers to identify and assess the use of suspect parts and materials.

b. Ensure that personnel aid in the preparation of reports when appropriate for GIDEP.

c. Ensure that reports for submittal to GIDEP are accurate and complete.

d. Review supplier procurement history.

e. Determine if contractor participation in GIDEP is appropriate based on the type of procurement, acquisition phase, contract cost, and criticality of equipment.

5.9 Orbital Debris Assessment

5.9.1 Each mission shall conduct a formal assessment of the potential to generate orbital debris in accordance with NPR 8715.6 and NASA-STD 8719.14.

5.9.2 These guidelines are applicable to all payloads, upper stages, and released objects.

5.9.3 The purpose of the Orbital Debris Assessment (ODA) is to cover the potential for generating debris during normal operations or malfunction conditions and the potential for generating debris by collision with space debris (natural or human-generated) or orbiting space systems.

- 5.9.3.1 The following issues shall be addressed:
- a. Debris released during normal operations
 - b. Debris generated by explosions and intentional breakups
 - c. Debris generated by on-orbit collisions during mission operations and orbital lifetime
 - d. Safe disposal of upper stages and spacecraft after mission completion
 - e. Structural components impacting the Earth following post-mission disposal by atmospheric reentry

CHAPTER 6: PARTS AND MATERIALS

6.1 General

- 6.1.1 This chapter identifies requirements for the selection and qualification of mechanical parts and components; electrical, electronic, electromechanical (EEE) parts and components; and materials used in flight products.
- 6.1.2 The parts and materials (P&M) section of the PAP shall be developed from the requirements of this chapter.
- 6.1.3 All mechanical and EEE parts and components shall be identified on a Parts Inventory Report (PIR).
- 6.1.4 Sufficient spares shall be procured to ensure the replacement of defective parts and parts required for destructive testing as dictated by the Project's sparing philosophy.

6.2 Mechanical Parts

- 6.2.1 Mechanical parts and components include structural and mechanical piece parts, fasteners (all types), mechanical devices, and springs.
 - 6.2.1.1 Fastener products destined for application in spaceflight hardware shall be selected in accordance with NASA-STD-6008 and LAPD 5330.3.
 - 6.2.1.2 All fasteners received at LaRC shall be verified by the Quality Assurance Branch (QAB), as specified on the PO, and as specified in LMS-CP-4520.6.
 - 6.2.1.3 Upon acceptance, fasteners and their associated certification documentation shall be maintained in the appropriate bonded stores area (Section 7.11).

6.3 EEE Parts

- 6.3.1 EEE parts and components include off-the-shelf components, motors, pyrotechnic devices, sensors, transducers, and detectors (i.e., all items with an electrical interface).
- 6.3.2 The PAP shall require the submittal of an EEE Parts Plan to the MAB for approval.

6.3.3 Implementation

- 6.3.3.1 The LaRC EEE Parts Manager (EPM) shall coordinate the NASA Electronic Parts and Packaging Program (NEPP) with the NASA Parts Project Office

of NASA Headquarters and the MAB.

6.3.3.2 The EPM shall develop and implement the EEE Parts Plan in accordance with LMS-OP-5515 for LaRC internal projects.

6.3.3.3 The EEE Parts Plan shall be submitted to and approved by the MAB prior to the PDR.

6.3.4 Standard Parts

6.3.4.1 Parts selected and procured from the NPSL or Goddard Space Flight Center (GSFC) Preferred Parts List are identified as “standard parts” and shall be used as a first order of preference.

6.3.4.2 The use of Grade 1 or Grade 2 standard parts (or their equivalents) will be determined by the ability of the product design to achieve the desired MSC.

6.3.4.3 The EPM shall ultimately approve all EEE parts.

6.3.5 Nonstandard Parts

6.3.5.1 Parts that do not meet the criteria of “standard parts” are identified as “nonstandard parts.”

6.3.5.2 The EEE Parts Plan shall identify qualification-testing requirements for all “nonstandard parts.”

6.3.5.3 The Electronic Systems Branch shall perform qualification testing of EEE parts.

6.3.5.4 Any nonstandard parts require the submittal of LF 170, “Nonstandard Part Approval Request (NSPAR),” with supporting data package for LaRC consideration and approval.

6.3.6 Counterfeit Parts

6.3.6.1 Counterfeit parts are defined as a suspect part that is a copy or substitute without legal right or authority to do so or one whose material, performance, or characteristics are knowingly misrepresented by a supplier in the supply chain. These parts, when identified, are treated as nonconformances (i.e., segregated from other flight hardware) and the PAM and GIDEP representative shall be notified, as well as the Office of Chief Counsel.

6.4 Materials

6.4.1 Selection

- 6.4.1.1 Flammability, stress corrosion, outgassing, and off-gassing requirements for materials, including mechanical parts and components, shall be based upon payload cleanliness goals and any specific launch vehicle requirements.
- 6.4.1.2 In the absence of requirements from the vehicle integrator, Johnson Space Center (JSC) 09604/Marshall Space Flight Center (MSFC) HDBK-527, "Materials Selection List for Space Handbook Systems," shall be used for guidance in determination of material requirements.
- 6.4.1.3 The National Space Transportation System (NSTS), International Space Station (ISS), and some other integrators require the submittal of a Material Usage Agreement (MUA) for materials which do not meet their flammability, stress corrosion, outgassing, and off-gassing requirements.
- 6.4.1.4 The MUA shall be routed through the MAB to the integrator's approving organization.

6.4.2 Composites

- 6.4.2.1 Composite materials selected for use in structural applications shall be evaluated on a case by case basis.
- 6.4.2.2 A Composite Material Qualification Plan (CMQP) shall be submitted to the MAB for approval.

6.4.2 Limited Life Items

- 6.4.3.1 Limited shelf life polymeric materials shall be identified and expiration dates observed.
- 6.4.3.2 Use of materials with expired date-codes shall require the submittal of test results demonstrating that material properties have not been compromised for their intended use.
- 6.4.3.3 Use of expired materials requires submission of the test results and justification to the MAB for approval.

6.4.4 Materials List

- 6.4.4.1 A listing of selected materials shall be developed and maintained up-to-date.

- 6.4.4.2 The Materials List (ML) shall contain a reference to the document from which acceptability was ascertained.

6.5 Responsibilities

- 6.5.1 The PM shall:

- a. Be responsible for material selection and procurement.
- b. Prepare the PIR and ML.
- c. Initiate the MUA process.

- 6.5.2 The PAM shall:

- a. Verify material compliance through review and approval of MLs and MUAs.
- b. Verify parts compliance through review and approval of PIRs, EEE Parts Plans, CMQPs, and limited life items.

- 6.5.3 The EPM shall:

- a. Coordinate the NASA Standard Parts Program with the NASA Parts Project Office of NASA Headquarters and the MAB.
- b. Develop and implementing the EEE Parts Plan for LaRC internal projects.

- 6.5.4 The Electronic Systems Branch shall:

- a. Perform surveys, audits, product inspections, qualification testing, risk assessments, and/or production line certifications to verify the capability and qualification of supply sources. The results of surveys, audits, and product inspections performed by other Centers, other Government agencies, accredited third-party organizations, or the private sector may be utilized on a risk-informed basis as a supplement to, or a substitute for, direct surveillance.
- b. Provide the results of supplier audits/surveys, product inspections, qualification testing, risk assessments, and production line certifications to other NASA Centers by way of the NASA Supplier Assessment System (<http://sas.nasa.gov>).
- c. Coordinate conformity assessment activities, including, but not limited to, the conduct of joint supplier audits and the sharing of conformity assessment information, with those of other NASA Centers, appropriate Government agencies, and the private sector to reduce unnecessary duplication. Federal

guidelines concerning the performance of joint conformity assessment activities are provided in 15 CFR Part 287.

d. Ensure that conformity assessment processes used by other Government agencies, third-party auditors, and the private sector, when utilized per paragraphs 5.c.(1) and 5.c.(3) above, provide satisfactory assurance of source capability and qualification.

e. Support program/project offices in carrying out applicable requirements including mitigation of risks associated with lead-free solder and surface finishes in accordance with criteria provided in NPD 8730.2C.

f. Develop, document, and implement a counterfeit EEE parts control plan for the avoidance, detection, mitigation, disposition, control, and reporting of counterfeit EEE parts. Control plans may be project unique or apply to multiple Center projects. Guidelines are provided in NPD 8730.2C.

g. Be responsible for qualification testing of nonstandard EEE parts.

6.5.5 The Quality Assurance Branch (QAB) shall verify fasteners received at LaRC are as specified on the PO.

CHAPTER 7: QUALITY ASSURANCE

7.1 Quality Assurance Scope and Requirements

7.1.1 General Information

- 7.1.1.1 Sections 7.1 through 7.18 of LPR 5300.1 identifies the Quality Assurance (QA) requirements for the fabrication, assembly, disassembly, integration, testing, handling, preservation, and shipping, and of flight products, ground support equipment (GSE) and associated software.
- 7.1.1.2 The Mission Assurance Branch (MAB) shall implement the QA requirements associated with the tasks specified in 7.1.1.
- 7.1.1.3 Flight project personnel shall read and be familiar with the general information contained in each Section in which they have a requirement.
- 7.1.1.4 When reading Sections 7.1 through 7.18, the use of the words “flight project personnel” will include the following functional project responsibilities:
 - a. MAB QA Specialists (MAB/QAS), or the LaRC QA contractor, as appropriate.
 - b. MAB PAM.
 - c. Project Engineers.
 - d. Technicians.
- 7.1.1.5 For purposes of Sections 7.1 through 7.18, the use of the word/acronym “MAB/QAS” will include and apply to any contractor performing work for the MAB or when technicians have been tasked with performing inspections on behalf of the MAB, as specified in 7.10.1.3.

7.1.2 Quality Assurance Requirements Implementation

- 7.1.2.1 PMs shall be aware of the requirements contained in Sections 7.1 through 7.18 in order to effectively manage the QA aspects of the project.
- 7.1.2.2 The MAB Head shall assign a PAM for each project, as specified in Section 1.3.
- 7.1.2.3 The PAM shall develop the QA chapters of a project’s PAP using the requirements of Sections 7.1 through 7.18.
- 7.1.2.4 The PAM shall tailor the QA requirements for each project, when developing the QA chapter of the PAP, as appropriate.

- 7.1.2.5 The MAB Head and the PM shall approve project PAP's, as specified in Section 2.3.
- 7.1.2.6 MAB/QAS shall perform QA activities from initial receipt of the flight hardware or GSE through final integration prior to launch/flight, as specified in the project's PAP.
- 7.1.2.7 The MAB Software Assurance Engineers shall perform software QA activities for project software, as specified in Section 7.3, "Software Assurance."
- 7.1.2.8 The PAM shall determine the inspection requirements, based on their assessment of the consequences of a potential noncompliant hardware failure, using the following criteria:
 - a. Noncompliance cannot result in loss of life or loss of mission: Use statistically-based sampling plans or 100 percent inspections, as applicable.
 - b. Noncompliance can result in loss of life or loss of mission: Perform Government Mandatory Inspection Points (GMIP) to ensure 100 percent compliance with safety/mission critical attributes (i.e., hardware characteristics, manufacturing process requirements, operating conditions, and functional performance criteria).
- 7.1.2.9 The PAM shall include the inspection requirements, as determined in Section 7.1.2.8, in the following:
 - a. The applicable FIOS, as specified in Section 7.6.
 - b. The assembly and integration procedures, as specified in Section 7.13.
 - c. The test procedures, as specified in Section 7.14.
- 7.1.2.10 Engineering, technicians, SFAB, and shipping and receiving shall implement the QA requirements, as specified in Sections 7.2 through 7.18, as appropriate.

7.2 Institutional Safety Interface

7.2.1 General Information

- 7.2.1.1 This chapter contains the requirements associated with the interface between flight project personnel, PMs and the LaRC codified facility safety requirements, which are necessary to ensure safety for both personnel, facility infrastructure and project hardware.

7.2.2 General Safety Compliance, Authority, and Responsibilities

- 7.2.2.1 Flight project personnel and PMs shall comply with LaRC safety policies as established by the SFAB for the all project work operations including the following:
- a. Fabrication.
 - b. Assembly.
 - c. Disassembly.
 - d. Test operations.
 - e. Handling operations.
 - f. Lifting operations.
 - g. Shipping operations.
- 7.2.2.2 Flight project personnel and PMs shall have the authority to terminate any action which creates an imminent danger or hazard to either personnel or equipment.
- 7.2.2.3 Flight project personnel and PMs shall terminate work when any unsafe condition exists that could cause injury to personnel or damage to either flight hardware or associated GSE.
- 7.2.2.4 Flight project personnel shall report unsafe conditions or situations to one of the following functional entities, as appropriate:
- a. The cognizant engineer
 - b. The PM
 - c. The Facility Coordinator
 - d. The PAM
 - e. The LaRC Safety Manger
- 7.2.2.5 Flight project personnel and PMs shall immediately notify the LaRC Safety Manager, extension 4-7233, when work is stopped due to an unsafe condition.

7.2.3 Specific Safety Implementation

- 7.2.3.1 The PM shall be responsible for having project personnel adhere to LaRC safety requirements, as specified in P.4 (ppp) through P.4 (III), during the performance of all project work operations.

- 7.2.3.2 Engineers and technicians shall conduct all flight hardware operations with approved written procedures, as specified in Section 7.13, "Assembly, Disassembly, and Integration of Flight Hardware" and Section 7.14, "Testing of Flight Hardware."
- 7.2.3.3 When monitoring project work, the MAB/QAS shall verify personnel are not exposed to hazards based on the following:
- a. Adherence to assembly procedures.
 - b. Adherence to test procedures.
 - c. General knowledge and awareness of LaRC safety requirements, as specified in P.4 (ppp) through P.4 (llll).
- 7.2.3.4 The MAB/QAS shall verify flight hardware is not exposed to hazards, when involved in tasks, as specified in 7.2.3.2(a) through 7.2.3.2(c).
- 7.2.3.5 The MAB/QAS shall coordinate resolution of safety concerns with one or more of the following functional entities, as appropriate:
- a. PAM
 - b. Institutional safety (SFAB) personnel
 - c. PM
 - d. MAB Head
- 7.2.4 Hazardous Operating Procedures**
- 7.2.4.1 Engineers shall include a LaRC Safety Manager signature block on the signature page, as specified in 7.13.2.3(b) and 7.14.3.3(b), in each assembly or test procedure for any operation designated as hazardous (i.e., potential risks of injury to personnel and/or illness and/or property damage/destruction), as determined 7.13.2.3(o) and 7.14.3.3(v).
- 7.2.4.2 The LaRC Safety Manager shall approve by his/her signature on the signature page, as specified in 7.2.4.1, all hazardous operating procedures submitted by engineers.
- 7.2.4.3 Engineers shall notify the LaRC Safety Manager immediately of any changes to previously approved operating procedures.
- 7.2.4.4 Engineers shall provide revised procedures or red-lined changes to the Safety Manager in the event of a change to a hazardous procedure.
- 7.2.4.4 The LaRC Safety Manager shall approve changes to hazardous operations procedures as appropriate prior to implementation.

- 7.2.4.5 Engineers and technicians shall only implement revised hazardous procedures after approval by the following:
- a. The LaRC Safety Manager or their designee.
 - b. Engineering and MAB/QAS or PAM, who are involved in the process of either revising or red-lining procedures, as specified in Sections 7.13 and 7.14.

7.2.5 Emergency Response/Reporting

- 7.2.5.1 If an incident occurs that results in personnel death/injury, fire, release of hazardous materials or damage to the facility, including GSE, flight project personnel or PMs shall implement the following:
- a. Call 911 from a NASA phone or call 757-864-2222 from a cell phone for emergency response.
 - b. Shut down the operation in a safe manner per established procedures without exposing personnel to hazards, if possible.
 - c. Report the incident to the Safety Office at extension 4-7233.
 - d. Report the incident to the PM.
- 7.2.5.2 The SFAB Safety Manager or their designee shall determine if the incident is a mishap using the definitions, as specified in NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping.
- 7.2.5.3 Upon determination the incident is a mishap, the PM shall initiate the mishap process, as specified in LMS-CP-8621.

7.3 Software Assurance

7.3.1 General Information

- 7.3.1.1 The Software Assurance (SA) requirements, as specified in 7.3.1.2 through 7.3.1.4, are applicable to both in-house developed (provider) software or contractor provided (acquired) software for LaRC flight projects.
- 7.3.1.2 The MAB SA engineer shall perform a software classification assessment for flight project software, as specified in LMS-CP-4754.
- 7.3.1.3 The MAB SA engineer shall develop an SA Plan (SAP) based on the software classification, as applicable.
- 7.3.1.4 The MAB SA engineer shall implement SA tasks, as specified in the SAP, or as specified in LMS-CP-4754, as applicable.

- 7.3.1.5 The PAM shall include a requirement in the PAP that software will be in compliance with LPR 7150.2 for in-house flight projects.
- 7.3.1.6 The PAM shall include a requirement in the PAP that software will be in compliance with one or more of the following procedures based on the flight project software classification(s) for in-house flight projects:
 - a. LMS-CP-7150.3, Class A, B and All Safety Critical Software
 - b. LMS-CP-7150.4, Class C Software
 - c. LMS-CP-7150.5, Class D Software
 - d. LMS-CP-7150.6, Class E Software

7.4 Metrology

7.4.1 General Information

- 7.4.1.1 For the purposes of this chapter, the word “equipment” means both precision measurement instruments and test equipment.
- 7.4.1.2 The following types of measurements for a flight project require controls, as specified in LMS-CP-0506:
 - a. Acceptance measurements
 - b. Certification measurements
 - c. Qualification measurements
 - d. Testing measurements

7.4.2 Metrology Implementation

- 7.4.2.1 When taking measurements, as specified in 7.4.1.2, technicians or MAB/QAS shall only use equipment in current calibration for assembly and/or integration (e.g., torque wrenches, voltmeters, etc.).
- 7.4.2.2 The MAB/QAS shall verify the equipment used is in current calibration, as specified in Section 5 of LMS-CP-0506 for the following flight hardware activities:
 - a. Fabrication
 - b. Assembly
 - c. Testing

- 7.4.2.3 The MAB/QAS shall verify the Metrology Control Number (MCN) for equipment is recorded in the appropriate documentation as noted below:
- a. The FIOS in the E2 system for fabrication.
 - b. The FIOS, where assembly is being governed by the E2 work package.
 - c. The appropriate logbook, where drawings are sufficient for assembly.
 - d. The assembly procedures, as applicable.
 - e. The test procedures, as applicable.
- 7.4.2.4 The MAB/QAS shall verify the calibration dates for equipment used is recorded in the appropriate documentation, as noted in 7.4.2.3(a) through 7.4.2.3(e).
- 7.4.2.5 When reviewing procedures for approval, the PAM shall verify assembly procedures contain fields for recording the MCN and calibration data for the required measurement equipment for the following items:
- a. Flight hardware
 - b. GSE

7.5 Receipt Inspection

7.5.1 General Information and Definitions

- 7.5.1.1 Prior to implementing the project design requirements associated with flight hardware or its associated GSE, there is a need to verify all safety-critical materials and parts earmarked for assembly and integration meet the project's specifications. Additionally parts, procured items, and materials need to be inspected upon receipt prior to placement in bonded storage to ensure the proper items were received and not damaged and the proper documentation was supplied. These essential QA functions are accomplished in the receipt inspection process.
- 7.5.1.2 The greater part of this chapter provides the set of requirements that ensures safety-critical flight hardware and GSE parts and materials, including fastener products, whether provided by in-house fabrication, contractor, or by PO, meet the project's specified requirements. Included in these requirements are provisions for the proper testing, inspection, verification, as well as the traceability of the safety-critical items listed in this paragraph. It is worth noting any fastener product associated with flight hardware and its associated GSE is defined as safety-critical.
- 7.5.1.3 In addition, this chapter provides the set of requirements for the inspection and traceability of flight hardware, GSE and other related flight hardware items that are required to be placed into a Bonded Storage area.

- 7.5.1.4 Finally, this chapter provides the set of requirements for the inspection and traceability of flight hardware, GSE, and other related flight hardware items that are not required to be placed into a bonded storage area, such as:
- a. Flight hardware with a physical size that precludes placement in a Bonded Storage area.
 - b. Flight hardware used as part of a test development/qualification process, which needs to be returned and/or shipped to an outside destination.
 - c. Potential future flight hardware from another project stored in an environmentally suitable area.
- 7.5.1.5 Other documents that contain relevant requirements relating to this chapter are specified in LAPD 4520.1, LAPD-5330.3, LMS-CP-4520.5, and LMS-CP-4520.6.
- 7.5.1.6 *Bonded stores operator:* A bonded stores operator is a technician assigned to implement the Bonded Stores function. The Bonded Stores requirements are specified in LMS-CP-4892 as well as in Section 7.11 of this document.
- 7.5.1.7 *Lot Number:* A Lot Number is an identification number that enables tracing of the materials, labor, and equipment records involved in the manufacturing of a product.
- 7.5.1.8 *Heat Number:* A Heat Number is the identification number of the batch of steel, or other metal, or metal alloy, from which metal materials are produced.
- 7.5.1.9 *NSI Number:* An NSI Number is a test number assigned by the Materials Analysis and Quality Assurance Laboratory (MAQAL) MAB/QAS, which is consigned to safety-critical hardware items, if there are no anomalies associated with the accompanying documentation. The NSI number is recorded on LF 285, LF 285L, LF 290, or LF 248, as applicable. The NSI number is issued with a “PASS” or “FAIL” notation on the documents specified in this paragraph, as applicable.
- 7.5.1.10 *MV Number:* An MV Number is a test number assigned by the MAQAL MAB/QAS to designate the safety-critical hardware item’s mechanical and chemical properties have been tested at the request of engineers by the MAQAL despite the fact the proper documentation from the supplier has one or more anomalies. The MV number is issued with a “PASS” or “FAIL” notation on the documents specified in 7.5.1.9, as applicable.

7.5.2 MAQAL Receipt Inspection and Certification

- 7.5.2.1 Engineers or technicians shall deliver flight or GSE safety-critical fastener products, which are defined in LAPD-4520.1, to the MAQAL.

- 7.5.2.2 Engineers or technicians shall deliver a completed LF 290 to the MAQAL MAB/QAS with the delivery of safety-critical fastener products.
- 7.5.2.3 Engineers or technicians shall deliver safety-critical pressure system components, excluding piping, as defined in LAPD-4520.1, to the MAQAL.
- 7.5.2.4 Engineers or technicians shall deliver a material coupon for safety-critical flight hardware metals, which will be used for fabrication or pipe/tubing, as defined in LAPD-4520.1, to the MAQAL.
- 7.5.2.5 Engineers or technicians shall identify all coupons brought to the MAQAL, as specified in 7.5.2.4, with the following information:
 - a. Heat Number
 - b. Lot Number
 - c. Work order
 - d. Tracking number
- 7.5.2.6 Engineers or technicians shall deliver a completed LF 248, Materials Analysis and Quality Assurance Laboratory (MAQAL) Work Request, to the MAQAL MAB/QAS, when delivering any safety-critical pressure system component(s) or any coupon for material used in fabrication or pipe tubing that does not involve fastener products.
- 7.5.2.7 Engineers or technicians that deliver safety-critical hardware items to the MAQAL MAB/QAS for testing shall provide documentation that includes the following information:
 - a. PO or task order
 - b. Customer shipping invoice or equivalent paperwork
 - c. Supplier's name and address
 - d. Part number
 - e. Raw material identification (Lot and/or Heat numbers) information
 - f. Quantity shipped
 - g. Certificate of Compliance (CoC)
 - h. Manufacturer's test reports for mechanical properties test results
 - i. Manufacturer's test reports for chemical analysis test results
 - j. Other documentation/test reports, as specified in the PO or task order

- 7.5.2.8 Engineers and technicians shall implement the requirements specified in 7.5.2.3 through 7.5.2.7, as applicable, for contractor-machined safety-critical hardware items obtained via a Fabrication Branch contract.
- 7.5.2.9 After receiving any safety-critical item(s), the MAQAL MAB/QAS shall obtain a copy of the documentation, as described in 7.5.2.7.
- 7.5.2.10 The MAQAL MAB/QAS shall verify the documentation/information has been received for all delivered safety-critical products.
- 7.5.2.11 The MAQAL MAB/QAS shall verify the documentation received is traceable to the same Heat Number, if applicable, as provided on the safety-critical material coupon, as described in 7.5.2.5(a).
- 7.5.2.12 The MAQAL MAB/QAS shall verify the documentation received is traceable to the same Lot Number as provided on the material coupon, as described in 7.5.2.5(b).
- 7.5.2.13 The MAQAL MAB/QAS shall notify engineers or technicians if the required documentation, as specified in 7.5.2.7, has not been received or has inconsistencies.
- 7.5.2.14 Engineers or technicians shall resolve any documentation discrepancy identified, if possible.
- 7.5.2.15 If the documentation discrepancy, as specified in 7.5.2.13, cannot be resolved, engineers shall determine if the safety-critical hardware item(s) will be returned to vendor or if the safety-critical hardware item(s) will require "material verification," as specified in Section 7.5.3.
- 7.5.2.16 If the decision is to return the safety-critical hardware item(s) to the vendor, engineers shall pick up the un-processed LF 290 or LF248, as appropriate, along with the safety-critical hardware item(s) that have the documentation discrepancy.
- 7.5.2.17 If the decision, as required by 7.5.2.15, is to perform a material verification on the safety-critical hardware item(s), engineers shall initiate a Nonconformance Report (NCR), as specified in Section 7.9.
- 7.5.2.18 After initiating a NCR, as specified in 7.5.2.17, engineers or technicians shall request the MAQAL MAB/QAS to process a "material verification," as specified in Section 7.5.3.
- 7.5.2.19 In the event the required documentation has been received or inconsistencies have been resolved, as specified in 7.5.2.10, the MAQAL MAB/QAS shall perform the following partial receipt inspection of the safety-critical fastener products or pressure system components, except piping, according to the following criteria:

- a. Correct Shipment – The items listed on the shipping invoice match the listed items requested on the PO.
- b. Kind – the item(s) matches the physical description on the shipping invoice.
- c. Condition – the item(s) are not damaged or contaminated.
- e. Count – the number of items received match the number of items ordered minus any noted back order items.

7.5.2.20 The MAQAL MAB/QAB shall inspect safety-critical fastener products to verify the packaging includes the following:

- a. Manufacturer's certification traceability documentation for fastener product identification.
- b. Manufacturer's certification traceability documentation for fastener product Lot Number.
- c. Containers/packaging are coded for identification of the lot to enable traceability of the certification back to the heat treatment of the material.
- d. Containers/packaging are coded for identification of the lot to enable traceability of the test reports back to the heat treatment of the material.
- e. Sealed containers that ensure no comingling of lots.

7.5.2.21 The MAQAL MAB/QAS shall perform the following on any safety-critical hardware fastener product in accordance with LMS-CP-4520.6, Receipt Inspection for Fastener, Insert and Nut Products:

- a. Visual inspection
- b. Dimensional inspection
- c. Mechanical testing
- d. Chemical analysis testing

7.5.2.22 The MAQAL MAB/QAS shall perform the following on any safety-critical hardware pressure system component, except piping, in accordance with LMS-CP-4520.5:

- a. Visual inspection
- b. Dimensional inspection
- c. Chemical analysis testing

- 7.5.2.23 The MAB/QAS shall sample multiple identical pressure system components, when implementing 7.5.2.22, in accordance with note 8 in Table B of LMS-CP-4520.6.
- 7.5.2.24 The MAQAL MAB/QAS shall perform the following testing on any material coupons that are associated with fabrication or piping in accordance with LMS-CP-4520.5:
- a. Mechanical testing
 - b. Chemical analysis testing
- 7.5.2.25 After the flight hardware items or coupons have been satisfactorily inspected and tested, including the verification of the documentation, as specified in 7.5.2.10 through 7.5.2.24, as applicable, the MAQAL MAB/QAS shall take the following actions:
- a. Complete an LF 285, MAQA Lab Material Release, for a MAQAL internal record.
 - b. Assign an NSI Number.
 - c. Complete an LF 285L for the engineer's or technician's records.
 - d. Record any required dimensions taken on an LF 285 and an LF 285L.
 - e. Attach any required mechanical test data on an LF 285 and an LF 285L.
 - f. Attach any required chemical test data on an LF 285 and an LF 285L.
 - g. Indicate whether the safety-critical hardware item or coupon has passed or failed the receipt inspection process by stamping "PASS" or "FAIL" on an LF 285 and an LF 285L.
 - h. Complete an LF 290, as applicable.
- 7.5.2.26 If a nonconformance is found as a result of the applicable inspections performed in 7.5.2.20 through 7.5.2.24, the MAQAL MAB/QAS shall document the following on an LF 285 and an LF 285L:
- a. Any visual nonconformance for safety-critical fastener products or pressure system components, excluding piping.
 - b. Any dimensional nonconformance for safety-critical fastener products or pressure system components, excluding piping.
 - c. Any mechanical nonconformance for safety-critical coupons, fastener products, or pressure system components, excluding piping.

- d. Any chemical nonconformance for safety-critical coupons, fastener products, or pressure system components, excluding piping.
 - e. Compromised packaging for safety-critical fastener products or pressure system components, excluding piping.
- 7.5.2.27 The MAQAL MAB/QAS shall keep a copy of the documentation associated with safety-critical items, as specified in 7.5.2.7, for a period of two years.
- 7.5.2.28 The MAQAL MAB/QAS shall keep the tested safety-critical hardware or coupons for a period of two years.
- 7.5.2.29 After implementing the requirements specified in 7.5.2.25 and 7.5.2.26, the MAQAL MAB/QAS shall inform engineers or technicians the safety-critical hardware item(s) and/or documentation is ready to be picked up.
- 7.5.2.30 The MAQAL MAB/QAS shall inform engineers or technicians of a nonconformance of any item as a result of the inspections performed.
- 7.5.2.31 The MAQAL MAB/QAS shall place any nonconforming items in a designated area marked as “non-conforming items” prior to engineers or technicians receiving the rejected parts.
- 7.5.2.32 After engineers or technicians have been notified, the MAQAL MAB/QAS shall return the following items to the customer:
- a. All untested safety-critical fastener products or pressure system components.
 - b. Documentation, e.g., PO, shipping invoice, CoC, test reports, etc., for safety-critical fastener products, pressure system components, and material coupons.
- 7.5.2.33 Engineers or technicians shall obtain the appropriate forms, as specified in 7.5.2.25(c) and 7.5.2.25(h), after notification of the receipt inspection process has been completed.
- 7.5.2.34 Engineers or technicians shall pick up the documentation, including the safety-critical items, as specified in 7.5.2.32.
- 7.5.2.35 If there is a “FAIL” notation on both an LF 285 and an LF 285L, as specified in 7.5.2.25(g), engineers shall determine whether to:
- a. Return the purchased items to the vendor, or
 - b. Use as-is.

- 7.5.2.36 For a “use-as-is” decision, engineers shall initiate a NCR for a Material Review Board review, as specified in Section 7.9.
- 7.5.2.37 Engineers or technicians shall follow the instructions in the final disposition associated with any “use-as-is” safety-critical item processed by the Material Review Board.

7.5.3 MAQAL Verification

- 7.5.3.1 This section contains the requirements that allow for the project to use safety-critical hardware items when the originating documentation is missing or has some discrepancy, as described in 7.5.2.13. Verification is the process of substantiating the dimensions and material properties of safety-critical fastener products and pressure system components as well as substantiating the material strength and chemical properties of safety-critical material coupons that will be used in fabrication and piping, and then documenting the results.
- 7.5.3.2 When the originating documentation is missing or has some discrepancy, as noted in 7.5.2.13, the MAQAL MAB/QAS shall perform a receipt inspection, as specified in 7.5.2.21 through 7.5.2.24, as applicable, when requested by engineers or technicians.
- 7.5.3.3 The MAQAL MAB/QAS shall document the results of the flight hardware material verification process by implementing the following:
- a. Complete an LF 285, for a MAQAL internal record.
 - b. Assign an MV Number, which denotes the safety-critical items, which had documentation discrepancies, were tested at the request of engineers.
 - c. Complete an LF 285L for the engineer’s or technician’s records, including data, as specified in 7.5.3.3(d) through 7.5.3.3(f).
 - d. Record any required dimensions taken on the LF 285 for fastener products or pressure system components.
 - e. Attach the data from any required mechanical test on the LF 285 and LF 285L for fastener products or material coupons, as applicable.
 - f. Attach the data from any required chemical test on the LF 285 for fastener products, pressure system components, or material coupons, as applicable.
 - g. Complete an LF 290 or LF 248, as applicable.
- 7.5.3.4 The MAQAL MAB/QAS shall keep a copy of any documentation associated with safety-critical items, as specified in 7.5.2.7 for a period of two years.

- 7.5.3.5 The MAQAL MAB/QAS shall keep the tested safety-critical hardware or coupons for a period of two years.
- 7.5.3.6 After implementing the requirements specified in 7.5.3.3, the MAQAL MAB/QAS shall inform engineers or technicians the safety-critical hardware items and/or documentation are ready to be picked up.
- 7.5.3.7 After engineers or technicians have been notified, the MAQAL MAB/QAS shall return the following items to the customer:
 - a. All untested safety-critical fastener products or pressure system components.
 - b. Documentation, e.g., PO, shipping invoice, CoC, test reports, etc., for safety-critical fastener products, pressure system components, and material coupons.
- 7.5.3.8 Engineers or technicians shall pick up the forms, as specified in 7.5.3.3(c) and 7.5.3.3(g), after receiving notification from the MAQAL MAB/QAS that the material verification process has been completed.
- 7.5.3.9 Engineers or technicians shall pick up the safety-critical items.
- 7.5.3.10 Engineers shall include the data obtained from the material verification, as specified in 7.5.3.3(d) through 7.5.3.3(f), for the Material Review Board assessment of the NCR initiated in 7.5.2.36.
- 7.5.3.11 Engineers or technicians shall follow the instructions in the final disposition associated with the material verification of the safety-critical items processed by the Material Review Board.
- 7.5.3.12 MAB/QAS shall verify safety-critical fastener products or materials with an MV designation are not used as flight hardware, unless the following criteria are met:
 - a. The final disposition of the appropriate NCR states “use-as-is.”
 - b. “Use-as-is” is designated on the appropriate fabrication paperwork or bonded stores issued parts kit.

7.5.4 Bonded Stores Operator Receipt Inspection

- 7.5.4.1 Engineers or a technicians shall deliver to the bonded stores operator, as defined in 7.5.1.6, a completed LF 177, Bonded Stores Receipt and Requisition Record, with the flight hardware items requiring Bonded Storage, as specified in Section 7.11.

- 7.5.4.2 The bonded stores operator shall receive from engineers or technicians the following documentation, prior to performing the receipt inspection:
- a. A copy of the PO for flight hardware items.
 - b. LF 177, Bonded Stores Receipt and Requisition Record.
- 7.5.4.3 The bonded stores operator shall perform a receipt inspection of flight hardware items before storing, according to the following criteria:
- a. Correct Shipment – The flight hardware items on the shipping invoice match the items requested on the PO.
 - b. Kind – the flight hardware item(s) matches the physical description on the shipping invoice for flight hardware items or the LF 177, Bonded Stores Receipt and Requisition Record, for items fabricated by LaRC.
 - c. Condition – the flight hardware item(s) are not damaged or contaminated.
 - d. Count – the number of flight hardware items received match the number of flight hardware items ordered minus any noted back ordered flight hardware items.
 - e. Documentation – the flight hardware item(s) have the proper paperwork requested in the PO.
 - f. Documentation – safety-critical fastener products are accompanied with a LF 285L.
 - g. Safety-critical fastener products received with an MV Number on the LF 285L, also have an NCR number referenced.
- 7.5.4.4 The bonded stores operator shall verify the requirements, as specified in 7.5.4.3, by initialing for each flight hardware item inspected on LF 150 in the receipt inspection column.
- 7.5.4.5 The bonded stores operator shall process flight hardware items that do not successfully pass the receipt inspection process according to LMS-CP-4892.

7.5.5 Receipt Inspection of Stored Flight Hardware Not Subject to Bonded Stores Requirements

- 7.5.5.1 Flight hardware items, which are not subject to bonded stores requirements, are described in 7.5.1.4.
- 7.5.5.2 When receiving flight hardware items, which are not subject to bonded stores requirements, engineers or technicians shall request MAB/QAS to perform a receipt inspection of the hardware upon receipt.
- 7.5.5.3 The MAB/QAS shall perform a receipt inspection of flight hardware items, as specified in 7.5.5.2, according to the following criteria:
 - a. Kind – the flight hardware item(s) matches the physical description on the shipping invoice.
 - b. Condition – the flight hardware item(s) are not damaged or contaminated.
 - c. Count – the number of flight hardware items received match the number of flight hardware items ordered minus any noted back ordered items.
 - d. Documentation – the flight hardware item(s) have the proper paperwork noted in the shipping invoice.
- 7.5.5.4 The MAB/QAS shall document the results of the receipt inspection, as determined in 7.5.5.3, on LF 532.
- 7.5.5.5 The MAB/QAS shall document nonconformances or damage, as specified in 7.5.5.3, on flight hardware items, as specified in 7.5.1.4(a), according to the project PAP.
- 7.5.5.6 The MAB/QAS shall place the LF 532 in the appropriate project component, subsystem, or system logbook, as specified in Chapter 12, for the flight hardware items, as specified in 7.5.1.4(a), which are processed, as specified in 7.5.5.4 and 7.5.5.5.
- 7.5.5.7 The MAB/QAS shall notify the customer/owner of nonconformances or damage associated with test hardware or potential future flight hardware items, as described in 7.5.1.4(b) and 7.5.1.4(c), as a result of the receipt inspection performed, as specified in 7.5.5.3.
- 7.5.5.8 The MAB/QAS shall provide the LF 532 to the customer/owner of test hardware or potential future flight hardware items.
- 7.5.5.9 The MAB/QAS shall retain a copy of the LF 532 for test hardware or potential future flight hardware according to the NASA record retention policy, as specified in the SMAO LF 192.

7.6 Fabrication Planning and Execution

7.6.1 General Information

7.6.1.1 This Section provides the QA requirements associated with the fabrication of flight hardware.

7.6.1.2 For the purposes of this Section, all flight project planning and execution is considered "Quality Sensitive," as defined in LMS-CP-5640, unless excluded by a negotiation between the Flight Project Directorate and the Safety and Mission Assurance Office and documented in the PAP.

7.6.2 Fabrication Work Request (FWR)

7.6.2.1 Engineers shall initiate a request for fabrication work for flight hardware using LF 133.

7.6.2.2 Engineers shall sign all flight hardware FWRs.

7.6.2.3 The Fabrication Representative (FR) shall populate the LF 133 as specified in LMS CP-5640.

7.6.2.4 The FR shall approve the LF 133 as specified in LMS CP-5640.

7.6.2.5 Engineers shall mark all flight hardware FWRs as "Quality Sensitive" or "Non-Quality Sensitive," as specified in the PAP.

7.6.3 Preparation of the Fabrication and Inspection Operations Sheet (FIOS)

7.6.3.1 The lead technician shall prepare an LF 136 for each serialized part, group of parts, or subassembly, as specified in section 3 of LMS CP-5640.

7.6.3.2 The lead technician shall include process specifications in the FIOS for certain fabrication and/or assembly operations, when any of the following conditions exist:

- a. The final result or complete operation cannot be inspected or tested.
- b. The operation is sufficiently complex such that an experienced operator cannot successfully perform the operation with repeatable results.
- c. The operation is potentially destructive to hardware or personnel.
- d. The operation can generate destructive by-products, such as contamination, not apparent to the operator.

7.6.3.3 The lead technician shall specify existing proven processes (i.e., soldering, welding, heat treatment, coatings, etc.) on flight hardware, including qualification hardware in the FIOS.

- 7.6.3.4 Engineers shall verify the fabrication process specifications in the FIOS to ensure the process complies with design requirements.
 - 7.6.3.5 The lead technician shall make all process documentation available for review at the facility where the process is implemented.
 - 7.6.3.6 Engineers or the lead technician shall identify fabrication processes by:
 - a. Number
 - b. Revision
 - 7.6.3.7 Engineers or the lead technician shall place all fabrication processes under configuration management.
 - 7.6.3.8 The lead technician shall include all First Article Inspection requirements, as specified in 7.6.4, in the FIOS, if applicable.
 - 7.6.3.9 Engineers shall assist the lead technician in preparing a “Quality Sensitive” FIOS.
 - 7.6.3.10 The PAM shall communicate the inspection requirements, as specified in 7.1.2.8, to the MAB/QAS.
 - 7.6.3.11 The MAB/QAS shall verify mandatory Quality Assurance Specialist (QAS) inspection points are included on the “Quality Sensitive” FIOS, as determined by the following requirement documents:
 - a. Workmanship requirements
 - b. Customer requirements
 - c. Inspections, as specified in 7.6.3.10
 - 7.6.3.12 MAB/QAS, the FR, and the Engineer responsible for the hardware design shall implement the following:
 - a. Review each “Quality Sensitive” FIOS.
 - b. Approve each “Quality Sensitive” FIOS.
- 7.6.4 First Article Inspection (FAI)**
- 7.6.4.1 The purpose of the FAI is to verify the first flight article of a manufacturing process meets the flight article’s engineering specifications.
 - 7.6.4.2 The FAI will only be performed on projects deemed “critical and complex,” and as identified by the project on the FWR.

- 7.6.4.3 Engineers shall provide the engineering specifications to the lead technician for the purpose of determining the FAI requirements.
- 7.6.4.4 The lead technician shall identify the FAI “Pass” and “Fail” steps/criteria during the preparation of the FIOS.
- 7.6.4.5 Engineers shall approve the FAI “Pass” and “Fail” steps/criteria.
- 7.6.4.6 The PAM shall approve the FAI after ensuring the FAI contains objective evidence that all the engineering design specification requirements meet the following criteria:
 - a. Correct
 - b. Included
 - c. Recorded
 - d. Required to be verified by MAB/QAS
- 7.6.4.7 After the FAI requirements are approved by MAB/QAS and engineers the lead technician shall include the FAI requirements in the FIOS.
- 7.6.4.8 The lead technician shall initiate an additional full FAI or partial FAI for affected characteristics, when any of the following events occur:
 - a. A change in the design affecting fit, form, or function of the part.
 - b. A change in manufacturing source(s), process(es), inspection method(s), location of manufacture, tooling or materials that can potentially affect fit, form, or function.
 - c. A change in numerical control program or translation to another media that can potentially affect fit, form, or function.
 - d. A natural or human initiated event which may adversely affect the manufacturing process.
- 7.6.4.9 If an additional full or partial FAI is initiated, the lead technician, engineers and the PAM shall implement the requirements, as specified in 7.6.4.3 through 7.4.6.7, as appropriate.

7.6.5 Fabrication Implementation

- 7.6.5.1 Technicians shall perform all work initiated by an LF 133 for flight project hardware fabrication, in accordance with LMS-CP-5640.
- 7.6.5.5 MAB/QAS shall perform inspections on operations of all flight project hardware fabrication and associated GSE performed at LaRC facilities, as required in the respective FIOS, which is specified in LMS-CP-5640.

- 7.6.5.6 When using a Blank Purchase Agreements (BPA) or existing Task-Order contracts for fabrication of flight hardware parts for LaRC in-house projects, the FR shall require contractors to utilize an approved fabrication planning process comparable to LMS-CP-5640.
- 7.6.5.7 Technicians preparing Task-Orders shall use the appropriate procurement requirements when procuring fasteners, as specified in Section 3.2.
- 7.6.5.8 Technicians shall apply their signature after the completion of each step of fabrication process.
- 7.6.5.9 The MAB/QAS shall verify all fabrication process steps are performed in sequence as indicated on the FIOS.

7.7 Workmanship Standards

7.7.1 General Information

- 7.7.1.1 This Section specifies the NASA workmanship standards and the requirements associated with those standards as applied to flight hardware.
- 7.7.1.2 All flight electronics work performed for both in-house projects and contracted projects/tasks are required to meet the Agency workmanship standards specified in 7.7.2.1 or 7.2.3.1, as applicable.
- 7.7.1.3 Worker certification is required for the NASA workmanship standards and for Electrostatic Discharge (ESD) work. The requirements for workmanship standards certification are specified in 7.7.4.
- 7.7.1.4 The requirements for the in-house training, certification, and handling of flight hardware that may be sensitive to electrostatic discharge are specified in Section 7.15 and LPR 8739.21, Langley Research Center (LaRC) Procedures and Guidelines for Electrostatic Discharge (ESD) Control of ESD-Sensitive Devices Program, and will not be a subject of this Section.

7.7.2 LaRC in-house Project Workmanship Standards Requirements

- 7.7.2.1 The PAM shall specify the appropriate workmanship standards in the PAP for in-house projects.
- 7.7.2.2 Technicians shall perform all flight hardware assembly and fabrication processes, as specified in the following workmanship standards, as applicable:
 - a. NASA-STD-8739.1
 - b. J-STD-001ES (Chapter 10 does not apply)

- c. NASA-STD-8739.4
 - d. NASA-STD-8739.5
- 7.7.2.3 MAB/QAS shall inspect all flight hardware, as specified in the appropriate workmanship standard, as applicable.
- 7.7.2.4 The PAM shall approve or disapprove the use of an alternate workmanship standard(s) for a project subject to the following criteria:
- a. A submission by engineers of an alternate workmanship standard(s) for review by the PAM.
 - b. A submission by engineers that documents the differences between the alternative workmanship standard(s) and the required workmanship standard(s), as specified in 7.7.2.2.
 - c. The alternative workmanship standard(s) do not introduce an unacceptable risk to the quality of the flight hardware, as determined by the PAM.
 - d. Approval by the Project Chief Engineer of the alternative workmanship standard(s), with special focus on the possibly risk to the quality of the flight hardware.
 - e. Approval by the PM of the alternative workmanship standard(s).
- 7.7.2.5 The Project Chief Engineer and the PM shall either approve or disapprove of the proposed alternative workmanship standard(s) for an in-house project.

7.7.3 Contract Workmanship Requirements

- 7.7.3.1 The PAM shall include the applicable workmanship standards, as specified below in Contract Specifications, SOWs, RFPs, and Task Orders, as appropriate:
- a. NASA-STD-8739.1
 - b. J-STD-001ES (Chapter 10 does not apply).
 - c. NASA-STD-8739.4
 - d. NASA-STD-8739.5
 - e. ANSI/ESD S20.20

- 7.7.3.2 The PAM shall approve or disapprove the use of an alternate workmanship standard(s) in the contracted work subject to the following criteria:
- a. A submission by the supplier of an alternate workmanship standard(s) for review by the PAM.
 - b. A submission by the supplier that documents the differences between the alternative workmanship standard(s) and the required workmanship standard(s) specified in 7.7.3.1, as appropriate.
 - c. The alternative workmanship standard(s) do not introduce an unacceptable risk to the quality of the flight hardware, as determined by the PAM.
 - d. Approval by the Project Chief Engineer of the alternative workmanship standard(s), with special focus on the possibly risk to the quality of the flight hardware.
 - e. Approval by the PM of the alternative workmanship standard(s).
- 7.7.3.3 The Project Chief Engineer and the PM shall either approve or disapprove of the proposed alternative workmanship standard(s) in the contracted work.

7.7.4 Worker Certification

- 7.7.4.1 The technicians and MAB/QAS that are either performing the flight hardware work or inspecting same shall be awarded a certificate upon completion of the following:
- a. The workmanship standards training.
 - b. Other training, as specified in 7.7.4.2, if required.
- 7.7.4.2 The supervisor(s) of MAB/QAS or technician personnel shall determine any additional requirements in addition to the class training, such as, on-the-job training, and hours/jobs worked, that are necessary for a worker to be certified.
- 7.7.4.3 The supervisor(s) of MAB/QAS or technician personnel, who are either performing the flight hardware work or inspecting same shall sign the LF 359, Workmanship Standards Certification Record, after the employee successfully completes the workmanship standards training, as specified in 7.7.4.1 and 7.7.4.2.
- 7.7.4.4 The supervisor(s) of MAB/QAS or technician personnel shall maintain the employee's records of certification, as specified in LPR 8739, Workmanship Standards Personnel Certification Program.

- 7.7.4.5 The technicians or supervisor(s) of MAB/QAS or technician personnel shall allow the PAM or MAB/QAS access to certification records to determine a worker's certification status.
- 7.7.4.6 The MAB/QAS or the PAM shall verify that a worker performing work on flight hardware is certified for the appropriate time duration by reviewing the worker's certification at the work site.
- 7.7.4.7 After a worker's certification has been verified, the MAB/QAS shall record the following information in the appropriate log book history record:
 - a. The worker's name.
 - b. The workmanship standard that was verified.
 - c. Expiration date of the certification.
 - d. Date the certification was verified.
- 7.7.4.8 The PAM shall determine if and when an audit of a contractor's training/certification program is to be conducted during the execution of managing the QA effort for the project.
- 7.7.4.9 The MAB/QAS shall periodically check contractor worker workmanship status when performing Government Mandatory Inspection Points (GMIPS).

7.8 Flight and GSE Hardware Identification

7.8.1 General Information

- 7.8.1.1 This Section specifies the requirements associated with marking flight and GSE hardware to ensure both the functionality, proper identification, and control of each item and/or assembly. For the purposes of this Section, parts, hardware articles, and assemblies refer to both flight hardware and GSE hardware.

7.8.2 Marking and Controlling of Hardware Parts and Assemblies

- 7.8.2.1 Engineers shall implement the requirements specified in 7.8.2.2 and 7.8.2.3, 7.8.3.1 and 7.8.3.2, 7.8.4.1 and 7.8.4.2, as well as 7.8.5.1 through 7.8.5.8, to ensure parts and/or assemblies are marked or can be controlled by a part number (PN).
- 7.8.2.2 Engineers shall not mark parts, when the parts meet the following criteria:
 - a. Permanently attached to other parts or assemblies (i.e., by welding, riveting, brazing, soldering, etc.).

- b. Batch- or lot-controlled and manufactured or processed in one operation.
 - c. Specifically exempted from marking, as specified on engineering drawings.
- 7.8.2.3 Engineers shall provide the following information on engineering drawings for parts and/or assemblies, as specified in Sections 7.8.3, 7.8.4 and 7.8.5, respectively:
- a. PN numbering instructions/methodology.
 - b. PN location.
 - c. PN marking method.
- 7.8.2.4 Engineers shall include hardware identification requirements, as specified in 7.8.2.3, to the first hardware article manufactured regardless of type (i.e., prototype, qualification unit, etc.).
- 7.8.2.5 Technicians shall mark hardware articles, as specified on engineers drawings, and as described in 7.8.5.9 through 7.8.5.16.
- 7.8.2.6 Technicians shall tag hardware articles, as specified in 7.8.4.4 and 7.8.4.5.
- 7.8.2.7 Technicians shall use PNs on hardware articles and/or assemblies as a method of properly identifying each part and assembly to:
- a. Maintain as built configuration, as specified in the project configuration plan.
 - b. Provide traceability of individual parts back to fabrication records, as specified in Section 7.6.
 - c. Provide traceability of inspections back to individual parts, as specified in Section 7.6.
 - d. Implement proper bonded storage requirements, as specified in Section 7.11.
 - e. Aid in assembly of articles according to engineering drawings and/or procedures, as specified in Section 7.13.
 - f. Allow for identification of parts in order to segregate for rejection and/or dispositioning a NCR, as specified in Section 7.9.
- 7.8.2.8 MAB/QAS shall use PNs on hardware articles and/or assemblies in order to identify the following:
- a. Parts for specific inspections, as specified in Section 7.6.

- b. Parts for specific rejections, as specified in Section 7.9.
- c. Parts when witnessing installation/assembly activities per engineering drawings and/or procedures, as specified in 7.13.

7.8.3 Elements of the Part Number

7.8.3.1 Engineers shall annotate PN numbering instructions on drawings consisting of the following elements:

- a. Drawing number from which the hardware article was fabricated.
- b. The hardware article drawing dash number.
- c. The hardware article drawing revision.
- d. Serial Number (SN), when there is more than one of the same part, article or assembly.

7.8.3.2 Engineers shall use the following PN format:

XXXXXXXX---XXX---X--XXX

---A-----B---C----D----E

Example: 1023907-001A001

Where:

- a. A = A maximum of seven digits for identifying a LaRC drawing number from which an article is fabricated.
- b. B = Dash for separating an article's drawing number from its drawing dash number.
- c. C = Three digits for an article's drawing dash number.
- d. D = One letter noting an article's drawing revision (if drawing revision is not applicable, a dash will be used in lieu of a letter).
- e. E = Serial number, a three digit number starting with "001" for the first of multiple parts and assemblies manufactured regardless of type (i.e., prototype, qualification unit, flight, etc.).

7.8.3.3 Engineers shall use consecutive serial numbers through all configuration changes, as specified in 7.8.3.2(e).

7.8.4 Location of the Part Number

- 7.8.4.1 Engineers shall note the location of the PN on the engineering drawing associated with the article.
- 7.8.4.2 Engineers shall select a PN location on the article, so the PN will remain visible after installation or assembly, whenever possible.
- 7.8.4.3 Technicians shall mark the PN directly on the hardware article, as specified in 7.8.4.1.
- 7.8.4.4 Technicians shall identify hardware articles with unsuitable or insufficient surfaces for direct marking (i.e., small springs, glass, plastic, optical elements, wire harnesses, etc.) or whose drawing specifies, "NO MARKING PERMITTED," by PN on an attached identification tag, such as LF 183, Hardware Identification Tag, or equivalent.
- 7.8.4.5 Technicians shall "Bag and Tag" articles that cannot be marked by other means or where individual tagging is not practical (i.e., small electrical or electronic parts, fasteners, attaching hardware, parts having dielectric properties, etc.), as follows:
 - a. Hardware articles: "bagged" in boxes, envelopes, bags, or other appropriate containers.
 - b. Containers: "tagged" by affixing an identification tag, such as LF 183 or equivalent.
- 7.8.4.6 The MAB/QAS shall be responsible for verifying the contents of "Bag and Tag" containers with the appropriate quality stamping, as specified in Section 7.10.

7.8.5 Marking Method of the Part Number

- 7.8.5.1 Engineers shall specify the PN marking method on the hardware article's drawing, taking into account the following criteria:
 - a. Contamination control requirements.
 - b. Size of the part.
 - c. Surface properties.
 - d. Etching depth effect on fatigue life and/or stress.
 - e. Other criteria, as appropriate.

- 7.8.5.2 Engineers shall specify one of the following methods of marking provided the marking is compatible with the article, as specified in 7.8.5.1:
- Ink.
 - Electrochemical etching.
 - Chemical etching.
 - Dot Peening.
 - Laser etching.
 - Computer Numerical Control (CNC) engraving.
- 7.8.4.3 Engineers shall select a marking method consistent with the size of each assembly, so the PN is visible under lighting that exists in mechanical workshops, which is greater or equal to 750 Lumen/m.²
- 7.8.5.4 Engineers shall select a marking method for articles that are, or contain, optical elements that meet the following criteria:
- Will not damage the optical element.
 - Will preclude condensable volatile contamination for optical elements that are subject to such contamination.
- 7.8.5.5 Engineers shall select electrochemical etching on flight hardware articles in preference to ink marking, when a non-injurious method is required for permanent marking of bare metallic or conductive surfaces.
- 7.8.5.6 If the depth of etching has been identified on the drawing as critical, technicians shall prepare test samples to determine the ranges of the following variables necessary to achieve an acceptable depth of etch:
- Voltages.
 - Application duration.
- 7.8.5.7 Engineers shall only select chemical etching as the PN marking method for printed circuit boards.
- 7.8.5.8 If more than one printed circuit board of the same drawing is fabricated, engineers shall stipulate the use of glass baking epoxy ink (NAZ-DAR-BE-1 12 White or BE-111 Black) to silk screen the SN on each board.
- 7.8.5.9 When applying electrochemical etching to flight hardware articles, technicians shall use the LECTROETCH Company power unit, or equivalent, following the manufacturer's recommendations (including the required electrolyte and cleaner), unless otherwise specified on the drawing.

- 7.8.5.10 Technicians shall thoroughly clean electrochemical etchings, including the surrounding area, to remove corrosive chemicals from flight hardware articles after marking.
- 7.8.5.11 Technicians shall apply ink markings when specified on engineering drawings directly on flight hardware articles or on LF 183 with direct type stamps, indirect type stamps, or stencils available in small typeface (3/32-in. height) or large typeface (1/8-in. height).
- 7.8.5.12. Technicians shall use white, black, or green colored Markem Ink Company 7224 ink, or equivalent, when marking flight hardware articles with ink, as specified in 7.8.5.12.
- 7.8.5.13 Technicians shall chemically etch the PN on printed circuit boards as part of the fabrication process.
- 7.8.5.14 If more than one printed circuit board of the same drawing is fabricated, technicians shall use glass baking epoxy ink (NAZ-DAR-BE-1 12 White or BE-111 Black) to silk screen the SN on each board.
- 7.8.5.15 After marking the SN on the board, technicians shall bake each circuit board at 250°F for one hour to cure the ink.

7.8.6 Removal of the Part Number Tag

- 7.8.6.1 MAB/QAS shall place the identification tag for items tagged, as specified in 7.8.4.4, or “bagged and tagged,” as specified in 7.8.4.5, in the appropriate logbook after removing the articles for final installation.
- 7.8.6.2 After final installation, MAB/QAS shall record the PNs in LF 154, Configuration Record.
- 7.8.6.3 After recording the PNs, MAB/QAS shall place the record in the appropriate logbook, as specified in Section 7.12.

7.9 Nonconformance and Failure Reporting

7.9.1 General Information and Definitions

- 7.9.1.1 When a nonconformance, a failure, or an anomaly is discovered, a Nonconformance Report (NCR) is initiated, as specified in 7.9.4. The elements of the NCR workflow are documented in LMS-CP-5507, Reporting and Disposition of Nonconforming Aerospace Hardware Items and Products, and rely heavily on the NCR reporting system Web site, located at this URL:

https://ncr.larc.nasa.gov/admin_index.cfm.

This Web site contains a user guide, “Nonconformance (NCR) and Anomaly

Reporting System,” under the Help pull-down menu on the home page.

To gain access to this website, new users must contact the site administrator, who will be identified when they click on the link above.

- 7.9.1.2 *Item(s)*: For purposes of this Section, the word “Item(s)” refers to flight hardware or an associated GSE part, component, device, subsystem, and/or system.
- 7.9.1.3 *Nonconformance*: A nonconformance is a condition or characteristic of any item, including software, which does not conform to a drawing or other specified project requirement.
- 7.9.1.4 A LaRC project nonconformance may be of 1 of 2 types, which are analogous to what LaRC specifies for a contractor’s nonconformance process, as defined in 3.1.1.9 and 3.1.1.10. These 2 types of nonconformances are defined as follows:
- a. *Major*: A nonconformance that adversely affects the safety, reliability, durability, performance, configuration, interchangeability, or weight requirements of a LaRC project. This type of nonconformance must be approved by the project’s Material Review Board (MRB), which is described in 7.9.2.3.
 - b. *Minor*: A nonconformance that does not adversely affect a LaRC project to the degree described in 7.9.1.4(a). This type of nonconformance is dispositioned by the cognizant engineer, as specified in 7.9.5.12, 7.9.5.15, and 7.9.5.16.
- Notwithstanding these definitions, the cognizant engineer has the authority to either scrap a part or return a part to vendor or return a part for completion without designating the nonconformance as Minor or Major, as specified in 7.9.5.2(a) through 7.9.5.2(c).
- 7.9.1.5 *Failure*: A failure is defined as the inability of any item, including software, to perform in accordance with a specified functional test. A failure must be referred to the MRB for disposition, except for a failure identified through the receipt inspection process, which is specified in Section 7.5.
- 7.9.1.6 *Anomaly*: An anomaly is an unexpected event during the testing or operation of any item, including software, which neither rises to the level of a nonconformance nor a failure, but needs to be investigated to understand the cause(s) and associated risks, if any. An anomaly must be referred to the MRB for disposition.
- 7.9.1.7 For the purposes of this entire Section 7.9, the phrase “flight project personnel” has the same meaning, as specified in 7.1.1.4.

7.9.2 Organizing the Project NCR Process

- 7.9.2.1 The MAB/QAS shall establish a new project link in the NCR reporting system Web site, cited in 7.9.1.1.
- 7.9.2.2 The PM shall assign personnel to the project's MRB with authority to make dispositions, as specified in 7.9.2.3.
- 7.9.2.3 The project MRB shall be a technical team minimally comprised of the following:
 - a. Cognizant engineer.
 - b. MAB/QAS.
 - c. PAM in lieu of MAB/QAS, as appropriate.
 - d. The PM or their designee (called a "project representative"), as specified in 7.9.2.4.
- 7.9.2.4 The PM shall assign a project representative to the MRB, as specified in 7.9.2.3(d), as appropriate.
- 7.9.2.5 If the PM assigns a project representative to the MRB, the designated project representative shall perform all MRB functions of the PM, except as specified in 7.9.2.6.
- 7.9.2.6 The designated project representative shall defer to the PM, when a unanimous agreement cannot be reached for approval of the project's MRB activities.
- 7.9.2.7 The PM shall not designate the engineer who initiates the disposition as the designee to the project's MRB.
- 7.9.2.8 The PM shall provide the MAB/QAS with the following:
 - a. A list of names of all personnel authorized to make MRB NCR disposition decisions.
 - b. The functional designations of those personnel listed in 7.9.2.8(a).
- 7.9.2.9 The PM shall provide the MAB/QAS with changes made to the list of personnel specified in 7.9.2.8(a), when changes to the project's MRB personnel are made during the project.
- 7.9.2.10 Flight project personnel or a PM using the NCR system for the first time shall register in the system following the instructions in the user's guide, as specified in 7.9.1.1.

- 7.9.2.11 If the flight project personnel or PM has used the NCR system on a previous project, the flight project personnel or PM shall log online to update their registered user's information by selecting the following:
- a. The name of the new project.
 - b. Their functional role.
- 7.9.2.12 The MAB/QAS shall complete the registration process in the NCR system, which was initiated in 7.9.2.10 and 7.9.2.11, by implementing the following:
- a. Verifying the name and their corresponding function are correct, as specified in 7.9.2.9.
 - b. Approving the name and their corresponding function.
- 7.9.2.13 The MAB/QAS shall maintain each name in the NCR reporting system along with their appropriate function, including the MRB membership, as specified in 7.9.2.8 through 7.9.2.11.

7.9.3 Handling of Nonconforming Items, Failures, and Anomalies

- 7.9.3.1 MAB/QAS or technicians shall mark nonconforming items, as specified in LMS-CP-5507.
- 7.9.3.2 MAB/QAS or technicians shall segregate nonconforming items, as specified in LMS-CP-5507.
- 7.9.3.3 If a reported nonconformance, failure, or anomaly, of an item, and/or software occurs, any flight project personnel shall discontinue operations in a manner that does not pose a hazard to personnel or equipment.
- 7.9.3.4 If the reported nonconformance, failure, or anomaly, of an item, and/or software poses a safety hazard to personnel or equipment, flight project personnel shall discontinue operations in a manner that does not pose an additional hazard to personnel or equipment.
- 7.9.3.5 Flight project personnel shall discontinue assembly or testing operations when an item, and/or software encounters a nonconformance, a failure, or an anomaly, until they receive an approved disposition of a NCR that is documented, as specified in 7.9.4.
- 7.9.3.6 Flight project personnel shall resume operations as directed by a final disposition of a NCR associated with a nonconformance, or failure, or anomaly.

7.9.4 Reporting of Nonconformance Reporting Items, Failures, and Anomalies

- 7.9.4.1 Any of the flight project personnel shall initiate a NCR by filling out Part A of a NCR, when they encounter a nonconformance, failure, or anomaly associated with any item and/or software, as defined in 7.9.1.3, 7.9.1.5, and 7.9.1.6, respectively.
- 7.9.4.2 If any of the flight project personnel initiates a NCR, as specified in 7.9.4.1, the initiator shall document all nonconformances, failures, or anomalies of items and/or software in part A of the LaRC Nonconformance Reporting (NCR) and Anomaly System.
- 7.9.4.3 Any of the flight project personnel shall not be required to process or document a NCR for a COTS item used as transportation GSE, when the type of nonconformance, failure, or anomaly is attributed to the following:
- a. General maintenance
 - b. Normal wear and tear issues
 - c. The disposition/fix maintains the “as-designed” configuration
- 7.9.4.4 Any of the flight project personnel shall bring paper copies of the NCR form to any work area that does not have computer access, when performing work in such areas. Note: A paper copy of a NCR form is available on the NCR website under the Help menu.
- 7.9.4.5 Any of the flight project personnel shall populate any paper copy of a NCR form, as described in 7.9.4.1, if required.
- 7.9.4.6 MAB/QAS shall establish the official record of the information contained on any paper copy of a NCR form, by inputting such information into the NCR reporting system.

7.9.5 Disposition of a Nonconforming Item, Failure, or Anomaly

- 7.9.5.1 Engineers shall complete Part B of the NCR.
- 7.9.5.2 In part B of the NCR, the cognizant engineer shall be the only person authorized to direct the following:
- a. Return a nonconforming item for completion of work to the provider of the item without MRB approval.
 - b. Return the nonconforming item for scrap without MRB approval.
 - c. Return the nonconforming item to supplier without MRB approval.
 - d. Initiate a detailed assessment of a nonconformance, or a failure, or an anomaly for disposition by the MRB, as appropriate.

- 7.9.5.3 The cognizant engineer shall judiciously balance the impact of cost and schedule on the project prior to returning items, as specified in 7.9.5.2(a) through 7.9.5.2(c).
- 7.9.5.4 The cognizant engineer shall provide a rationale for returning or requiring a detailed assessment, as specified in 7.9.5.2(a) through 7.9.5.2(d), in part B of the NCR.
- 7.9.5.5 If the cognizant engineer selects a disposition specified in 7.9.5.2(a) through 7.9.5.2(c), the cognizant engineer shall complete part D of the NCR.
- 7.9.5.6 If a detailed assessment is selected, as specified in 7.9.5.2(d), the cognizant engineer shall select the NCR disposition type in part C, which is either a Major or Minor Type, according to the definitions in 7.9.1.4(a) and 7.9.1.4(b), respectively.
- 7.9.5.7 If a Minor type is chosen, the cognizant engineer shall provide a rationale for selecting the Minor category in part C of the NCR.
- 7.9.5.8 MAB/QAS or the MAB SA engineer shall approve or disapprove the cognizant engineer's assessment, if the type of NCR designation is Minor.
- 7.9.5.9 If the cognizant engineer's Minor NCR designation is disapproved by MAB/QAS or the MAB SA engineer, as specified in 7.9.5.8, the PM or his/her designee shall resolve the conflict regarding the Minor designation.
- 7.9.5.10 The cognizant engineer shall determine if a Minor disposition requires an interim disposition based on the need for a further assessment of the nonconformance.
- 7.9.5.11 The cognizant engineer shall mark "Interim Disposition" in Part C of the NCR, if required by the assessment specified in 7.9.5.10.
- 7.9.5.12 The cognizant engineer shall provide an interim Minor NCR disposition in Part C of the NCR with detailed instructions for implementing the interim disposition activities.
- 7.9.5.13 Technicians and/or engineers shall perform the interim Minor disposition tasks.
- 7.9.5.14 MAB/QAS or the MAB SA engineer shall verify the interim Minor tasks, have been accomplished as required in 7.9.5.12.
- 7.9.5.15 The cognizant engineer shall provide a final disposition of a Minor interim nonconformance in Part C of the NCR, after the final assessment of a nonconformance has been accomplished.
- 7.9.5.16 If an interim disposition is not required, as specified in 7.9.5.10, the cognizant

- engineer shall provide a final NCR Minor disposition in part C of the NCR.
- 7.9.5.17 The cognizant engineer shall mark the Minor NCR disposition as “Final” after providing a NCR disposition, as specified in 7.9.5.15 or 7.9.5.16.
- 7.9.5.18 Technicians and/or engineers shall perform the work to implement the final Minor NCR disposition, if necessary.
- 7.9.5.19 Engineers shall complete Part D of the NCR form after completing Part C for the Minor NCR.
- 7.9.5.20 For Major dispositions, as determined in 7.9.5.6, the cognizant engineer shall determine if an interim disposition is required based on the need for a further assessment of the nonconformance, failure, or anomaly.
- 7.9.5.21 The cognizant engineer shall mark “Interim Disposition” in Part C of the NCR, if required by the assessment, as specified in 7.9.5.20.
- 7.9.5.22 The cognizant engineer shall provide an interim Major NCR disposition in Part C of the NCR with detailed instructions for implementing the interim Major disposition activities.
- 7.9.5.23 The MRB shall approve the Major interim disposition activities.
- 7.9.5.24 Technicians and/or engineers shall perform the interim Major disposition tasks.
- 7.9.5.25 MAB/QAS or the MAB SA engineer shall verify the interim Major tasks have been accomplished as required in 7.9.5.22.
- 7.9.5.26 The cognizant engineer shall provide a final disposition of a Major interim nonconformance, failure, or anomaly in Part C of the NCR, after the final assessment of a nonconformance has been accomplished.
- 7.9.5.27 If an interim disposition is not required, as specified in 7.9.5.20, the cognizant engineer shall provide a final NCR disposition in part C of the NCR.
- 7.9.5.28 The cognizant engineer shall mark the Major NCR disposition as “Final” after providing a NCR disposition, as specified in 7.9.5.26 or 7.9.5.27.
- 7.9.5.29 The cognizant engineer shall include the following in part C of the final Major NCR disposition:
- a. Rationale or technical justification for “use-as-is” dispositions as the basis of acceptance in the NCR.
 - b. Appropriate details of engineering analyses, as required, or as requested by MRB members.

- c. Detailed instructions for implementing the disposition activities, as appropriate.
- 7.9.5.30 The MRB shall review the final Major NCR disposition to ensure the disposition is compatible with the following requirements:
- a. Specified design
 - b. Performance
 - c. Interface
 - d. Reliability
 - e. Safety
- 7.9.5.31 The MRB shall judiciously balance the impact upon costs and schedules, when considering the compatibility of the requirements, as specified in 7.9.5.30.
- 7.9.5.32 The MRB shall require the appropriate details of engineering analyses, as appropriate, for inclusion in the NCR disposition.
- 7.9.5.33 The MRB shall evaluate whether a waiver is required for a nonconformance, failure, or anomaly, as specified in LMS-CP-5507 and LMS-CP-7151.
- 7.9.5.34 The MRB shall initiate a waiver requiring approval from the customer, if required by 7.9.5.33.
- 7.9.5.35 If the customer disapproves the waiver request, the PM shall negotiate with the customer to resolve the issue(s).
- 7.9.5.36 Engineers shall record the customer approval or disapproval from the waiver actions specified in 7.9.5.34 and 7.9.5.35 in the box titled, "Disposition Instructions/Rationale," of Part C of the NCR.
- 7.9.5.37 The MRB shall approve dispositions of Major nonconformances, failures, and anomalies, in Part C of the NCR.
- 7.9.5.38 The PM shall authorize an appropriate disposition, if a unanimous agreement cannot be reached by the MRB.
- 7.9.5.39 The designated MAB/QAS or the MAB SA engineer shall notify the Head of the MAB, if MAB/QAS or the MAB SA engineer does not concur with the PM's disposition.
- 7.9.5.40 Technicians and/or engineers shall perform the work to implement the final Major MRB disposition, if necessary.

7.9.5.41 Engineers shall complete Part D of the NCR form after completing Part C of the NCR for Major type NCRs.

7.9.6 Scrap

7.9.6.1 Technicians shall implement the requirements specified in 7.9.6.4, as applicable for all nonconforming parts and/or materials identified as scrap to ensure the following results:

- a. The parts are unusable for their original application.
- b. The parts are incapable of being reworked or camouflaged to provide the appearance of being serviceable.

7.9.6.2 Technicians shall mark parts and materials dispositioned to be scrapped prior to performing 7.9.6.4, by any of the following methods:

- a. Ink Marking
- b. Electrochemical etching
- c. Chemical etching
- d. Dot Peening
- e. Tagging
- f. Labeling
- g. Red paint

7.9.6.3 Technicians shall segregate scrap items after marking, as specified in 7.9.6.2, from conforming materials by storing them in a designated area until disposal.

7.9.6.4 Technicians shall render parts and/or materials designated to be scrapped as “scrap” by one or a combination of the following methods:

- a. Grinding
- b. Burning
- c. Removal of a major integral feature
- d. Permanent distortion of parts and materials
- e. Cutting a significant size hole with a cutting torch or saw
- f. Melting

- g. Sawing into many small pieces
- h. Removing manufacturer identification, part, lot, batch, and serial number
- i. Other methods, as appropriate

7.9.6.5 MAB/QAS shall witness the part(s) being rendered unusable.

7.9.6.6 Technicians shall place scrap parts and/or materials in suitable disposal containers for pickup by contractors, after implementing one of the disposal methods specified in 7.9.6.4.

7.9.6.7 MAB/QAS shall verify the scrap disposal was witnessed by signing on the verification portion of Part E on the NCR.

7.9.7 Documentation

7.9.7.1 MAB/QAS shall record any NCR numbers generated during the fabrication process in the appropriate FIOS, which is described in Section 7.6.3 of Section 7.6.

7.9.7.2 MAB/QAS shall attach an electronic file of any NCR involving a fabrication work order, LF 133, which is used for fabrication processes only, and specified in LMS-CP-5640.

7.9.7.3 MAB/QAS shall archive NCR records at the end of each project according to the project's archiving requirements.

7.9.7.4 Pursuant to 7.9.7.4, MAB/QAS shall either print paper copies of NCR records or electronically save NCR records from the NCR website, as required.

7.9.8 Verification and Closeout of NCRs

7.9.8.1 If applicable, the technician or engineer shall verify, by electronic signature in Part E of the NCR form that the final assembly, repair, or software revision was accomplished, as specified in 7.9.5.18 or 7.9.5.40.

7.9.8.2 To close out a NCR, MAB/QAS or the MAB SA engineer shall verify, by electronic signature in Part E of the NCR form, the completion of the following:

- a. Repair inspection, if applicable.
- b. Test or re-test witnessing, including software, if applicable.
- c. Updating of documentation, if required.

7.9.8.3 The MAB/QAS or MAB SA engineer shall verify closure of all NCRs by checking the "open" or "closed" status at the project NCR main menu in the NCR system.

7.9.9 The NCR Process for Contracts

- 7.9.9.1 If a contract requires a designated LaRC engineer, to have voting rights, as part of the contractor's NCR process for Major NCRs, then the LaRC engineer shall either approve or disapprove the contractor's NCR disposition.
- 7.9.9.2 The designated LaRC engineer shall approve or disapprove the contractor's NCR disposition, according to the Government's position, which is determined by a team of cognizant LaRC engineers.
- 7.9.9.3 At a minimum, the PM, the LaRC cognizant engineer, MAB/QAS or the MAB SA engineer, as well as the PAM shall comprise the team that formulates the Government's position of the contractor's NCR disposition.

7.10 Quality Status Stamps

7.10.1 General Information

- 7.10.1.1 This Section focuses on the set of requirements that ensures the QA requirements, which are contained throughout this document, are executed as required. More specifically, there is a need to document and/or verify the quality status at each QA task, e.g., inspections, witnessing, etc., associated with such flight article processes as assembly, testing, storage, shipping and handling. To accomplish this essential objective, MAB/QAS employs sets of Quality Status Stamps (QSS). The requirements that specify QSS issuance and control, QSS use and type and QSS stamping procedures are specified in Sections 7.10.2, 7.10.3, and 7.10.4, respectively.
- 7.10.1.2 QSS issuance and control provides accountability of who performed the QA tasks through identification of designated QA personnel by QSS number and the ability to trace the status of QSS sets that are issued. The requirements for this key QSS function are specified in Section 7.10.2.
- 7.10.1.3 For the purposes of this Section, "items" refers to flight and GSE hardware parts and/or devices, and the use of "technicians" is for those instances where technicians have been issued a QSS set to perform the actual QA functions, with the exception of the requirement specified in 7.10.4.4. In addition, "QA tasks," refer to such activities as inspections, or witnessing or other tasks, as specified in a FIOS or in the AI&T Plan and its associated test and assembly procedures.
- 7.10.1.4 Inappropriate and unauthorized use of stamps will lead to disciplinary action.

7.10.2 Issuance and Control

- 7.10.2.1 The Head of the MAB shall assign a MAB/QAS to be the Stamp Control Authority.
- 7.10.2.2 The Head of the MAB shall approve the issuance of QSS sets to technicians, as specified in 7.10.1.3, or the PAM, as appropriate.
- 7.10.2.3 The QSS Control Authority shall maintain a control system for the traceability of QSS sets by implementing the following requirements:
- a. Issue QSS sets using the Stamp Receipt section of the LF142.
 - b. Verify each of the stamps in a QSS set is legible when processing the LF 142.
 - c. Issue only one stamp of each design and size, which is referred to as a QSS set, and is defined in Section 10.3.1.
 - d. Establish a user log for each QSS set to record the names of the individuals who have been issued the QSS sets.
 - e. Maintain the user log for each issued QSS set.
 - f. Maintain an LF 142 for each issued QSS set.
 - g. Maintain an LF 450 for each issued QSS set.
 - h. Control the records of the documents, which are specified in 7.10.2.3(e) through 7.10.2.3(g), by locking them in an appropriate cabinet.
 - i. Perform a yearly inventory of all issued QSS sets using the LF 450.
 - j. Place an impression of each stamp of a QSS set that is assigned to each MAB/QAS or technician assignee on the LF 450 when performing the QSS yearly inventory.
 - k. Inspect each stamp impression on the LF 450 to assess the efficacy of each stamp.
 - l. Approve only stamps on the LF 450 for continued use that produce a clearly legible impression.
 - m. Verify all QSS records, as specified in 7.10.2.3(e) through 7.10.2.3(g), are accurate as a part of the yearly QSS set inventory.
 - n. Request the return of all QSS sets issued to personnel no longer performing a QA function.

- o. Record QSS sets that are returned using the return section of LF 142.
 - p. Only authorize the reissuance of a QSS set that has been reclaimed due to either the termination or transfer of personnel after a period of one year.
 - q. Dispose of a damaged QSS to prevent reuse or misuse.
 - r. Issue a replacement QSS for a QSS that needs to be exchanged due to damage, as determined in 7.10.2.7(a) or 7.10.2.3(k).
 - s. Issue a replacement QSS for a QSS that has become illegible due to extended use, as determined in 7.10.2.7(b) or 7.10.2.3(k).
 - t. Record the loss of a QSS.
 - u. Investigate circumstances of a lost QSS.
 - v. Record the results of the investigation for the lost QSS in the user log.
 - w. Update the user log, as specified in 7.10.2.3(v), as appropriate.
- 7.10.2.4 Technicians or the PAM, as specified in 7.10.2.2, or MAB/QAS shall use LF 142 for the following actions:
- a. Requesting receipt of a set of QSS.
 - b. Acknowledging receipt of a set of QSS.
 - c. Returning a set of QSS for disposition by the QSS Control Authority.
- 7.10.2.5 MAB/QAS, technicians or the PAM shall sign the LF 450 when requested by the Stamp Control Authority during performance of the Annual QSS Inventory.
- 7.10.2.6 MAB/QAS, technicians or the PAM shall provide stamp impressions on the LF 450 for the Annual Inventory of QSS, as specified in 7.10.2.3(i).
- 7.10.2.7 MAB/QAS, technicians or the PAM shall return their QSS to the QSS Control Authority in the following circumstances:
- a. A QSS is damaged.
 - b. A QSS has become illegible.
 - c. Technicians or the PAM, who were designated to perform a QA function, as specified in 7.10.2.2, are no longer performing the QA function.
 - d. If requested to do so by the QSS Stamp Control Authority.
 - e. The QSS assignee is terminated, transferred, or retires.

- 7.10.2.8 MAB/QAS, technicians or the PAM shall report a lost QSS to the QSS Control Authority.

7.10.3 Use of Stamp Types

- 7.10.3.1 Technicians or the PAM, as specified in 7.10.2.2, or MAB/QAS shall mark the quality status of items using the following stamps, as appropriate:
- a. Conformance Stamp: A triangular shaped stamp used to indicate that items satisfy requirements and conform to their prescribed criteria.
 - b. Nonconformance Stamp: A hexagonal shaped stamp used to indicate that items have been inspected and/or tested, but do not conform to their requirements.
 - c. Void Stamp: A “D” shaped stamp used to indicate that an inspection, a test, a procedure, or the accompanying documentation is void.

7.10.4 Quality Stamp Procedures

- 7.10.4.1 Technicians or the PAM, as specified in 7.10.2.2, or MAB/QAS shall use quality stamps, as specified in 7.10.4.2, to verify any QA step or task witnessed, and/or inspected as delineated in project documentation, e.g., fabrication work documents, logbook forms, assembly, disassembly and integration procedures, and test procedures.
- 7.10.4.2 MAB/QAS, technicians or the PAM shall take the following actions, as appropriate, based on the results of inspections or witnessing of a QA task:
- a. In the assembly history record, as specified in Section 7.12, or other documentation as appropriate, use ink for all written entries requiring a QSS for QA validation.
 - b. Apply a QSS to documentation upon completion of inspection or witnessing of a QA task, as specified in 7.10.4.2(e) through 7.10.4.2(p).
 - c. Apply only one stamp for each acceptance or rejection to the documentation.
 - d. Apply a handwritten date accompanying each stamped impression that establishes the date a stamped impression was performed.
 - e. Apply a “CONFORMANCE” stamp on each discrete entry, step, or other QA task, which is satisfactorily completed.
 - f. Apply a “NONCONFORMANCE” stamp on each discrete entry, step, or other QA task, when any condition is unsatisfactory or nonconforming.

- g. Document all “NONCONFORMANCE” stamped items in a NCR, as specified in Section 7.9.
 - h. When a “NONCONFORMANCE” stamp is used, the MAB/QAS or technician shall record the appropriate NCR number in the appropriate documentation after the NCR is generated.
 - i. Apply a “CONFORMANCE” stamp to the right of the “NONCONFORMANCE” stamp when the nonconforming condition has been corrected.
 - j. Apply a “VOID” stamp across the face of an erroneous impression to cancel a QSS impression made in error.
 - k. Apply a “CONFORMANCE” or “NONCONFORMANCE” stamp, as appropriate, to the right of the “VOID” stamp, when an error, as specified in 7.10.4.2(j), has been corrected.
 - l. Draw a single line through an error and enter the correct information, when an erroneous data entry has been made on an inspection record.
 - m. Apply a “CONFORMANCE” stamp next to the corrected value.
 - n. Apply the applicable stamp to the left side of the appropriate acceptance area in the test procedure to indicate the status of a partial inspection of an article or a test.
 - o. Apply the applicable stamp in the appropriate acceptance area in the test procedure after the final inspection has been completed.
 - p. Slightly overlap each QSS impression from left to right to indicate the sequence in which the stamping occurred without obscuring any impression, when multiple QSS impressions are required, as specified in 7.10.4.2(e) through 7.10.4.2(o).
- 7.10.4.3 MAB/QAS, technicians or the PAM shall apply the appropriate QSS, as specified in 7.10.4.2, to the LF 183, Hardware Identification Tag, attached to the item for “tagging” or the bag or container for “bagging and tagging” of articles, such as “O” rings, fasteners, connectors, packaging materials, electrical and electronic components, or optical components that are not individually marked per the requirements of Section 7.8.
- 7.10.4.4 Technicians shall not separate stamped containers or tags from items prior to installation.
- 7.10.4.5 MAB/QAS, technicians or the PAM shall use a “pull-down” menu to select the name of the QAS and their stamp number to electronically apply a QA Stamp in the appropriate step(s) within the Fabrication Work Management System Package, which is used for fabrication processes only, as specified in LMS-CP-5640.

7.11 Bonded Stores

7.11.1 General Information and Definitions

- 7.11.1.1 The purpose of Bonded Stores is to ensure the traceability, safety, reliability, and functionality of those items specified in 7.11.1.3.
- 7.11.1.2 The requirements associated with Bonded Storage are specified in LMS-CP-4892, Bonded Storage as well as in 7.11.1.4 and 7.11.1.5.
- 7.11.1.3 *Bonded Stores*: Bonded Stores are secure, controlled and environmentally compatible areas where materials, and hardware, used in assembling flight and GSE hardware are receipt inspected and closely controlled for accountability.
- 7.11.1.4 Engineers, technicians and PMs shall follow the Bonded Stores requirements, as specified in LMS-CP-4892.
- 7.11.1.5 The MAB/QAS shall audit project Bonded Stores using LF 191.

7.12 Logbooks

7.12.1 General Information

- 7.12.1.1 This Section specifies the requirements for using logbooks in the QA process when work is performed or data is captured associated with the assembly/integration, disassembly, testing as well as launch integration activities of flight hardware, and GSE. Logbooks provide a record of verification and traceability of essential QA tasks such as inspection and witnessing, etc. Equally important, logbooks also provide a record of the work history and configuration associated with such activities. This Section provides the requirements for the issuance, control of, and contents of logbooks throughout the life cycle of a project.
- 7.12.1.2 The requirements for the procedures for assembly/integration, and disassembly of flight hardware and associated GSE are specified in Chapter 13, whereas the requirements for the procedures for testing assembly/integration, and disassembly of flight hardware and associated GSE are specified in Chapter 14.
- 7.12.1.3 For the purposes of paragraph 7.12.1.4, the phrase “flight project personnel” has the same meaning, as specified in 7.1.1.4.
- 7.12.1.4 Flight project personnel shall write entries in logbooks with ink.

7.12.2 Issuance of Logbooks

- 7.12.2.1 Technicians and/or cognizant engineers shall request the appropriate

logbooks, as specified in 7.12.4.1, 7.12.5.1, 7.12.6.1 and 7.12.7.1, from the MAB/QAS.

- 7.12.2.2 MAB/QAS shall tailor the content of each logbook, as specified in 7.12.4.2, 7.12.5.2, 7.12.6.2, and 7.12.7.2, to correspond to the specific hardware.
- 7.12.2.3 MAB/QAS shall number each logbook, as specified in Section 7.12.3.
- 7.12.2.4 MAB/QAS shall issue the appropriate logbooks to technicians and/or engineers, as specified in 7.12.2.1.
- 7.12.2.5 The technicians and/or engineers shall populate all logbook forms.
- 7.12.2.6 Technicians, engineers, and/or MAB/QAS shall make entries in logbooks that, at a minimum, contain the following elements:
 - a. The date
 - b. The time
 - c. A description of event or activity
 - d. The name of the individual performing the activity
- 7.12.2.7 Technicians and/or engineers shall maintain custody of the logbooks, as specified in Sections 7.12.4 through 7.12.7.
- 7.12.2.8 The MAB/QAS shall use QSS to verify written entries on logbook forms, as specified in Section 7.10.
- 7.12.2.9 The MAB/QAS shall verify logbooks are maintained current by the technicians and/or engineers during performance of each QA task (e.g., witnessing assembly and testing).
- 7.12.2.10 MAB/QAS shall audit logbooks using LF 387, as requested by either the PAM or MAB Head.
- 7.12.2.11 The PAM shall archive LF 387 as specified in LMS-CP-8705.2.

7.12.3 Numbering System

- 7.12.3.1 MAB/QAS shall provide logbook numbers consisting of the following:
 - a. The first three letters of the project name
 - b. A sequential three-digit number beginning with "001"
 - c. A three-letter abbreviation denoting the type of logbook

7.12.3.2 The MAB/QAS shall incorporate a three-letter abbreviation in the logbook number, as specified in 7.12.3.1(c), according to the following nomenclature:

- a. COM: Component logbook
- b. SUB: Subsystem logbook
- c. SYS: System logbook
- d. GSE: GSE logbook

7.12.3.2.1 An example logbook number as, specified in 7.12.3.1 and 7.12.3.2, is given below:

HAL-001-COM.

7.12.3.3 MAB/QAS shall maintain a list of all logbooks issued using the numbering system template, as specified in 7.12.3.2.1, in a spreadsheet on the SMAO server, which is located here: <Z:\USERS\Logbooks>

7.12.3.4 MAB/QAS shall contact the SMAO administrative assistants for access to the SMAO/MAB documentation library server.

7.12.4 Component Logbook

7.12.4.1 Engineers and/or technicians shall use a component logbook when two or more parts are assembled after the fabrication process that will perform a distinctive function.

7.12.4.2 Engineers and/or technicians shall complete the following forms in the component logbook, as applicable:

- a. LF 132
- b. LF 138
- c. LF 154, kept up-to-date.
- d. LF 155, containing entries for all activities performed on the component including assembly, test, calibration, disassembly, etc.

7.12.4.3 Engineers and/or technicians shall include the following elements in the component logbook, as applicable:

- a. "As-Built" assembly procedures.
- b. "As-Run" test procedures.

- 7.12.4.4 Engineers and/or technicians shall co-locate the component logbooks with the hardware until the integration of the component into the next level of assembly.
- 7.12.4.5 After integration of the component into the next higher level of assembly, technicians shall store the component logbooks in a centrally accessible location until completion of the project.
- 7.12.5.6 After the completion of the project, engineers shall archive the component logbooks according to the project's Configuration Management (CM) or record archive requirements.
- 7.12.4.7 If the component is to be delivered to an external customer for use in assembly integration or launch integration, engineers shall implement the following:
 - a. Include a paper copy of all open NCRs, as defined in 7.9.8.3, with the component logbooks.
 - b. Deliver a copy of the component logbooks to the customer in the Acceptance Data Package, as specified in 7.17.3.1(q), if required by the customer.

7.12.5 Subsystem Logbook

- 7.12.5.1 Engineers and/or technicians shall use a subsystem logbook when components or parts are assembled to perform a major functioning entity identified as a subsystem by the project. (e.g., power, sensor, radar, etc.).
- 7.12.5.2 Engineers and/or technicians shall complete the following forms in the subsystem logbook, as applicable:
 - a. LF 132, entered as generated
 - b. LF 138
 - c. LF 144
 - d. LF 154, continued from the component logbook
 - e. LF 155, continued from the component logbook
- 7.12.5.3 Engineers and/or technicians shall include the following elements in the subsystem logbook, as applicable:
 - a. "As-Built" assembly procedures
 - b. "As-Run" test procedures

- 7.12.5.4 Engineers and/or technicians shall co-locate the subsystem logbooks with the hardware until integration of the subsystem into the next level of assembly.
- 7.12.5.5 After integration of the subsystem into the next higher level of assembly, technicians shall store the subsystem logbooks in a centrally accessible location until completion of the project.
- 7.12.5.6 After the completion of the project, engineers shall archive the subsystem logbooks according to the project's CM or record archive requirements.
- 7.12.5.7 If the subsystem is to be delivered to an external customer for use in assembly integration or launch integration, engineers shall implement the following:
 - a. Include a paper copy of all open NCRs, as defined in 7.9.8.3, with the subsystem logbooks.
 - b. Deliver a copy of the component logbooks to the customer in the Acceptance Data Package, as specified in 7.17.3.1(q), if required by the customer.

7.12.6 System Logbook

- 7.12.6.1 Engineers and/or technicians shall use a system logbook when the subsystems are integrated into a system, which provides a major function to the final assembly, such as thermal protection, propulsion, control, etc., and/or becomes the project's deliverable.
- 7.12.6.2 Engineers and/or technicians shall complete the following forms in the system logbook, as applicable:
 - a. LF 132, entered as generated
 - b. LF 138
 - c. LF 144
 - d. LF 154, continued from the subsystem logbook
 - e. LF 155, continued from the subsystem logbook
- 7.12.6.3 Engineers and/or technicians shall include the following elements in the system logbook, as applicable:
 - a. "As-Built" assembly procedures
 - b. "As-Run" test procedures

- 7.12.6.4 Engineers and/or technicians shall co-locate the system logbooks with the hardware until successful completion of the System Acceptance Review (SAR).
- 7.12.6.5 After a successful SAR, engineers shall archive the logbooks according to the project's CM or record archive requirements.
- 7.12.6.6 If the system is to be delivered to an external customer for use in assembly integration or launch integration, engineers shall implement the following:
 - a. Include a paper copy of all open NCRs, as specified in 7.9.8.3, with the system logbooks.
 - b. Deliver a copy of the component logbooks to the customer in the Acceptance Data Package, as specified in 7.17.3.1(q), if required by the customer.

7.12.7 GSE Logbook

- 7.12.7.1 Engineers and/or technicians shall use a GSE logbook(s) for the following:
 - a. When GSE is assembled
 - b. When GSE is tested
 - c. When GSE is required for flight hardware assembly/integration and/or disassembly procedures
 - d. When GSE is required for flight hardware testing procedures
 - e. When GSE is required for flight hardware launch integrations
- 7.12.7.2 Engineers and/or technicians shall complete the following forms in the GSE logbook(s), as applicable:
 - a. LF 132, entered as generated
 - b. LF 138
 - c. LF 144
 - d. LF 154
 - e. LF 155
- 7.12.7.3 Engineers and/or technicians shall include the following elements in the GSE logbook(s), as applicable:
 - a. "As-Built" assembly procedures
 - b. "As-Run" test procedures

- 7.12.7.4 Engineers and/or technicians shall co-locate the GSE logbooks with the GSE equipment throughout its use.
- 7.12.7.5 After a flight component, subsystem, or system has been completed, engineers and/or technicians shall store the GSE logbook, as required by 7.12.4.4 and 7.12.4.5, 7.12.5.4 and 7.12.5.5, and 7.12.6.4 and 7.12.6.5, as appropriate.
- 7.12.7.6 If the GSE is to be delivered to an external customer for use in assembly integration or launch integration, engineers shall implement the following:
- a. Include a paper copy of all open NCRs, as specified in 7.9.8.3, with the pertinent GSE logbooks.
 - b. Deliver a copy of the component logbooks to the customer in the Acceptance Data Package, as specified in 7.17.3.1(q), if required by the customer.

7.13 Assembly, Disassembly, and Integration of Flight Hardware

7.13.1 General Information

- 7.13.1.1 For the purposes of this Section, the term “hardware” includes both flight and GSE hardware, and the phrase “assembly, disassembly, and/or integration procedures” includes operational procedures associated with GSE aiding in the assembly, disassembly, and/or integration process, as applicable.
- 7.13.1.2 For the purposes of this Section, the requirements, as specified in Sections 7.13.2 and 7.13.3, including all appropriate engineering LMS documents, such as OPs, CPs and LPRs not cited herein, comprise the QA requirements for assembly, disassembly, and/or integration of hardware.
- 7.13.1.3 Engineers and technicians are assigned to each flight project for the purpose of planning and conducting assembly, disassembly, and/or integration activities under their organizational jurisdiction/discipline.
- 7.13.1.4 Assembly, disassembly, and/or integration of hardware is sometimes performed concurrent with the appropriate component, subassembly, and system testing. Engineers produce an Assembly, Integration and Test Plan that orchestrates these essential activities, which is described in Paragraph 7.14.1.4 and Section 7.14.2. Additional requirements for the testing of components, subassemblies, subsystems, and systems are specified in Section 7.14.
- 7.13.1.5 For the purposes of this entire Section 7.13, the phrase “flight project personnel” has the same meaning, as specified in 7.1.1.4.

7.13.2 Writing of Assembly, Disassembly and Integration Procedures

7.13.2.1 Engineers shall generate an assembly, disassembly, and/or integration procedure when the drawing does not provide adequate detail.

7.13.2.2 Engineers shall implement the following, pursuant to 7.13.2.1:

- a. Prepare the individual assembly, disassembly, and/or integration procedures, if required, and as specified in 7.13.2.1.
- b. Include procedural steps for hazardous tasks to protect personnel, hardware, and equipment.
- c. Approve the procedures.

7.13.2.3 Engineers shall include, but are not limited to, the following information in the assembly, disassembly, and/or integration procedures:

- a. A cover sheet.
- b. An approval signature page.
- c. The scope of the procedure, as specified in the Assembly, Integration and Test Plan.
- d. The technical intent or detailed objective(s) of the procedure, as specified in the Assembly, Integration and Test Plan.
- e. A list of personnel required to perform the procedure.
- f. A description of each hardware item.
- g. The identification of a hardware item, which is marked, as specified in Section 7.8.
- h. The facility environmental requirements, e.g., cleanliness category, etc., as specified in Section 7.16.
- i. The required reference documents, e.g., specifications, drawings, layouts, schematics, etc.
- j. A hardware configuration list.
- k. The video and/or photographic requirements.
- l. A list of required equipment.
- m. The sequential detailed steps describing the task to be performed with signature and date line to be completed by the individual performing task.

- n. All required inspection/verification steps, as specified in the Assembly, Integration and Test Plan.
- o. A determination of whether a step is hazardous.
- p. A warning or caution note that precedes each hazardous task.
- q. A warning or caution note, as specified in 7.13.2.3(p), which is easily distinguishable from the other text.

7.13.2.4 The PAM shall verify each procedure to determine:

- a. The elements identified in 7.13.2.3 are included in the procedure.
- b. The sequential detailed steps result in meeting the intended objective(s) of the procedure.
- c. Whether or not the procedural steps associated with assembly, disassembly, and/or integration are hazardous to either personnel, hardware, including associated equipment.
- d. If procedures are found to be hazardous, as specified in 7.13.2.4(c), a proper safety review, as specified in 7.13.2.6, is possible.
- e. If procedures are found to be hazardous, as specified in 7.13.2.4(c), the proper signatures are obtained, as specified in 7.13.2.7.
- f. That procedures or procedural steps that are hazardous include appropriate hazard mitigations.
- g. The appropriate formal and informal lessons learned have been included, prior to the procedure being approved.
- h. The inspection requirements, as determined in 7.1.2.8, are included.

7.13.2.5 The PAM shall appoint an appropriate designated safety person to approve hazardous tasks, as determined in 7.13.2.4(c), if required.

7.13.2.6 The designated safety person and/or engineers shall revise all hazardous procedural steps identified in 7.13.2.4(c), as necessary, to ensure the procedures contain the necessary steps to mitigate the hazard to personnel, hardware, or equipment, prior to approval.

7.13.2.7 The LaRC Safety Manager, or their designee shall approve a procedure that contains hazardous steps, as specified in 7.2.4.2, by signing the procedure signature page, delineated in 7.13.2.3(b).

7.13.2.8 The PAM shall approve all assembly, disassembly, and/or integration procedures, including any procedures containing hazardous steps.

- 7.13.2.9 Engineers shall generate red-line changes in assembly, disassembly, and/or integration procedures, as required.
- 7.13.2.10 Engineers shall approve any red-line changes to assembly, disassembly, and/or integration procedures by consecutively initialing and dating each red-line of each procedure affected.
- 7.13.2.11 The MAB/QAS shall approve any red-line changes to assembly, disassembly, and/or integration procedures only for changes to non-hazardous parts of the procedure by consecutively initialing and dating each red-line of each affected procedure, after approval by an engineer, as specified in 7.13.2.10.
- 7.13.2.11.1 The PAM shall approve any red-line changes to assembly, disassembly, and/or integration procedures by consecutively initialing and dating each red-line of the non-hazardous parts of the procedure affected in lieu of the MAB/QAS, if the MAB/QAS is unavailable.
- 7.13.2.12 The MAB/QAS shall contact the PAM for a review of any red-line changes that involve hazardous tasks in a procedure or if the MAB/QAS suspects or is concerned the changes may be introducing new hazards to personnel, hardware, or equipment.
- 7.13.2.13 When notified, as specified in 7.13.2.12, the PAM shall assess the red-line changes to any assembly, disassembly, and/or integration procedure in order to:
- a. Determine how the red-line changes might impact previously identified hazards.
 - b. Determine if the red-line changes have introduced new hazards.
 - c. Propose mitigation steps for hazards, as identified in 7.13.2.13(a) and 7.13.2.13(b), if required.
- 7.13.2.14 Engineers shall resolve mitigation steps proposed by the PAM, as specified in 7.13.2.13(c).
- 7.13.2.15 The PAM shall consecutively initial and date each red-line for changes to the following:
- a. Hazardous steps.
 - b. New red-lined additions containing hazardous steps.
 - c. Steps associated with a MAB/QAS concern, as specified in 7.13.2.12, which have been determined to introduce no hazard.

- 7.13.2.16 The LaRC Safety Manager, or their designee shall approve a red-lined hazardous procedure, as determined in in 7.13.2.3(o), 7.13.2.4(c) or 7.13.2.13, by initialing the red-line changes.
- 7.13.2.17 Engineers shall generate blue-line changes in an assembly, disassembly, and/or integration procedure, when the following criteria are met:
- The change is not required to be included in future revisions of the procedure.
 - The project PAP allows for use of blue-lines.
- 7.13.2.18 MAB/QAS, the PAM, engineers, and the LaRC Safety Manager or their designee shall approve any blue-line changes using the same approval process as red-line changes, which is specified in 7.13.2.9 through 7.13.2.16.
- 7.13.2.19 Engineers shall initiate a change(s) to assembly, disassembly, and/or integration procedure(s), other than red-lines, by implementing the following:
- Revising the procedure according to the project configuration management plan requirements.
 - Revising the procedure following the applicable requirements, as specified in 7.13.2.2 through 7.13.2.8.
- 7.13.2.20 After the engineer initiates a change(s) to assembly, disassembly, and/or integration procedure(s), as specified in 7.13.2.19, the PAM, engineers, the designated safety person, and the LaRC Safety Manager shall implement the requirements specified in 7.13.2.4 through 7.13.2.8, as appropriate.

7.13.3 Implementation of Assembly and Integration Work

- 7.13.3.1 The PM shall provide overall personnel coordination, when more than one organization is involved in the assembly, disassembly, and/or integration of hardware.
- 7.13.3.2 Engineers and technicians shall only use measuring equipment in current calibration for assembly, disassembly, and/or integration (i.e., torque wrenches, voltmeters, etc.), as specified in Section 7.4.
- 7.13.3.3 Technicians shall visibly affix evidence of current calibration to the measurement equipment, as specified in Section 7.4.
- 7.13.3.4 Technicians shall only use certified GSE (i.e., slings, hoists, tables, carts, etc.), as specified in LPR 1740.2 for the following critical tasks:
- Handling
 - Lifting

- 7.13.3.5 MAB/QAS shall issue project logbooks for assembly, disassembly, and/or integration of all hardware, as specified in Section 7.12.
- 7.13.3.6 Technicians shall maintain project logbooks during assembly, disassembly, and/or integration of all hardware, as specified in Section 7.12.
- 7.13.3.7 Technicians shall assemble or disassemble all hardware using approved drawings and/or procedures.
- 7.13.3.8 The MAB/QAS shall verify, by witnessing the implementation of assembly, disassembly, and/or integration operations to ensure the following essential QA elements are met:
 - a. The implementation used the correct drawings.
 - b. The implementation was accomplished according to the drawings.
- 7.13.3.9 MAB/QAS shall verify, by quality stamping, as specified in Section 7.10, assembly, disassembly, and/or integration procedure steps requiring inspection or witnessing.
- 7.13.3.10 MAB/QAS shall verify the calibration of required measuring equipment.
- 7.13.3.11 MAB/QAS shall verify certification of handling and lifting GSE.
- 7.13.3.12 MAB/QAS shall verify safety of hardware and personnel, as specified in 7.2.3.3 and 7.2.3.4, during assembly, disassembly, and/or integration procedures.
- 7.13.3.13 Flight project personnel shall discontinue the affected assembly, disassembly, and/or integration procedure, or operation in an orderly manner, when any of the following incidents occur:
 - a. A nonconformance, as defined in 7.9.1.3, is encountered that poses a safety hazard to personnel, hardware, or equipment.
 - b. A failure, as defined in 7.9.1.5, is encountered that poses a safety hazard to personnel, hardware, or equipment.
 - c. A nonconformance is encountered that forces the procedure or operation to stop, until the nonconformance can be addressed.
 - d. A failure is encountered that forces the procedure or operation to stop, until the failure can be addressed.
- 7.13.3.14 Flight project personnel shall initiate a NCR, as specified in Section 7.9, for any nonconformance or failure.
- 7.13.3.15 After the closeout of any NCR, as specified in Section 7.9, which is initiated

as a result of any nonconformance or failure, flight project personnel shall use approved documented assembly, disassembly, and/or integration hardware procedures for resumption of a discontinued assembly, disassembly, and/or integration procedure or operation, if a procedure was required, as specified in 7.13.2.1.

7.14 Testing of Flight Hardware

7.14.1 General Information

- 7.14.1.1 For the purposes of this section, the term “hardware” includes both flight and GSE hardware.
- 7.14.1.2 For the purposes of this Section, the requirements, as specified in Paragraph 7.14.1.5, as well as Sections 7.14.2 through 7.14.5, including all appropriate engineering LMS documents, such as OPs, CPs and LPRs not cited herein, comprise the QA requirements for the testing of hardware.
- 7.14.1.3 Engineers and technicians are assigned to each flight project for the purpose of planning, scheduling, and conducting testing activities under their organizational jurisdiction/discipline.
- 7.14.1.4 The assembly, disassembly, and/or integration of hardware are sometimes accomplished concurrent with the appropriate component, subassembly, and system testing. Engineers produce an Assembly, Integration and Test Plan for each project that provides the work flow for these essential activities. The purpose of the Assembly, Integration and Test Plan is to orchestrate the tasks of assembly, disassembly, and/or integration of hardware with the appropriate intermediate functional and environmental testing of components and/or subassemblies until system functionality has been established by a successful end-to-end testing of the system, if required. The top level requirements for the Assembly, Integration and Test Plan are specified in Section 7.14.2, whereas the requirements for assembly, disassembly, and/or integration of hardware are specified in Section 7.13.
- 7.14.1.5 For the purposes of this entire Section 7.14, the phrase “flight project personnel” has the same meaning as specified in 7.1.1.4.

7.14.2 The Assembly, Integration and Test (AI&T) Plan

- 7.14.2.1 Engineers shall generate an AI&T Plan for each project for the purposes specified in 7.14.1.4.
- 7.14.2.2 Engineers shall include the following elements in the project’s AI&T Plan:
 - a. Scope
 - b. Technical intent
 - c. Success criteria.

- 7.14.2.3 Engineers shall include in the AI&T Plan all requirements necessary to accomplish the testing and assembly, disassembly, and/or integration of the following project deliverables, as appropriate:
- a. Component(s)
 - b. Subsystem(s)
 - c. System
 - d. Payload
 - e. GSE
 - f. Software
- 7.14.2.4 Engineers shall include, but are not limited to, the following elements in the AI&T Plan for each test:
- a. Overall test objectives
 - b. Overall test requirements
 - c. General testing rules
 - d. Test sequence flow diagram
 - e. Summary matrix, which includes an indented list of test items versus the type of test in each category
 - f. Description of test facilities
 - g. Description of major support equipment
 - h. Disposition of test data
 - i. list of QA responsibilities, e.g., inspections, witnessing, verification, etc.
- 7.14.2.5 Engineers shall also include in the AI&T Plan the identification of the organizations responsible for the following functions for each test:
- a. The development of each test plan
 - b. The implementation of each test plan
 - c. The approval of each test plan
 - d. The specifications associated with all hardware, and/or electrical components of each test plan
 - e. The procedures, as specified in each test plan

- 7.14.2.6 Engineers shall submit the AI&T Plan to the PAM for approval.
- 7.14.2.7 The PAM shall verify the AI&T Plan test requirements, as specified in 7.14.2.4 and 7.14.2.5, have been included.
- 7.14.2.8 The PAM or MAB Head shall negotiate with engineers any requirements deficiencies identified during the performance of 7.14.2.7.
- 7.14.2.9 The PAM shall approve the AI&T Plan after verifying the AI&T Plan test requirements, as specified in 7.14.2.7 or 7.14.2.8, as appropriate.

7.14.3 Writing of Test Procedures

- 7.14.3.1 Engineers shall prepare the individual test procedures, which are specified in the AI&T Plan.
- 7.14.3.2 Engineers shall verify the degree of detail in each test procedure is sufficient to clearly convey the information needed for the performance of all tasks.
- 7.14.3.3 Pursuant to 7.14.3.2, engineers shall include in each test procedure the following minimum set of elements:
 - a. A cover sheet that includes the title, date, and test number.
 - b. An approval signature page with positions as determined by the project configuration management plan.
 - c. The telephone numbers of designated personnel to be contacted in an emergency.
 - d. A list of personnel required to accomplish the test.
 - e. The detailed test objectives.
 - f. The test hardware item description.
 - g. The test hardware item identification.
 - h. The expected results with pass/fail criteria.
 - i. The data measurement requirements.
 - j. The recording requirements.
 - k. The analysis requirements.
 - l. The facility environmental requirements, including cleanliness category, as specified in Section 7.16.

- m. The facility power requirements.
 - n. Other facility requirements, as required.
 - o. A list of the required reference documents, e.g., specifications, drawings, layouts, schematics, etc.
 - p. Other documents, as required.
 - q. A hardware configuration checklist.
 - r. A software configuration checklist.
 - s. The video and/or photographic requirements.
 - t. A list of required equipment, such as, special purpose test equipment with or without simulator software, which includes provisions for recording serial numbers, calibration due dates, and software version numbers.
 - u. A set of sequential detailed steps describing the task to be performed with the date of the signature of the individual performing the completed task (e.g., setup of special equipment, entry of parameters into software tables, and preliminary calibrations and operational checks).
 - v. A set of detailed sequential steps for all identified emergency “shut-down” conditions.
 - w. The names of people to be contacted in case of a failure, nonconformance, anomaly, and/or an emergency.
 - x. A determination of whether a step is hazardous.
 - y. A warning or caution note that precedes each hazardous step.
 - z. A warning or caution note, as specified in 7.13.2.3(y), which is easily distinguishable from the other text.
- 7.14.3.4 For tasks requiring manual recording of data, the test engineer shall include a formatted table or chart that contains the following test parameters:
- a. The expected values adjacent to the data being recorded.
 - b. The allowable tolerances adjacent to the data being recorded.
- 7.14.3.5 The PAM shall verify each test procedure contains the following essential PA requirements:
- a. The test procedure elements identified in 7.14.3.3 and 7.14.3.4 are included, as required in the test procedure.

- b. The sequential detailed steps result in meeting the intended objective(s) of the test procedure.
 - c. Whether or not the procedural steps associated with testing during assembly, disassembly, and/or integration are hazardous to either personnel, hardware, including associated equipment.
 - d. If the procedural steps are found to be hazardous, as specified in 7.14.3.5(c), a proper safety review, as specified in 7.14.3.7, is possible.
 - e. If procedures are found to be hazardous, as specified in 7.14.3.5(c), the proper signatures are obtained, as specified in 7.14.3.8.
 - f. That procedures or procedural steps that are hazardous include appropriate hazard mitigations.
 - g. The appropriate formal and informal lessons learned have been included, prior to the procedure being approved.
 - h. Applicable inspection requirements for the testing, as determined in 7.1.2.8, are included.
- 7.14.3.6 The PAM shall appoint an appropriate designated safety person to approve hazardous tasks, as determined in 7.14.3.5(c), if required.
- 7.14.3.7 The designated safety person and/or engineer shall revise all hazardous procedural steps identified in 7.14.3.5(c), as necessary, to ensure the procedures contain the necessary steps to mitigate the hazard to personnel, hardware, or equipment, prior to approval.
- 7.14.3.8 The LaRC Safety Manager or their designee shall approve hazardous operating procedures, as specified in 7.2.4.2, by signing a signature page, as specified in 7.14.3.3(b).
- 7.14.3.9 The PAM shall approve all test procedures prior to the test, including any procedures containing hazardous steps.
- 7.14.3.10 The test engineer shall generate red-line changes to approved test procedures, as required.
- 7.14.3.11 Engineers shall approve any red-line changes to test procedures by consecutively initialing and dating each red-line of each procedure affected.
- 7.14.3.12 The MAB/QAS shall approve any red-line changes to test procedures only for changes to non-hazardous parts of the procedure by consecutively initialing and dating each red-line of each affected procedure after approval by the engineer, as specified in 7.14.3.11.

- 7.14.3.12.1 The PAM shall approve any red-line changes to test procedures by consecutively initialing and dating each red-line of the non-hazardous parts of the procedure affected, in lieu of the MAB/QAS, if the MAB/QAS is unavailable.
- 7.14.3.13 The MAB/QAS shall contact the PAM for a review of any red-line changes that involve hazardous tasks in a test procedure or if the MAB/QAS suspects or is concerned the changes may be introducing new hazards to personnel, hardware, or equipment.
- 7.14.3.14 When notified, as specified in 7.14.3.13, the PAM shall assess the red-line changes to any test procedure in order to:
- a. Determine how the red-line changes might impact previously identified hazards.
 - b. Determine if the red-line changes have introduced new hazards.
 - c. Propose mitigation steps for hazards, as identified in 7.14.3.14(a) and 7.14.3.14(b), if required.
- 7.14.3.15 Engineers shall resolve any mitigation steps proposed by the PAM, as specified in 7.14.3.14(c).
- 7.14.3.16 The PAM shall consecutively initial and date each red-line for changes to the following:
- a. Hazardous steps.
 - b. New red-lined additions containing hazardous steps.
 - c. If the MAB/QAS concern, as specified in 7.14.3.13, introduces no hazard.
- 7.14.3.17 The LaRC Safety Manager or their designee shall approve a red-lined hazardous test step, as specified in in 7.14.3.3(v), 7.14.3.5(c) or 7.14.3.14, by initialing the red-line changes.
- 7.14.3.18 Engineers shall generate blue-line changes in a test procedure, when the following criteria are met:
- a. The change is not required to be included in future revisions of the procedure.
 - b. The project PAP allows for the use of blue-lines.
- 7.14.3.19 MAB/QAS, the PAM, engineers, and the LaRC Safety Manager, or their designee shall approve any blue-line changes using the same approval

process as red-line changes, which are specified in 7.14.3.10 through 7.14.3.17, as appropriate.

- 7.14.3.20 Engineers shall initiate a change(s) to a test procedure(s), other than red-lines, by implementing the following:
- a. Revising the test procedure(s) according to the project configuration management plan requirements.
 - b. Revising the test procedure(s), following the applicable requirements, as specified in 7.14.3.2 through 7.14.3.9.
- 7.14.2.21 After engineers initiate a change(s) to a test(s) procedure, as specified in 7.14.2.20, the PAM, engineers, the designated safety person, and the LaRC Safety Manager shall implement the requirements specified in 7.14.2.5 through 7.14.2.9, as appropriate.

7.14.4 Implementation of Testing of Hardware

- 7.14.4.1 The PM shall provide overall personnel coordination when more than one organization is involved in the testing of hardware.
- 7.14.4.2 Engineers and technicians shall only use measuring equipment in current calibration for testing (i.e., thermocouple, voltmeters, etc.), as specified in Section 7.4.
- 7.14.4.3 Engineers shall verify all software used for test purposes is in a known and controlled configuration.
- 7.14.4.4 Technicians shall only use certified GSE (i.e., tables, carts, slings, hoists), as specified in LPR 1740.2, for the following critical tasks:
- a. Handling
 - b. Lifting
- 7.14.4.5 Technicians shall visibly affix evidence of current calibration to the measurement equipment, as specified in Section 7.4.
- 7.14.4.6 MAB/QAS shall issue project logbooks for testing of all hardware, as specified in Section 7.12.
- 7.14.4.7 Technicians shall maintain project logbooks, initiated for testing operations, as specified in Section 7.12.
- 7.14.4.8 The MAB/QAS shall be present during all inspection activities identified in the AI&T Plan during each test.

- 7.14.4.9 MAB/QAS shall verify compliance with test procedures by participating in test operations to monitor and/or witness each step, as required.
- 7.14.4.10 Engineers and technicians shall conduct functional testing of hardware for the purposes of flight acceptance in accordance with approved written test procedures, as specified in the AI&T Plan.
- 7.14.4.11 MAB/QAS shall verify handling and lifting GSE used in testing of hardware is certified.
- 7.14.4.12 MAB/QAS shall verify current calibration of equipment used in testing of hardware.
- 7.14.4.13 MAB/QAS shall quality stamp tasks requiring inspection, as specified in Section 7.10.
- 7.14.4.14 MAB/QAS shall quality stamp tasks requiring verification, as specified in Section 7.10.
- 7.14.4.15 Flight project personnel shall discontinue the affected test procedure in an orderly manner, when any of the following incidents occur:
 - a. A nonconformance, as defined in 7.9.1.3, is encountered that poses a safety hazard to personnel, hardware, or equipment.
 - b. A failure, as defined in 7.9.1.5, is encountered that poses a safety hazard to personnel, hardware, or equipment.
 - c. An anomaly, as defined in 7.9.1.6, is encountered that poses a safety hazard to personnel, hardware, or equipment.
 - d. A nonconformance is encountered that forces the test procedure to stop, until the nonconformance can be addressed.
 - e. A failure is encountered that forces the test procedure to stop, until the failure can be addressed.
 - f. An anomaly is encountered that forces the test procedure to stop, until the anomaly can be addressed.
- 7.14.4.16 Flight project personnel shall initiate a NCR, as specified in Section 7.9, for any nonconformance, failure or test anomaly.
- 7.14.4.17 After the closeout of any NCR, as specified in Section 7.9, which is initiated as a result of a nonconformance, failure or test anomaly, flight project personnel shall use approved documented testing procedures for resumption of a discontinued test procedure.

7.14.5 Reporting of Testing of Flight Test Results

- 7.14.5.1 The test engineer shall prepare a copy of a Quick-Look Test Report (QLTR), after the completion of each test.
- 7.14.5.2 The test engineer shall include in the QLTR the following minimum set of elements:
 - a. The test objectives
 - b. A summary of the test results
 - c. Any assigned open issues with dates of expected resolution
 - d. The “as-run” test procedure, including failed and/or aborted tests
- 7.14.5.3 The test engineer shall verify the test objectives have been satisfied.
- 7.14.5.4 The test engineer shall prepare a Final Test Report (FTR), after it is determined the test objectives have been satisfied.
- 7.14.5.5 The test engineer shall include in the FTR the following minimum set of elements:
 - a. A detailed discussion that focuses on the degree to which objectives were satisfied.
 - b. A detailed discussion that focuses on how well the mathematical models were validated, if applicable.
 - c. A chronological listing of the significant activities and related events that occurred during the performance of the test.
 - d. A detailed discussions of any procedural changes.
 - e. A detailed discussions of any failures.
 - f. The data generated by the test.
 - g. The status for the performance data.
 - h. The reporting plans for the performance data.
 - i. The post-test status of the test article.
 - j. Any changes to the test article during test.
 - k. A list of NCRs.

- I. A list of authorized activities (i.e., troubleshooting) not originally planned, with approved procedures.
 - m. A copy of the "as-run" test procedure.
- 7.14.5.6 The test engineer shall forward the completed FTR to the PM.

7.15 Protection Against Electrostatic Discharge (ESD)

7.15.1 General Information and Definitions

- 7.15.1.1 The requirements for protecting devices against damage from ESD are specified in LPR 8739.21.
- 7.15.1.2 The requirements specified in 7.15.1.8 through 7.15.1.12, as well as those specified in Sections 7.15.2 through 7.15.5, are either a supplement to or an enhancement to the requirements specified in LPR 8739.21.
- 7.15.1.3 The definitions of both a class MBM 1A and a class 0 ESD Protected Area (EPA), which are discussed in 7.15.3.1 and 7.15.4.4, respectively, are specified in LPR 8739.21.
- 7.15.1.4 *Electrostatic discharge (ESD)*: Electrostatic discharge (ESD) is defined as the transfer of an electrostatic charge (static electricity) between two bodies electrically charged at different potentials, caused by direct contact or induced by an electrostatic field. Certain electrical and electronic parts (i.e., microelectronic and semiconductor devices, thick and thin film resistors, chips and hybrid devices, piezoelectric crystals, etc.) are sensitive to the damaging effects of ESD. This damage can manifest itself immediately as a catastrophic failure, or in the future as a latent defect. Assemblies and equipment containing these parts are also susceptible to damage when an ESD event occurs at their terminals or when they are exposed to electrostatic fields.
- 7.15.1.5 *ESD Sensitive (ESDS) devices*: For the purposes of this section, ESD Sensitive (ESDS) devices refer to electrical and electronic parts, assemblies, and equipment sensitive to ESD voltages of 8,000 volts or less.
- 7.15.1.6 *Life cycle of ESDS devices*: For the purposes of this section, the life cycle of ESDS devices consists of the following events:
 - a. Handling
 - b. Packaging
 - c. Inspection
 - d. Shipping

- f. Assembly
 - g. Testing
 - h. Installation
 - i. Maintenance
 - j. Storage
- 7.15.1.7 For the purposes of this entire Section 7.15, the phrase “flight project personnel” has the same meaning, as specified in 7.1.1.4.
- 7.15.1.8 Flight project personnel that may be required to design, handle, ship, and/or transport ESDS devices shall comply with the requirements, as specified in 7.15.1.9 through 7.15.1.11 and 7.15.3.1(a).
- 7.15.1.9 Flight project personnel shall be trained in ESD precautionary measures, as specified in LPR 8739.21.
- 7.15.1.10 Flight project personnel shall be certified in ESD precautionary measures, as specified in LPR 8739.21.
- 7.15.1.11 Flight project personnel shall retain a copy of their certification in ESD, as specified in LPR 8739.21.
- 7.15.1.12 The MAB ESD Program Manager and the PM shall concur in the approval of any deviation of the ESD requirements contained in the following, as appropriate:
- a. LPR 8739.21
 - b. Sections 7.15.2 through 7.15.4 of this section
- 7.15.2 Design of ESDS Devices**
- 7.15.2.1 Engineers shall design ESDS devices, as specified in LPR 8739.21.
- 7.15.2.2 Engineers shall designate the following flight hardware or devices that are sensitive to ESD voltages of 8,000 volts or less as ESDS:
- a. Electrical and electronic parts
 - b. Assemblies
 - c. Equipment

- 7.15.2.3 Engineers shall identify all ESDS devices on the following:
- a. Drawings
 - b. Parts lists
 - c. Purchase Requests
- 7.15.2.4 Engineers shall design electrical and/or electronic circuits for the protection against ESD.
- 7.15.2.5 Engineers shall use design techniques that reduce the susceptibility of ESDS devices to ESD.
- 7.15.3 ESD Protected Areas**
- 7.15.3.1 Technicians shall incorporate the following minimum items in a typical work station that is designated as a class HBM 1A protected area:
- a. Personnel grounding wrist strap
 - b. ESD protective work surface whose resistivity is equivalent to the dissipative range from 10⁶ ohms to 10⁹ ohms
 - c. Humidity control, as specified in LPR 8739.21
 - d. ESD caution signs, as specified in LPR 8739.21
 - e. Records of all inspections
 - f. Records of all wrist strap checks
 - g. Records of all humidity readings
 - h. Records of any other documentation, as specified in LPR 8739.21
- 7.15.3.2 Flight project personnel shall not permit materials that are prime generators of ESD (i.e., common plastics, such as polyethylene, polystyrene foam, polyurethane, vinyl, foam, synthetic textiles, fiberglass, glass, rubber, etc.) in an EPA.
- 7.15.3.3 Personnel other than flight project personnel, who enter an EPA within 1 meter of an ESDS device shall use a personnel grounding wrist strap.
- 7.15.3.4 Flight project personnel shall enforce the requirement specified in 7.15.3.3.
- 7.15.3.5 PMs shall determine training requirements for project personnel or others that enter EPAs but do not work on the ESD hardware.

7.15.4 Handling of ESDS Devices

- 7.15.4.1 Flight project personnel shall Handle ESDS devices, as specified in LPR 8739.21.
- 7.15.4.2 Flight project personnel shall take precautions to prevent damage from ESD throughout the life cycle of ESDS devices, by implementing the following requirements, as appropriate:
 - a. Sections 7.15.2 and 7.15.3.
 - b. Paragraph 7.15.4.3.
- 7.15.4.3 Flight project personnel shall implement the following requirements:
 - a. Handle all ESDS devices only in an EPA.
 - b. Wear ESD garments while within an EPA.
 - c. Wear a conductive wrist strap, tied to the EPA's Common Point Ground (CPG), both prior to and while handling any ESDS device.
 - d. Be fully ESD safe, as specified in 7.15.3.2 (b) and 7.15.3.2 (c), prior to removing ESDS devices from anti-static material.
 - e. Place ESDS devices on an anti-static work surface after removing such ESDS devices from their anti-static packaging material.
- 7.15.4.4 Technicians shall follow the requirements in LPR-8739.21 when involved in the following tasks within a Class 0 EPA:
 - a. Operating tools
 - b. Operating equipment
- 7.15.4.5 For the proper storage and transportation of ESDS, technicians shall implement the following requirements:
 - a. Store all ESDS devices in anti-static material, preferably with the exposed leads at a common potential.
 - b. Transport all ESDS devices in anti-static material, preferably with the exposed leads at a common potential.

7.15.5 ESD Verification, Audits and Inspection

- 7.15.5.1 Engineers or technicians designated as ESD Program Monitors shall verify the following requirements are complied with, as appropriate:

- a. LPR 8739.21
 - b. Sections 7.15.2, 7.15.3 and 7.15.4.
- 7.15.5.2 Engineers or technicians designated as ESD Program Monitors shall verify personnel are properly certified, as specified in 7.15.1.10.
- 7.15.5.3 The MAB/QAS shall use diagnostic equipment to verify personnel are properly grounded, when ESDS devices are removed from their protective packaging during payload build-up.
- 7.15.5.4 The MAB/QAS shall use diagnostic equipment to verify flight products are properly grounded when ESDS devices are removed from their protective packaging during payload build-up.
- 7.15.5.5 MAB/QAS shall verify personnel are certified, as specified in 7.15.1.10.
- 7.15.5.6 The MAB EDS Program Manager shall perform inspections, as appropriate, to ensure the proper implementation of the requirements specified in LPR 8739.21
- 7.15.5.7 The MAB EDS Program Manager shall perform audit assessments of either engineers or technician ESD Program Monitors, as appropriate, to ensure the proper implementation of the requirements specified in LPR 8739.21.

7.16 Contamination Control

7.16.1 General Information and Definitions

- 7.16.1.1 Contamination control consists of controlling two aspects of the fabrication, assembly, disassembly, integration, and testing of flight hardware and its associated GSE.
- a. The first aspect is the control of Foreign Objects to prevent damage to aerospace flight hardware and/or aerospace vehicles.
 - b. The second aspect is establishing the requirements for the overall cleanliness levels specified for flight hardware and its associated GSE, which are contained in the project's Contamination Control Plan (CCP). The requirements that are contained in a project's CCP are developed by the project based on the requirements specified in NASA-STD-6016 and determine the class of clean room(s) required throughout the project's life cycle.
- 7.16.1.1.1 Contamination Control is primarily focused on the requirements of the Center's Foreign Object Damage Prevention Program requirements, as applicable to flight hardware and its associated GSE, which are specified in Section 7.16.2 and for the three LaRC classes of clean rooms, which are specified in Sections 7.16.4 through 7.16.6.

- 7.16.1.2 The purpose of the Center's FOD Prevention Program is to prevent injury to personnel and/or prevent damage to critical hardware, GSE, experiments, systems, aircraft and facilities through proper classification of FOD areas, training of personnel, and implementing the appropriate FOD prevention techniques.
- 7.16.1.3 The Center's FOD Prevention Program applies to all personnel performing fabrication, assembly, maintenance, operations and inspection on LaRC aircraft, models, tunnels, facilities and flight hardware for Center Projects, where foreign objects can potentially cause damage or loss of mission success.
- 7.16.1.4 *Clean room:* A clean room is defined as an enclosed work area and included work station(s) that has the capability to control the air temperature, humidity, and the air pressure of the work area. A clean room is further defined by the capability to control the maximum allowed particulate size in the air and the number of particulates allowed per cubic feet of air that are greater than a certain size.
- 7.16.1.5 *A Foreign Object (FO):* A Foreign Object (FO) is defined as a substance, debris, or article alien to flight hardware or to a flight hardware system, and/or associated GSE, which could potentially cause damage. The object may be foreign to an area that is in close proximity to flight hardware or to a flight hardware system, and/or associated GSE, and may be ingested by, or lodged in a mechanism of such items.
- 7.16.1.6 *Foreign Object Damage (FOD):* Foreign Object Damage (FOD) is defined as any damage attributed to a foreign object that can be expressed in physical or economic terms, which may or may not degrade the product's required safety and/or performance characteristics.
- 7.16.1.7 For the purposes of paragraph 7.15.2.1, the phrase "flight project personnel" has the same meaning as specified in 7.1.1.4.

7.16.2 Foreign Object Damage (FOD) Prevention Program

- 7.16.2.1 Flight project personnel and PMs shall implement the FOD Prevention Program requirements, as specified in LPR 5310.1, Foreign Object Damage (FOD) Prevention Program.

7.16.3 Contamination Control Plans

- 7.16.3.1 Engineers shall develop a project Contamination Control Plan (CCP).
- 7.16.3.2 Engineers shall include in the CCP the class of clean room(s) required to meet the project's cleanliness requirements for the project's flight hardware and associated GSE throughout the project's life cycle.
- 7.16.3.3 The PAM shall approve the CCP.

7.16.4 Class 100 Clean Room and Included Work Stations(s)

7.16.4.1 Engineers and technicians shall implement the Class 100 clean room and included work station(s) requirements, as specified in the following documents, as applicable:

- a. FED-STD-209D, Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones.
- b. IEST-STD-CC1246D, Product Cleanliness Levels and Contamination Control Program.

7.16.5 Class 10,000 Clean Room and Included Work Station(s)

7.16.5.1 Engineers and technicians shall implement the Class 10,000 clean room and included work station(s) requirements, as specified in the following documents, as appropriate:

- a. FED-STD-209D
- b. IEST-STD-CC1246D

7.16.6 Class 100,000 Clean Room and Included Work Station(s)

7.16.6.1 Engineers and technicians shall implement the Class 100,000 clean room and included work station(s) requirements, as specified in the following documents, as applicable:

- a. FED-STD-209D
- b. IEST-STD-CC1246D

7.16.7 General Operations

7.16.7.1 Engineers and technicians shall conduct appropriate training classes for all personnel using their clean room facilities.

7.16.7.2 Engineers and technicians shall comply with the following criteria for the successful operation of clean rooms and included work station(s):

- a. Equipment used to control clean room and included clean work station(s) conditions is calibrated, as specified by the manufacturer.
- b. Equipment used to monitor clean room and included clean work station(s) conditions is calibrated, as specified by the manufacturer.
- c. Equipment used to record clean room and included clean work station(s) conditions is calibrated, as specified by the manufacturer.

- d. All equipment is cleaned before being passed into the clean environment by suitable means compatible with the equipment involved.
- e. All equipment is decontaminated before being passed into the clean environment by suitable means compatible with the equipment involved.
- f. Environmental conditions, such as temperature and humidity are controlled, as specified in the project CCP, or as required for ESD control, as specified in LPR 8739.21.
- g. Environmental conditions, such as temperature and humidity are continuously recorded, as specified in the project CCP, or as required for ESD control, as specified in LPR 8739.21.
- h. Environmental conditions, such as temperature and humidity are reviewed, as specified in the project CCP, or as required for ESD control, as specified in LPR 8739.21.
- i. A maximum noise level of 85 dB is not exceeded without proper hearing protection and controls.
- j. An air pressure of 0.05 inches of water above that of surrounding areas is maintained in clean rooms to ensure an outward flow of air.
- k. Gloves, tweezers, or other mechanical barriers to prevent contact between skin and hardware are used, while working with or handling sensitive parts.
- l. Exhaust systems for grinding, welding, soldering, machining, or other related operations are installed, as specified in the Industrial Ventilation Manual published by the American Conference of Government Industrial Hygienists.
- m. Equipment used to maintain the cleanliness of the clean area is stored within the clean area in a manner to prevent accumulation or dispersion of particulates or microbiota on the surfaces of such equipment.
- n. Flexible conductors, such as vacuum hoses, electrical cables, are stored on reels or racks off the floor of the clean room.
- o. Use of particle shedding materials, such as bristle brushes, steel wool, are not permitted.

- 7.16.7.3 The MAB/QAS shall audit clean rooms and included workstation(s) operations to ensure compliance with the CCP utilizing LF 320, Cleanroom Audit Checklist.
- 7.16.7.4 The MAB/QAS shall verify operations are in compliance with the clean room requirements, as specified in the following:
 - a. Sections 7.16.4 through 7.16.6.
 - b. Paragraphs 17.16.7.2 and 17.16.7.3.

7.17 Acceptance Data Package

7.17.1. Generation Information

- 7.17.1.1 The Acceptance Data Package (ADP) is provided at the point of delivery to an integration test facility or launch site and documents the following elements:
 - a. The configuration of the flight hardware, including spares.
 - b. The configuration of the flight software.
 - c. Functional characteristics of all deliverable flight products.
 - d. Functional characteristics of all deliverable GSE.
 - e. Flightworthiness of all deliverable flight products.
 - f. Suitability of GSE.
 - g. Flightworthiness of spares associated with elements 7.17.1.1(a) and 7.17.1.1(c) through 7.17.1.1(e).

7.17.2 ADP Preparation and Delivery

- 7.17.2.1 The PM shall designate an engineer(s) to be responsible for developing the following:
 - a. ADP materials for LaRC developed hardware.
 - b. ADP materials for LaRC developed software.
 - c. ADP requirements for flight project contracts.
- 7.17.2.2 The PAM shall assist the designated engineer(s) in the preparation of the ADP for in-house projects by implementing the following:
 - a. Review the ADP for completeness in complying with the scope of an ADP, as specified in 7.17.1.1.
 - b. Review the ADP for completeness using the ADP item lists, as specified in 7.17.3.1 and 7.17.3.2, as applicable.
 - c. Provide feedback to the engineer on the completeness of the ADP.
 - d. Provide the status of QA paperwork, such as open NCRs, etc., as requested by the engineer.

7.17.2.3 The PAM shall assist the designated engineer(s) in ADP activities for flight project contracts by implementing the following:

- a. Review the ADP Data Requirements Document (DRD) for completeness in complying with the scope of an ADP, as specified in 7.17.1.1.
- b. Review the ADP DRD using the ADP item lists, as specified in 7.17.3.1 and 7.17.3.2, as applicable.
- c. Review the completed ADP contract deliverable with regard to QA and safety related documentation.
- d. Provide the results of the reviews, as specified in 7.17.2.3(a) through 7.17.2.3 (c), to the engineer.

7.17.2.4 The designated engineer shall implement the following:

- a. Confer with the PAM in establishing the ADP requirements for LaRC developed hardware and software, as specified in 7.17.2.2(a) through 7.17.2.2(d).
- b. Confer with the PAM in establishing the ADP requirements for flight project contracts, as specified in 7.17.2.3(a) through 7.17.2.3(d).
- c. Use the scope of an ADP, as specified in 7.17.1.1, as applicable, when developing ADP requirements.
- d. Identify documentation for incorporation into the ADP for LaRC developed flight projects, as specified in 7.17.3.1 through 7.17.3.2.
- e. Compile the ADP documentation, as specified in 7.17.2.4(d).
- f. Verify the ADP complies with all integration test facility or launch site specific requirements in addition to the requirements, as specified in 7.17.3.1 and 7.17.3.2.
- g. Verify the ADP reflects the status of each applicable hardware item at the time of the Systems Acceptance Review (SAR).
- h. Verify the ADP reflects the status of each applicable software item at the time of the SAR.
- i. Include the ADP documentation with the project's hardware delivery, as specified in Section 7.18.
- j. Include the ADP documentation with the project's software delivery, as specified in Section 7.18.

- k. Identify the ADP elements required for flight project contracts, as specified in 7.17.3.1 through 7.17.3.2.
- l. Develop the ADP DRD for flight project contracts.
- m. Review the contractor developed ADP for completeness with the ADP DRD contract requirements.

7.17.3 ADP Content

- 7.17.3.1 The PAM and the designated engineer(s) shall include, at a minimum, the following items in an ADP, as applicable.
 - a. Index of included items.
 - b. Notes/Documents, as required by the customer.
 - c. All Deviations/Waivers that are both open and closed.
 - d. List of flight hardware, software and/or documentation shortages.
 - e. Closed NCRs affecting LaRC.
 - f. Open NCRs affecting integration activities.
 - g. List of unplanned or deferred work.
 - h. List of flight hardware, as specified on “as-built” configuration/drawings.
 - i. List of limited operating life or age sensitive items.
 - j. Pyrotechnic data.
 - k. List of all installed non-flight items.
 - l. Current certification of proof-load of deliverable GSE.
 - m. Current certification of calibration of deliverable GSE.
 - n. Operating test procedures.
 - o. List of open items from Phase III Ground Safety Review (see Section 8.5).
 - p. Integrated test facility or launch site specific ADP requirements.
 - q. Flight hardware logbooks which are described in Section 7.12, when required by the ADP customer.

- 7.17.3.2 For human-rated flight hardware deliverables, the PAM and the designated engineer(s) shall include in an ADP the following items, in addition to those items specified in 7.17.3.1, as applicable:
- a. Preplanned or assigned work
 - b. Nonstandard Calibration information
 - c. Repair Limitations
 - d. Pressure vessel data
 - e. Certification of human rating requirements, as applicable
 - f. Safety Data Sheet (SDS)
 - g. Acceptance requirements
 - h. Operating Time/Cycle of flight hardware system

7.18 Handling/Lifting, Preservation, Packaging, Storage, and Shipping

7.18.1 General Information and Definitions

7.18.1.1 The requirements and processes for handling, preserving, shipping, packaging, and storing of hardware are specified in LMS-CP-4756, as well as in paragraphs 7.18.1.5 and 7.18.1.6, and sections 7.18.2 through 7.18.6.

7.18.1.2 *Hardware:* For purposes of this section, the word “hardware” includes the following items:

- a. Flight hardware, including optics and ESDS devices
- b. Hazardous materials
- c. GSE

7.18.1.3 *Critical lift:* For the purposes of this section, a critical lift is defined as a lift where a failure and/or loss of control could result in loss of life or serious injury, loss of or damage to hardware, or a lift involving special high dollar hardware, such as spacecraft, one-of-a-kind articles, or major facility components, whose loss would have serious programmatic or institutional impact. A critical lift also includes the lifting of personnel with a crane or a lift where personnel are required to work under a suspended load or operations with special personnel and equipment safety concerns beyond normal lifting hazards.

The requirements associated with a critical lift are specified in 7.18.2.8 through 7.18.2.15.

- 7.18.1.4 For the purposes of paragraph 7.18.1.5, the phrase “flight project personnel” has the same meaning, as specified in 7.1.1.4.
- 7.18.1.5 Flight project personnel and the PM shall implement the requirements, as specified in LPR-1710.12, as applicable, when performing the tasks identified in the title of this Section involving hazardous materials.
- 7.18.1.6 The PAM shall include in the handling/lifting, preservation, packaging, storage and shipping Section of the PAP, the following requirements:
 - a. LMS-CP-4756
 - b. Sections 7.18.2 through 7.18.6.

7.18.2 Handling/Lifting of Hardware

- 7.18.2.1 Engineers shall identify the handling requirements for hardware items on drawings or in procedures, as specified in LMS-CP-4756, as appropriate.
- 7.18.2.2 Engineers shall provide detailed handling instructions for hardware items during all phases of fabrication, when normal shop or trade practices or requirements of standards are not sufficient.
- 7.18.2.3 Engineers shall provide detailed handling instructions for hardware items during all phases of processing, when normal shop or trade practices or requirements of standards are not sufficient.
- 7.18.2.4 MAB/QAS shall approve detailed handling instructions for hardware items.
- 7.18.2.5 Technicians shall handle hardware items in compliance with the requirements, as specified in 7.18.2.1 through 7.18.2.3.
- 7.18.2.6 MAB/QAS shall verify hardware items are handled in compliance with the following:
 - a. LMS-CP-4756
 - b. Paragraph 7.18.2.5.
- 7.18.2.7 Engineers shall identify lifting operations as non-critical on an LF 358, as appropriate.
- 7.18.2.8 Engineers shall identify lifting operations as critical, according to the definition specified in 7.18.1.4, on an LF 358, as appropriate.
- 7.18.2.9 Engineers shall obtain the approval of the Lifting Device Equipment Manager on LF 358 as specified in LPR 1740.2, Facility Safety Requirements.

- 7.18.2.10 The PAM shall approve or disapprove the lift designation of non-critical hardware items, as specified in 7.18.2.7.
- 7.18.2.11 The PAM shall approve or disapprove the lift designation of critical hardware items, as specified in 7.18.2.8.
- 7.18.2.12 Engineers shall verify handling equipment is in compliance with specified site requirements prior to the use of such equipment.
- 7.18.2.13 Technicians shall attach evidence of proof-load testing to Lifting/handling equipment, such as slings, hoists, cables, carts, etc., prior to use of such equipment for both non-critical and critical lifts.
- 7.18.2.14 Technicians shall use non-critical lifting or rigging equipment, as specified in the following documents:
 - a. LPR 1740.2
 - b. NASA-STD-8719.9
- 7.18.2.15 Engineers and technicians shall conduct critical lifting or rigging operations, as specified in the following documents:
 - a. LPR 1740.2
 - b. NASA-STD-8719.9
- 7.18.2.16 MAB/QAS shall verify hardware items are lifted in compliance with the following:
 - a. LMS-CP-4756
 - b. Paragraphs 7.18.2.13 through 7.18.2.15

7.18.3 Preservation of Project Hardware

- 7.18.3.1 Engineers shall identify the preservation requirements, as specified in LMS-CP-4756, on all drawings or in all procedures concerning hardware items.
- 7.18.3.2 Engineers shall identify additional protective measures to prevent contamination of optics from anti-static packing materials.
- 7.18.3.3 Engineers and technicians shall implement protective measures to prevent deterioration of hardware items from potentially damaging environmental conditions, as specified in 7.18.3.1 and 7.18.3.2.
- 7.18.3.4 MAB/QAS shall verify flight hardware items are preserved in compliance with the following:

- a. LMS-CP-4756
- b. Paragraph 7.18.3.3.

7.18.4 Packaging of Project Hardware

- 7.18.4.1 Engineers and technicians shall identify the packaging requirements, as specified in LMS-CP-4756, on all drawings or in all procedures concerning hardware items.
- 7.18.4.2 MAB/QAS, engineers and SFAB shall approve packaging procedures for hazardous materials.
- 7.18.4.3 The LaRC Pyrotechnic Support Engineer shall approve procedures for packaging pyrotechnics.
- 7.18.4.4 Technicians shall use packaging materials that are in compliance with the requirements, as specified in 7.18.4.1 through 7.18.4.3, to ensure the safety of the flight hardware items during the following phases of processing:
 - a. Handling
 - b. Preservation
 - c. Storage
 - d. Shipment
- 7.18.4.5 MAB/QAS shall verify hardware items are packaged in compliance with the following:
 - a. LMS-CP-4756
 - b. Paragraph 7.18.4.4

7.18.5 Shipping of Project Hardware

- 7.18.5.1 Engineers shall identify the shipping requirements, as specified in LMS-CP-4756, on all drawings or in all procedures concerning hardware items.
- 7.18.5.2 Engineers or technicians shall mark the “flight/ground support hardware” box on LF 52.
- 7.18.5.3 Technicians and shipping and receiving shall label containers with the following warning designations, as appropriate:
 - a. CAUTION-HAZARDOUS MATERIAL
 - b. GLASS

- c. THIS END UP
 - d. FRAGILE
 - e. HANDLE WITH CARE
 - f. Other labels, as appropriate
- 7.18.5.4 Shipping and Receiving personnel shall affix a packing list on packaged articles that contains the following information:
- a. Name of contents
 - b. Identification number of contents, e.g., model number, serial number, or item number, etc.
- 7.18.5.5 MAB/QAS shall verify hardware items are shipped in compliance with the following:
- a. LMS-CP-4756
 - b. Paragraphs 7.18.5.1 through 7.18.5.4
- 7.18.5.6 Shipping and receiving shall ship hardware items in compliance with those requirements specified in 7.18.5.2 through 7.18.5.4, after MAB/QAS has verified the hardware items are in compliance with the shipping requirements.
- 7.18.6 Storage of Project Hardware**
- 7.18.6.1 Engineers shall identify the storage requirements, as specified in LMS-CP-4756 on all drawings or in all procedures concerning hardware items.
- 7.18.6.2 Technicians shall store hardware items, as identified in 7.18.6.1, according to the storage requirement specified in LMS-CP-4756.
- 7.18.6.3 Engineers shall identify hardware items that require unique internal environments, such as inert gases, to prevent degradation or deterioration, while stored.
- 7.18.6.4 Technicians shall store hardware items that require unique internal environments, such as inert gases, in a manner that prevents degradation or deterioration, while stored.
- 7.18.6.5 MAB/QAS shall verify hardware items are stored in compliance with the following:
- a. LMS-CP-4756
 - b. Paragraphs 7.18.6.2 and 7.18.6.4

CHAPTER 8: SYSTEM SAFETY

8.1 General

- 8.1.1 This Section identifies the plans, analyses, documentation, and reviews required for the identification and disposition of payload related hazards to ensure the protection of personnel, launch vehicles, flight hardware, and GSE.
- 8.1.2 The System Safety section of the PAP shall be developed in accordance with the requirements of this Section for aerospace products launched or used by Exploration developed vehicles, the National Space Transportation System (NSTS), expendable launch vehicles (ELVs), and hypersonic and subsonic vehicles.
- 8.1.3 Support provided by the LaRC MAB shall include performing System Safety in accordance with NASA directives, requirements, policy and procedural requirements, and guidelines as instituted by Program(s)/Project(s) in order to assure safety.

8.2 System Safety Plan

- 8.2.1 A System Safety Plan (SSP) shall be prepared for each flight product by the integrating organization.
 - 8.2.1.1 When LaRC is the Initiating Organization (IO), the SSP shall be submitted under separate cover or included in the System Safety Section of the PAP.
 - 8.2.1.2 In all instances, the SSP requires MAB approval.
- 8.2.2 The SSP shall address the following items for the appropriate launch system and site:
 - a. Organizational responsibilities, authority, and interrelationships as related to system safety
 - b. Orbital debris assessment (see Section 5.9)
 - c. Required system safety analyses
 - d. Internal and external safety review processes
 - e. Hazardous operation surveillance
 - f. Accident investigation and reporting
 - g. Operator training and certification
 - h. Required Safety Compliance Data Package documentation

- 8.2.3 The PAM shall review and approve all procedures affecting aerospace product safety, including hazardous operations, for compliance with identified system safety requirements and implementation in accordance with the PAP.

8.3 Safety Compliance Data Package

- 8.3.1 A Safety Compliance Data Package (SCDP) shall be submitted to the applicable Safety Review Panel.
- 8.3.1.1 If an established safety review process does not exist for a particular launch system or site, the PAM shall establish and implement an independent review process for the SCDP.
- 8.3.2 The SCDP shall provide information and data which assures all subsystem and system hazards have been identified, controlled by appropriate methods, and that control methods are verifiable.
- 8.3.3 The SCDP shall include the following for the appropriate launch system and site:
- a. Mission overview
 - b. List of applicable documents
 - c. Payload description
 - d. Safety overview
 - e. Flight safety analyses with hazard reports
 - f. Ground safety analyses with hazard reports
 - g. Supplemental analyses
 - h. Approved deviations and waivers
 - i. Payload safety noncompliance reports

8.4 Flight Safety Analysis

- 8.4.1 A Flight Safety Analysis (FSA) shall be prepared for aerospace products and updated throughout the various product life cycle including design, fabrication, test, transportation, integration, and launch.
- 8.4.2 The FSA shall include the following:

- a. Description of the potential hazard
 - b. Identification of the cause of the potential hazard
 - c. The control or technical explanation demonstrating that the potential hazard does not pose a catastrophic or critical condition for the launch system
 - d. Method of verification of control
 - e. Current status of hazard control and verification
- 8.4.3 A separate payload hazard report, similar to JSC Form 542, shall be generated for each specific hazard identified.
- 8.4.3.1 NSTS payload "STANDARD HAZARDS," with their appropriate controls, are identified on JSC Form 1230.

8.5 Ground Safety Analysis

- 8.5.1 A Ground Safety Analysis (GSA) shall be prepared for each payload and its associated GSE when the use of a facility or the performance of an activity could result in subjecting facilities and/or personnel to hazards.
- 8.5.2 The GSA shall include the following:
- a. Description of the potential safety hazards to the flight hardware, GSE, facility, and personnel at the launch site
 - b. Identification of the cause of the potential hazard
 - c. The control or technical explanation demonstrating that the potential hazard does not pose a catastrophic or critical condition for the launch system
 - d. Method of verification of control
 - e. Current status of hazard control and verification

8.6 Constellation and National Space Transportation System (NSTS) Review and Approval Process

8.6.1 Reviews

8.6.1.1 All safety reviews are to be held according to the following phased system:

a. Phase 0: Requires potential hazards, hazard causes, and applicable safety requirements be identified and is held after the conceptual design has been established.

b. Phase I: Requires the methods of hazard control or elimination be provided and is held after the preliminary design has been established.

c. Phase II: Requires identification and status of the method for verifying implementation of hazard controls and is held after the final design has been established.

d. Phase III: Requires that all system safety actions have been satisfactorily closed out and is held upon completion of fabrication and testing prior to the SAR.

8.6.1.2 Any configuration change after the Phase III review process is to be reviewed and approved by the Safety Review Panel for possible hazards as a result of the change.

8.6.2 Approvals

8.6.2.1 All safety analyses shall be approved by safety review panels established and chartered by JSC and Kennedy Space Center (KSC) management.

8.6.2.2 The cycle for this process is dependent upon the number of organizations involved.

8.7 Expendable Launch Vehicle (ELV) Payload Review and Approval Process

The guidelines, safety reviews, and approvals provided in this Section are applicable to both the Eastern and Western Ranges.

8.7.1 Launch Services and Mission Orientation Briefing

8.7.1.1 Launch Services and Mission Orientation Briefing (LSMOB) shall be conducted by the Range User for the Range Safety Organization approximately 45 days after project approval or contract award.

- 8.7.1.2 The LSMOB shall cover the following topics, as appropriate:
- a. Changes to the launch vehicle
 - b. Changes to the payload bus
 - c. Planned payload additions for the mission
 - d. Changes to hazardous systems and operations
- 8.7.1.3 Range Safety concurrence for mission concept and proposed schedule will be provided within 14 days after briefing.
- 8.7.2 System Safety Program Plan**
- 8.7.2.1 Range Users shall submit a System Safety Program Plan (SSPP) for Eastern and Western Ranges safety purposes.
- 8.7.2.2 Such a program shall be consistent with MIL-STD-882, System Safety, for DoD programs and the requirements of AFI 91-202 for Air Force programs.
- 8.7.2.3 The program shall include the corresponding requirements for a Range User SSPP described in AFSPCMAN 91-710 and identify hazard analysis and risk assessment requirements.
- 8.7.2.4 The Range User shall submit a draft SSPP to Range Safety for review and approval within 45 days of the program introduction and a final SSPP at least 45 days before any program CDR.
- 8.7.3 Missile System Prelaunch Safety Package Review**
- 8.7.3.1 A payload Missile System Prelaunch Safety Package (MSPSP) shall be delivered to Range Safety by the Range User approximately 12 months before launch.
- 8.7.3.1.1 A MSPSP shall contain the data requirements identified during the mission orientation safety briefing on the changes to the launch vehicle and payload unique for the mission and identified in the initial operation's concept review.
- 8.7.3.2 For commercial payloads, the payload MSPSP shall be submitted to Range Safety through the launch vehicle contractor.
- 8.7.3.3 A final MSPSP that satisfies all Range Safety concerns addressed at the CDR shall be submitted to Range Safety at least 45 calendar days prior to the intended shipment of hardware to the Range.

8.7.4 Ground Operations Plan Review

- 8.7.4.1 The Range User shall perform and document an operating and support hazard analysis (O&SHA) to examine procedurally controlled activities.
- 8.7.4.2 The purpose of the O&SHA is to evaluate activities for hazards or risks introduced into the system by operational and support procedures and to evaluate adequacy of operational and support procedures used to eliminate, control, or abate identified hazards or risks.
- 8.7.4.3 The O&SHA identifies and evaluates hazards resulting from the implementation of operations or tasks performed by persons, considering the following criteria:
- a. Planned system configuration and/or state at each phase of activity
 - b. Facility interfaces
 - c. Planned environments or the ranges thereof
 - d. Supporting tools or other equipment including software controlled automatic test equipment specified for use
 - e. Operational and/or task sequence, concurrent task effects and limitations
 - f. Biotechnological factors, regulatory or contractually specified personnel safety and health requirements
 - g. Potential for unplanned events, including hazards introduced by human errors
- 8.7.4.2 A Ground Operations Plan (GOP) supplement describing changes to approved operations and/or new or modified safety critical or hazardous procedures shall be delivered to Range Safety approximately 120 days before payload arrival on the range.
- 8.7.4.2.1 This supplement is required only if changes have been made to operations and procedures that affect hazardous levels or risks.
- 8.7.4.3 Range Safety shall provide responses within 45 days after receipt of the GOP supplement.

8.7.5 Mission Approval Safety Review

- 8.7.5.1 A Mission Approval Safety Review (MASR) is to be conducted approximately 120 days prior to launch.

8.7.5.2 The MASR shall provide approval for the following activities:

- a. Launch vehicle processing
- b. Payload processing
- c. Transport to payload launch pad
- d. Payload launch vehicle mating
- e. Launch pad payload processing

8.7.5.3 Range Safety will typically provide mission safety approval within 14 days after review completion.

8.7.6 Final Launch Approval

8.7.6.1 Final approval to proceed with launch vehicle and payload processing up to beginning the final countdown shall be provided by Range Safety at least 60 days before payload arrival at the launch complex.

8.7.6.2 Flight plan approval for a mission that involves public safety may not be granted until just before the Launch Readiness Review (LRR) depending on the complexity of the public safety issue encountered. For example, typically, at the Eastern Range (ER), easterly launch azimuths can be approved at least 120 days before launch; on the other hand, high inclination launches may require extensive risk analyses that can delay final flight plan approval until just before the LRR.

8.8 Responsibilities

8.8.1 The PM shall be responsible for:

- a. The design of project hardware and associated GSE hardware for compliance with agency flight and GSE and ground operations safety requirements as specified in the latest revisions of NSTS 1700.7, Safety Policy and Requirements for Payloads Using the Space Transportation System and KHB 1700.7, Space Shuttle Payload Ground Safety Handbook or EWR 127-1, Eastern and Western Range Safety Requirements for ELV launches on a national range.
- b. Developing provisions for verifying safety requirements that are satisfied by inspection and/or tests.
- c. Supporting the PAM in the coordination and preparation of required technical analyses.

- d. Presenting technical discussions of safety analyses to the JSC and KSC safety review panels or the Eastern/Western Range.
- e. Supporting MAB in post safety panel review activities.

8.8.2 The PAM shall be responsible for:

- a. Preparation of the SSP.
- b. Preparation of the FSA, GSA, and other safety related tasks in accordance with program/project requirements (e.g., NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements, Constellation document CxP 70038, Constellation Program Hazard Analyses Methodology, and Air Force Space Command Manual 91-710).
- c. Preparation of the SCDP.
- d. Tailoring of the safety requirements based on the program/project (e.g., Shuttle, Constellation, Expendable Launch Vehicle, and the International Space Station).
- e. Serving as the single point of contact with the JSC, KSC, or Range Flight Safety Office representatives on safety related issues, and resolving any differences of interpretation of the requirements.
- f. Monitoring/verifying close out of all safety items identified in safety verification tracking lists.

APPENDIX A – DEFINITIONS

A.1 ANOMALY	Unexpected event during the testing or operation of any item, including software, which neither rises to the level of a nonconformance nor a failure, but needs to be investigated to understand the cause(s) and associated risks, if any.
A.2 BONDED STORES	Secure, controlled, and environmentally compatible areas where materials, and hardware, used in assembling flight and GSE hardware are receipt inspected and closely controlled for accountability.
A.3 BONDED STORES OPERATOR	Technician assigned to implement the Bonded Stores function.
A.4 CLEAN ROOM	Enclosed work area and included work station(s) with the capability to control air temperature, humidity, and air pressure of the work area and the capability to control the maximum allowed particulate size in the air and the number of particulates greater than a certain size allowed per cubic feet of air.
A.5 COMPLEX WORK	Any work that involves: <ol style="list-style-type: none"> a. the design, manufacture, fabrication, assembly, testing, integration, maintenance, or repair of machinery, equipment, subsystems, systems, or platforms. b. the manufacture/fabrication of parts or assemblies that have quality characteristics not wholly visible in the end item and for which conformance to the design requirement can be established only progressively through precise measurements, tests, or applied controls.
A.6 CRITICAL GROUND SUPPORT EQUIPMENT	Ground-based equipment, implements, or devices used to store, transport, handle, service, test, maintain, align, adjust, calibrate, service, inspect, or control on the ground an operational end item, subsystem, system, payload, spacecraft, or launch vehicle for a flight project.
A.7 CRITICAL LIFT	Lift where a failure and/or loss of control could result in loss of life or serious injury, loss of or damage to hardware, or a lift involving special high-cost hardware, such as spacecraft, one-of-a-kind articles, or major facility components, whose loss would have serious programmatic or institutional impact.

A.8 CRITICAL WORK	Any hardware task that, if performed incorrectly or in violation of prescribed requirements, could result in loss of human life, serious injury, loss of mission, or loss of significant mission resource.
A.9 DESIGNATED AGENCY (DA)	Any government agency other than NASA.
A.10 DEVIATION	Authorizes departure from a particular requirement that does not strictly apply; involves the approval of alternate means that meet the intent of the requirement or formal acceptance of increased risk due to the fact that the requirement is not satisfied.
A.11 EEE PARTS	Off-the-shelf parts, components, motors, pyrotechnic devices, sensors, transducers, and detectors (i.e., all items with an electrical interface).
A.12 ELECTROSTATIC DISCHARGE (ESD)	Transfer of an electrostatic charge (static electricity) between two bodies electrically charged at different potentials, caused by direct contact or induced by an electrostatic field.
A.13 ESD SENSITIVE (ESDS) DEVICES	Electrical and electronic parts, assemblies, and equipment sensitive to ESD voltages of 8,000 volts or less.
A.14 FAILURE	Inability of any item, including software, to perform in accordance with a specified functional test.
A.15 FAULT TREE ANALYSIS (FTA)	Provides a systematic and deductive methodology for defining a single specific undesirable event and determining all possible failures that could cause that event to occur.
A.16 FOREIGN OBJECT (FO)	Substance, debris, or article alien to flight hardware or to a flight hardware system, and/or associated GSE, which could potentially cause damage.
A.17 FOREIGN OBJECT DAMAGE (FOD)	Damage attributed to a foreign object that can be expressed in physical or economic terms, which may or may not degrade the product's required safety and/or performance characteristics.
A.18 HEAT NUMBER	Identification number of the batch of steel, or other metal, or metal alloy, from which metal materials are produced.
A.19 LOT NUMBER	Identification number that enables tracing of the materials, labor, and equipment records involved in the manufacturing of a product.

- A.20 MAJOR NONCONFORMANCE** Nonconformance that adversely affects the safety, reliability, durability, performance, configuration, interchangeability, or weight requirements of a LaRC project.
- A.21 MINOR NONCONFORMANCE** Nonconformance that does NOT adversely affect the safety, reliability, durability, performance, configuration, interchangeability, or weight requirements of a LaRC project.
- A.22 “MV” NUMBER** Test number assigned by the MAQAL MAB/QAS to designate the safety-critical hardware item’s mechanical and chemical properties have been tested at the request of engineers by the MAQAL despite the fact the proper documentation from the supplier has one or more anomalies.
- A.23 NONCONFORMANCE** Condition or characteristic of any item, including software, which does not conform to a drawing or other specified project requirement.
- A.24 “NSI” NUMBER** Test number assigned by the Materials Analysis and Quality Assurance Laboratory (MAQAL) MAB/QAS, which is consigned to safety-critical hardware items, if there are no anomalies associated with the accompanying documentation.
- A.25 QUALITY CHARACTERISTICS** Features of hardware that are required to meet design specifications.
- A.26 RISK** The combination of the probability that a program or project will experience an undesired event and the consequences, impact, or severity of the undesired event, were it to occur.
- A.27 RISK LIST** Listing of all identified risks in priority order from highest to lowest risk, together with the information that is needed to manage each risk and document its evolution over the course of the project.
- A.28 RISK MITIGATION (RM)** A continuous, iterative process wherein the Program/Project Team is responsible for identifying, analyzing, planning, tracking, controlling, and communicating effectively the risks (and the steps being taken to handle them) both within the team and with management and stakeholders in order to achieve mission success; a key element and an integral part of normal program/project management and engineering processes.

- A.29 RISK MITIGATION PLANS** Description of actions to mitigate identified risks, as well as risk measures, indicators, and trigger levels used in the tracking of the risks and the effectiveness of their mitigation actions.
- A.30 RISK PROFILE** A qualitative or quantitative projection of overall expected risk trend over the life of the program/project.
- A.31 RISK TRENDS** Displays (graphical, tabular, or textual) showing changes to risk indicators over time (i.e., decreasing, staying the same, or increasing).
- A.32 TYPE I OR MAJOR NONCONFORMANCE** A nonconformance that adversely affects the safety, reliability, durability, performance, interchangeability, or weight requirements of a contract; requires approval by both the contractor's Material Review Board (MRB) and the LaRC project's designated representative.
- A.33 TYPE II OR MINOR NONCONFORMANCE** A nonconformance other than that specified as a Type I or Major nonconformance. A Type II or Minor nonconformance requires approval by the contractor according to the contractor's nonconformance and MRB process and will not require approval from the LaRC project's designated representative.
- A.34 WAIVER** Authorizes departure from a specific requirement and is requested during the implementation of a project, usually after an operation; involves approval of an increase in risk, due to the fact that the requirement is not satisfied and has been documented and accepted by the appropriate authority.
- A.35 WORK THAT IS NEITHER CRITICAL NOR COMPLEX** Work that includes manufacture of "build to print" piece parts or performance of a discrete manufacturing/test operation such as plating, heat treating, non-destructive testing, or laboratory testing for chemical composition or mechanical properties.

APPENDIX B – ACRONYMS

ANSI	American National Standards Institute
ASRB	Airworthiness and Safety Review Board
CAP	Corrective Action Plan
CCP	Contamination Control Plan
CDR	Critical Design Review
CIL	Critical Items List
CMC	Center Management Council
CMQP	Composite Material Qualification Plan
CO	Contracting Officer
CoDR	Conceptual Design Review
COR	Contracting Officer's Representative
CP	Center Procedure
CSO	Chief Safety Officer
DA	Delegated Agency
DoD	Department of Defense
DRD	Data Requirements Description
DRL	Documents Requirements List
DWR	Deviation and Waiver Request
EEE	Electrical, Electronic, and Electromechanical
ELV	Expendable Launch Vehicle
EPM	EEE Parts Manager
ER	Eastern Range
ESD	Electrostatic discharge
ESDS	ESD Sensitive
EWR	Eastern Western Range
FAI	First Article Inspection
FAR	Federal Acquisition Regulation
FIOS	Fabrication Inspection and Operations Sheet

FMEA	Failure Modes and Effects Analysis
FOD	Foreign Object Damage
FR	Fabrication Representative
FRR	Flight Readiness Review
FSA	Flight Safety Analysis
FTA	Fault Tree Analysis
FTR	Final Test Report
FWR	Fabrication Work Request
GIDEP	Government-Industry Data Exchange Program
GMIP	Government Mandatory Inspection Points
GOP	Ground Operations Plan
GSA	Ground Safety Analysis
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HQ	Headquarters
IDP	Integrated Data Package
IM&TE	Inspection, Measuring, and Test Equipment
IO	Initiating Organization
JSC	Johnson Space Center
KSC	Kennedy Space Center
LAPD	Langley Policy Directive
LaRC	Langley Research Center
LF	Langley Form
LLIS	Lessons Learned Information System
LMS	Langley Management System
LoD	Letter of Delegation
LPR	Langley Procedural Requirements
LRR	Launch Readiness Review
LRU	Line replaceable unit

LSMOB	Launch Services and Mission Orientation Briefing
MAB	Mission Assurance Branch
MAB/QAS	MAB Quality Assurance Specialist
MAP	Mission Assurance Program
MAQAL	Material Analysis and Quality Assurance Laboratory
MASR	Mission Approval Safety Review
MIL-HDBK	Military Handbook
MIL-Std	Military Standard
ML	Materials List
MRB	Materials Review Board
MSC	Mission Success Criteria
MSFC	Marshall Space Flight Center
MSPSP	Missile System Prelaunch Safety Package
MUA	Material Usage Agreement
NARS	NASA Alert Reporting System
NASA	National Aeronautics and Space Administration
NCR	Nonconformance Report
NEPAG	NASA EEE Parts Assurance Group
NEPP	NASA Electronic Parts and Packaging Program
NPR	NASA Procedural Requirements
NPSL	NASA Parts Selection List
NSC	NASA Safety Center
NSPAR	Nonstandard Part Approval Request
NSTS	National Space Transportation System
O&SHA	Operating and Support Hazard Analysis
ODA	Orbital Debris Assessment
OP	Office of Procurement
OSMA	Office of Safety & Mission Assurance
P&M	Parts and Materials

PA	product assurance
PAM	Product Assurance Manager
PAM	Product Assurance Manager
PAP	Product Assurance Plan
PAR	Product Assurance Requirements
PDR	Preliminary Design Review
PIR	Parts Inventory Report
PM	Project Manager
PN	Part Number
PO	Purchase Order
POC	Point of Contact
PQASP	Program/Project Quality Assurance Surveillance Plan
PR	purchase requisition
PRA	Probabilistic Risk Assessment
PRR	Project Requirements Review
QA	Quality Assurance
QAAR	Quality Audit, Assurance, and Review
QAB	Quality Assurance Branch
QAS	Quality Assurance Specialist
QLTR	Quick-Look Test Report
QMS	Quality Management Systems
QRAS	Quantitative Risk Assessment System
QSS	Quality Status Stamps
RFP	Request For Proposal
RG	Reliability Goal
RM	Risk Management
RMAS	Reliability, Maintainability, Availability, and Supportability
SA	Software Assurance
SAP	Software Acquisition Plan

SAR	Systems Acceptance Review
SCDP	Safety Compliance Data Package
SFAB	Safety and Facility Assurance Branch
SMA	Safety & Mission Assurance
SMAO	Safety Mission Assurance Office
SMSR	Safety and Mission Success Review
SN	Serial Number
SoR	Statement of Risk
SOW	Statement of Work
SRR	Systems Requirements Review
SSP	System Safety Plan
SSPP	System Safety Program Plan
STD	Standard
TRL	Technology Readiness Level
UAV	Unmanned Aerial Vehicle
WCA	Worst Case Analysis

APPENDIX C – PRODUCT ASSURANCE PLAN (PAP) OUTLINE

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- 7.14.4 Procedures
- 7.14.5 Reporting
- 7.14.6 Responsibilities
- 7.16 CONTAMINATION CONTROL
 - 7.16.1 Foreign Object Debris (FOD)
 - 7.16.2 Class 100 Clean Room/Work Station
 - 7.16.3 Class 10,000 Clean Room/Work Station
 - 7.16.4 Class 100,000 Clean Room/Work Station
 - 7.16.5 General Operations
 - 7.16.6 Responsibilities
- 7.17 INTEGRATED DATA PACKAGE
 - 7.17.1 General
 - 7.17.2 Responsibilities
- 7.18 HANDLING, PRESERVATION, AND SHIPPING
 - 7.18.3 Handling
 - 7.18.4 Preservation
 - 7.18.5 Shipping
 - 7.18.6 Storage
 - 7.18.7 Responsibilities

8. SYSTEM SAFETY

- 8.1 GENERAL
- 8.2 SYSTEM SAFETY PLAN
- 8.3 SAFETY COMPLIANCE DATA PACKAGE
- 8.4 FLIGHT SAFETY ANALYSIS
- 8.5 GROUND SAFETY ANALYSIS
- 8.6 CONSTELLATION AND NATIONAL SPACE TRANSPORTATION SYSTEM (NSTS) REVIEW AND APPROVAL PROCESS
 - 8.6.1 Reviews
 - 8.6.2 Approvals
- 8.7 EXPENDABLE LAUNCH VEHICLE (ELV) PAYLOAD REVIEW AND APPROVAL PROCESS
 - 8.7.1 Launch Services and Mission Orientation Briefing
 - 8.7.2 System Safety Program Plan
 - 8.7.3 Missile System Prelaunch Safety Package Review
 - 8.7.4 Ground Safety Data Package Review
 - 8.7.5 Mission Approval Safety Review
 - 8.7.6 Final Launch Approval
- 8.8 RESPONSIBILITIES