



**Langley Research Center**

**LPR 5300.1**

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## **PRODUCT ASSURANCE PLAN**

**National Aeronautics and Space Administration**

Verify the correct revision before use by checking the LMS Web site.

**Responsible Office: Safety and Mission Assurance Office**

**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. The Mission Assurance Branch (MAB), Safety and Mission Assurance Office (SMAO) is 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.
- c. 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/Constellation projects, atmospheric science instruments, satellites and missions, Shuttle and International Space Station payloads and experiments, and planetary science payloads and missions. SMAO requirements must also be met on risk reduction flights; flight experiments; flights of opportunity that are sub-orbital; involve sounding rockets; un-crewed aerospace vehicles; drop models; and major Unmanned Aerial Vehicle (UAV) operations. 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)."

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### **P.3 AUTHORITY**

See Appendix B.

### **P.4 APPLICABLE DOCUMENTS**

See Appendix B.

### **P.5 MEASUREMENTS/VERIFICATIONS**

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

### **P.6 CANCELLATION**

LPR 5300.1, dated January 28, 2005 should be destroyed.

Original signed on file, October 26, 2009

Cynthia C. Lee  
Associate Director

### **DISTRIBUTION**

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## **Chapter 1**

# **INTRODUCTION**

## **1.1 GENERAL**

This Section identifies the Langley Research Center (LaRC) internal product assurance (PA) requirements and activities to produce, launch, and operate Critical and Complex products designed, fabricated, and/or managed at LaRC or to procure a contractor for providing these products and/or services (as defined in the P.2 Applicability section). This includes flight and qualification hardware, software, firmware, and critical ground support equipment (GSE). The requirements and activities identified herein, form the basis for the development of project unique Product Assurance Plans (PAPs).

## **1.2 MISSION SUCCESS CRITERIA**

The sponsoring LaRC organization and the principal investigator, if applicable, shall establish Mission Success Criteria (MSC) for each project. 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 Mission Assurance Branch (MAB) involvement in the preparation of an internal Project Description 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 required 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). The RFP may require the submittal of PAP elements with the contractor proposal that satisfies the PA requirements outlined by this document. A contractor developed PAP shall be required as a government approved deliverable following contract award.

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- f. The Head of MAB and the Project Manager (PM) will review and approve the PAP or RFP PA requirements.

## Chapter 2

### PRODUCT ASSURANCE PLAN

#### 2.1 GENERAL

- a. All LaRC flight projects (as defined in the P.2 Applicability section), regardless of cost or where managed, must have a PAP developed in accordance with LMS-CP-4750, "Develop Product Assurance Plans."
- b. Project offices shall ensure that sufficient funding is available for PAP development and implementation.

#### 2.2 CONTENT

The PAP shall identify the applicable requirements of this document necessary to achieve the specified MSC. 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 C.

##### 2.2.1 Key Characteristics

- a. These are features of a material, process, or part whose variation has a significant influence on product fit, performance, service life, or manufacturability.
- b. In order to meet the Mission Success Criteria for a given project, the end product will have either specified or derived key characteristics that must be met in order to provide satisfactory performance. 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 be defined. 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. The key characteristics are to be 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

All PAPs shall be approved by the Head, MAB, and the LaRC Project Manager. 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 is achievable.

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- b. The selected contractor's proposed PAP, with negotiated additions, modifications, and subsequent revisions shall be approved by 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 baselined and placed under the project configuration control system (see Chapter 4).

## **2.4 CHANGES**

All changes to an approved PAP shall be subject to the configuration management process. PAPs shall be promptly updated to include all approved changes.

## **2.5 ASSESSMENT**

- a. All PA activities identified in an approved PAP shall be subject to audits or reviews by the MAB or its designee. These audits or reviews will insure 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. All identified deficiencies shall be promptly corrected by the responsible organization.
- b. 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 Technical Representative (COTR) to stop work on any contractor activity assessed to be noncompliant with an approved PAP.

## **2.6 RESPONSIBILITIES**

- a. The Mission Assurance Branch (MAB) is responsible for:
  - (1) Preparing and maintaining the PAP for in-house projects.
  - (2) Submitting in-house PAPs for project approval.
  - (3) Establishing PA requirements for the SOW on flight projects performed by contractors.
  - (4) Reviewing contractors' PAPs.
  - (5) Head of the MAB approves in-house PAPs.
  - (6) Conducting audits or reviews to assure implementation of PAPs for in-house and contracted projects.
- b. The Project Manager (PM) is responsible for:

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- (1) Approving PAPs.
- (2) Managing implementation of the PAP.

## Chapter 3

### ACQUISITION QUALITY ASSURANCE

#### 3.1 GENERAL

This chapter identifies requirements and procedures to ensure that suppliers, contractors, and subcontractors deliver products and services which comply with LaRC PA requirements.

##### 3.1.1 Purchases of Hazardous Materials

Purchases of hazardous materials shall be in accordance with LMS-CP-4759, "Acquisition of Hazardous Materials."

##### 3.1.2 Quality System Requirements

- a. NASA solicitations, contracts, and work-tasking documents shall invoke/specify the quality system requirements identified in the paragraphs below, as applicable.
  - (1) Work that is both critical and complex shall be performed in accordance with the quality system requirements of AS9100.
  - (2) Critical work is 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 a significant mission resource (e.g., Government test or launch facility).
- b. Complex work involves either:
  - (1) The design, manufacture, fabrication, assembly, testing, integration, maintenance, or repair of machinery, equipment, subsystems, systems, or platforms
  - (2) 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.
- c. Critical, but not complex, work shall be performed in accordance with the quality system requirements of AS9100 or ISO 9001, or the inspection and test quality system requirements of AS9003. Noncomplex work 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.
- d. Complex, but not critical, work shall be performed in accordance with the quality system requirements of AS9100 or ISO 9001.

e. Work that is neither critical nor complex shall be performed in accordance with the quality system requirements of AS9100, ISO 9001, or AS9003, or in accordance with test and inspection requirements that are specified or approved by the contracting agent and supported by records evidencing their performance and outcome.

## **3.2 ACQUISITIONS**

Applicable products (see P.2 Applicability section) and services are acquired by purchase orders and contracts. Purchase requests are necessary to initiate procurement actions.

### **3.2.1 Purchase Requests**

a. Using the Software Acquisition Plan (SAP) system, originators of a purchase request (PR) for the acquisition of flight hardware or for the development of flight software are to comply with the requirements of LMS-CP-4703 "Review of Purchase Requests by the Safety and Mission Assurance Office (SMAO)." In addition, PR originators shall designate these PRs as "critical and complex" and mark them Quality Sensitive per LMS-CP-4505, "Purchase Requisition (PR) Initiation/Modification/Cancellation and Supporting Documentation." See LMS-CP-5523, "Statement of Work (SOW) Review Procedure," for Statement of Work (SOW) development.

b. The PAM will review the submitted PR to determine if adequate PA provisions are included (per the requirements of this document), if PA evaluation of proposed subcontractors is required, and if Government source inspection is required.

c. As a minimum, the PAM will assure that the following have been considered for inclusion:

- (1) PA requirements, including, if applicable, the appropriate documented quality system.
- (2) Delegation of quality assurance (QA) provisions to other Government agencies.
- (3) Department of Defense (DoD) Form-250, "Material Inspection and Receiving Report."
- (4) Information to supplier for special shipping instructions.
- (5) Pre-award survey.
- (6) Inspection/acceptance testing requirements (including acceptance/rejection criteria).
- (7) Safety and environmental considerations.

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d. The PAM will prepare any additional required PA and delegation documentation and attach appropriate receiving and inspection instructions. All critical and complex products PR's shall be approved by the MAB.

### **3.2.2 Contracts**

a. The Office of Procurement (OP) shall ensure that a copy of the proposed SOW for development of flight hardware and software is forwarded to MAB as per LMS-CP-4751, "Response to Requests for Mission Assurance Support in Proposal or Contract Development." The PAM, in conjunction with project personnel, will prepare the Product Assurance Requirements (PAR) Appendix for inclusion in the proposed SOW. The PAR is to be based upon the requirements of this document. The PAR shall become part of the contract negotiated between the contractor and LaRC.

b. In addition, the PAM will develop a "Documents Requirements List (DRL)," NASA Langley Form 47, which identifies required PA documentation to be submitted to LaRC during the contract period. The DRL is to identify the following:

- (1) Name of required document.
- (2) Reference paragraph of PAR's Appendix.
- (3) Submittal frequency.
- (4) Updating frequency.
- (5) Distribution.
- (6) LaRC action required.

c. NASA Langley Form 45, "Data Requirements Description (DRD)," will be prepared which identifies the content and format requirements for each document identified in the DRL.

d. The OP shall ensure that all RFPs and resultant contracts require the contractor to comply with the MAB approved PAR when developing the PAP.

e. The procurement package development process is to include reviews at various milestones as defined by the OP and PM. During these reviews, the PAM is to ensure that appropriate language is included in the RFP for the following:

- (1) Compliance to PA requirements (including any higher level quality requirements to be compliant with the AS9100).
- (2) Reference to mandatory QA elements of the Federal Acquisition Regulations (FAR's) and NASA FAR Supplement.



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- (3) Implement Quality System Requirements and deliver conforming product in accordance with NPR 8735.2, "Management of Government Quality Assurance Functions for NASA Contracts" (see Chapters 1 and 2).

### 3.2.3 Responsibilities

a. The Mission Assurance Branch (MAB) is responsible for:

- (1) Reviewing all specifications, SOW, and RFPs (that are considered to be quality sensitive) to determine if adequate PA provisions have been included, if PA evaluation of proposed suppliers might be required, and if Government Source Inspection may be required.
- (2) Coordinating with the originator of the PR action recommended from the PA review.
- (3) Any comments should be provided electronically in SAP at the time of review. Review comments for all PRs shall be documented on LF 188, "Contract/Purchase Order /Solicitation Quality Assurance Requirements Form" and transmitted electronically through SAP per LMS-OP-5146, "Purchase Request Quality Assurance Review." Review comments for contract SOWs shall be completed during the procurement strategy stages and transmitted to the Office of Procurement through electronic mail.
- (4) Preparing all PA related NASA Langley Forms 45 and 45A, "Data Requirements Description, Continued".

b. The Office of Procurement (OP) is responsible for:

- (1) Assuring that PO (RFP if applicable) has been reviewed by the MAB.
- (2) Adding PA provisions to appropriate procurement documents.
- (3) Inviting the designated PA representative to proposal/source evaluations and contract technical negotiations.
- (4) Delegating PA functions to other Government agencies as specified by the MAB.

c. The originator of the PR is responsible for:

- (1) Creating the PR as a Quality Sensitive purchase order (PO) per LMS-CP-4505 and ensuring that the flow is created correctly in order to require MAB coordination and approval for all PRs that include critical and complex items.

### **3.3 DELEGATION OF QUALITY FUNCTIONS**

- a. Delegation of quality functions to another agency will be done on selected procurements. MAB will provide the OP with a description of the delegated functions. The basic elements to be evaluated by the Delegated Agency (DA) in the Letter of Delegation (LoD), include, but are not limited to procedure approvals, bonded stores, configuration management, contamination control, engineering model, fabrication control, failure reporting and corrective action, metrology, parts and materials, processes, receiving inspection, software quality assurance, software testing, supplier audits, hardware testing, inspection, training, and certification. The DA may be required to submit a Quality Assurance (QA) Plan.
- b. The OP will prepare a LoD, NASA Form 1430, "Letter of Contract Administration Delegation, General," which includes clear intent and definitive authorities. The LoD does not revoke LaRC's ultimate responsibility, but provides for LaRC's right to intercede.

#### **3.3.1 Criteria**

The need for delegation to another agency at or near LaRC contractor facilities will be established by consideration of the following criteria:

- a. Inspection at any point other than the source 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 and shipment of unacceptable hardware or from the delay in making necessary corrections.
- c. Special instruments, gages, or facilities required for inspection or testing are available at the source and are not readily available to the LaRC organization responsible for acceptance.
- d. Government inspection at any other point would destroy or require the replacement of costly special packing or packaging.
- e. Quality control and inspection requires verification of process controls that are critical to the product, and can be accomplished only at the contractor's facility.
- f. Deliverables requiring technical inspection are to be shipped to locations other than LaRC.
- g. Inspection and testing will be done at the contractor's facility to determine product compliance and acceptance, and will not be repeated after delivery and installation.
- h. MAB workload and available MAB personnel.

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### 3.3.2 Implementation

a. Once the need for delegation has been established, the PAM will implement the following actions based upon the preceding criteria:

- (1) Prepare and deliver delegation requirements, including the names, mail codes, and telephone numbers of the QA representatives, to the Contracting Officer (CO) for inclusion in the overall delegation.
- (2) Contact the DA to make initial arrangements and generally discuss the contract and delegation assignments.
- (3) Participate with the DA to finalize delegated supplemental QA instructions, discuss manpower and the DA QA plan, and identify reports and submittal frequency to MAB.
- (4) Review and approve the DA QA Plan.
- (5) Monitor the implementation of the LoD during the contract duration to assure the QA delegation is being accomplished; adequate, capable manpower is being provided; required reports are being submitted; and proper records are maintained.

b. If a Materials Review Board (MRB) is authorized in the contract, the DA will provide a representative, authorized by LaRC, to serve on the MRB (see Chapter 7.9).

### 3.3.3 Delegation to Other NASA Field Installations

a. Under certain, conditions it may be advantageous or necessary to delegate directly to another NASA field installation. These conditions are as follows:

- (1) To support tests or launches being performed at another NASA facility.
- (2) Technical expertise to perform delegated functions is not readily available from the agency that would normally perform these functions.
- (3) It is in the best interest of the Government.

b. Delegation is to be administered in a manner that does not affect the contractual relationship between the contractor and LaRC, or between the contractor and subcontractor. Delegation to other NASA field installations will be managed the same as a delegation to another agency, but may not require a QA plan or other elements specified above depending on the extent of the inspection required.

### 3.3.4 Responsibilities

a. The Office of Procurement (OP) will:

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- (1) Provide a copy of NASA Form 1430 and NASA Form 1430A, "Contract Administration," including the QA delegation requirements to the Head of the MAB for review prior to submittal to the agency.
  - (2) Provide a copy of the final letter of delegation issued to the agency to the Head of the MAB.
- b. The Mission Assurance Branch (MAB) will:
- (1) Determine, upon receipt of a PR, if a letter of delegation is necessary.
  - (2) Prepare and deliver the QA delegation requirements to the Contracting Officer for inclusion in the overall delegation. Include with these requirements the names of the QA representatives, mail codes, and telephone numbers.
  - (3) Contact the DA to make initial arrangements and generally discuss the contract and delegation assignments.
  - (4) Arrange and participate in a planning conference with the DA to:
    - (a) Finalize the delegated supplemental QA instructions.
    - (b) Discuss manpower.
    - (c) Review the DA QA plan.
    - (d) Identify reports to be submitted to NASA.
  - (5) Arrange and participate in a post-award conference with the DA, if necessary, to review and discuss the applicable items stated above in paragraph (4), the contractor's PA program and PAP, and delegations for major subcontracts.
  - (6) Monitor the DA during the contract duration to assure that the QA delegation is being accomplished; that adequate, capable manpower is being provided; and required reports are being submitted and records maintained.

### **3.4 CONTRACT DEVIATIONS AND WAIVERS**

#### **3.4.1 General**

LaRC contracts for flight products and services will provide for utilization of Deviation and Waiver Requests (DWRs). DWRs are to be prepared using NASA Langley Form 147, "Contractor Deviation/Waiver Request," and submitted to the CO and/or the Contracting Officer's Technical Representative (COTR). The Project Office shall make a determination as to whether or not the deviation or waiver requested requires external

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customer approval first. The specifics and process for this type of determination is generally contained in the appropriate project plan(s).

### **3.4.2 Responsibilities**

- a. The Project Manager (PM) will:
  - (1) Assure provisions for Deviation/Waiver Requests (DWRs) are incorporated into statements of work.
  - (2) Obtain comments and recommendations from the appropriate project support personnel on matters relating to the DWR.
  - (3) Determine per Project requirements, what Center level of approval is required and whether or not the requested DWR requires an external customer's notification and approval as well.
- b. The Contracting Officer (CO) will:
  - (1) Receive, distribute to project managers, and contractually approve all DWRs received from the contractor. Provide notification of approval/disapproval to the contractor on all DWRs.
  - (2) Prepare and implement contract modifications for DWRs approved as necessary.
  - (3) Assure delegated Government agencies at the contractor's plants are notified of the disposition of the DWRs.
- c. The Product Assurance Manager (PAM) will:
  - (1) Provide comments and recommendations on DWRs where the DWR is related to program assurance.
  - (2) Obtain comments and recommendations from the cognizant delegated Government Quality Assurance representative on DWRs.
  - (3) Provide recommendation for DWR approval/disapproval to the Project Manager.
- d. The Contracting Officer's Technical Representative (COTR) will:
  - (1) Provide comments and recommendations on DWRs when it affects safety, durability, performance, design, or interchangeability of parts or assemblies.
  - (2) Provide recommendation for DWR approval/disapproval to the PM.

## Chapter 4

### Risk Management

#### 4.1 GENERAL

This chapter identifies the risk management (RM) requirements and tools necessary to evaluate and provide risk management for Langley programs and projects.

##### 4.1.1 Risk Management Concept

a. 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.

b. Risk Management (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 1, RM is a continuous, iterative process to manage risk in order to achieve mission success. It should be a key element and an integral part of normal program/project management and engineering processes.

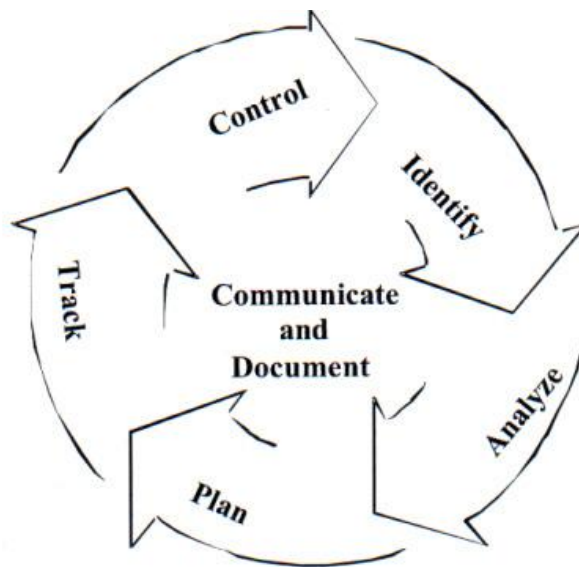


Figure 1

#### **4.1.2 Risk Management Requirements**

a. NPR 8000.4, "Risk Management Procedural Requirements," and NPR 7120.5C, "NASA Program and Project Management Processes and Requirements," provide the basic RM requirements that are applicable to all Langley programs and projects.

b. In addition to the RM requirements contained within NPR 7120.5C, other RM and RM-related requirements are included within applicable regulations and other directives. Examples include NPR 5100.4, "Federal Acquisition Regulation Supplement (NASA/FAR Supplement)," 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. NPR 2810.1A, "Security of Information Technology," 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. NPR 8705.2, "Human-Rating Requirements for Space Flight Systems," includes requirements related to risks associated with humans involved in or exposed to space flight activities. NPR 8715.3, "NASA General Safety Program Requirements," includes requirements related to safety risks. As appropriate, requirements from other sources such as these are referenced within this document.

#### **4.1.3 Risk Management Responsibilities**

a. The Project Managers (PM) are responsible for the following:

- (1) Applying a continuous risk management process within the program/project throughout its life cycle.
- (2) Documenting and approving the process within a Risk Management Plan.
- (3) Documenting and managing risks throughout the program/project's life cycle.
- (4) Approving the formal acceptance/closure of all program/project risks.
- (5) Providing program risk status, especially concerning primary risks, to the CMC or other applicable management council.
- (6) Providing project risk status, especially concerning primary risks, to the PM, Center Director, CMC, or other applicable management council.

b. The Center Management Council (CMC) or other identified management council is responsible for the following:

- (1) 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.

Verify the correct revision before use by checking the LMS Web site.



- (2) Concurrence on the acceptance of all primary risks.
- c. The Mission Assurance Branch (MAB) is responsible for the following:
  - (1) providing ongoing risk management consultation, facilitation, and training to program/project organizations.

## **4.2 OVERVIEW OF THE RISK MANAGEMENT PROCESS AT LANGLEY**

- a. RM begins early in program/project formulation and must continue in a disciplined manner throughout all program/project life cycle phases. 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.
- b. 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. For example, the IT security process as described in NPR 2810.1A considers threats (equivalent to undesirable events as used in the definition of risk in NPR 8000.4 and NPR 7120.5C), 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. The RM process identified in Figure 1 contains the basic elements of the process.

### **4.2.1 Documenting and Communicating Risk**

Effective RM requires open, clear, and ongoing communication within the program/project team. 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. RM documentation shall be readily accessible to the entire team (e.g., in an automated form, and under configuration control).

### **4.2.2 Langley Program/Project Plan**

The Program/Project Plan shall include a summary of the basic risk management planning for the program/project. The implementation of the basic strategy/philosophy for program/project risk management described in the Program/Project is then further detailed within the Risk Management Plan. The Program/Project Plan is also the location where the acceptable risk level for the program/project is defined and documented and a summary of the primary risks for the program/project is documented.

### **4.2.3 Risk Management Plan**

As specified in NPR 7120.5C, "NASA Program and Project Management Processes and Requirements," every program/project is required to have an RM Plan. This stand-



alone plan, approved by the PM during the Formulation phase, shall be an integral element of the program/project documentation. The RM Plan shall be placed under formal configuration control. The RM Plan shall be reviewed and updated as necessary when a change in program phase occurs or when significant changes in success criteria, program architecture, or design occur.

#### 4.2.3.1 Risk Management Plan Content

- a. The RM Plan shall be program/project specific, configuration controlled, and include the elements suggested in NPR 8000.4.
- b. The Process Based Mission Assurance Knowledge Management System Website <http://pbma.nasa.gov/> contains sample RM plans, a template for preparing them, and additional templates for tailoring RM to a specific project, whether large or small.

#### 4.2.3.2 Statement of Risk

The Statement of Risk is a clear, concise, and complete statement of the risk. In general, risk statements are written in a condition - consequence format (that is given the there is a possibility that will occur). It can be supported by additional information if required to place the risk in context or explain the assumptions associated with the risk. If supporting information is required, the Statement of Risk should be clearly linked to that information and where it is maintained.

#### 4.2.3.3 Risk List

- a. Every program/project shall have a risk list. 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. Risk prioritization is performed by the project team and consolidated and approved by the PM. Further instruction on this process can be found in NPR 8000.4
- b. The risk list shall be updated as changes (including changes in assumptions) occur. Extracts from the list should be presented at project meetings, reviews, and milestones as required by the RM Plan. 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). The Risk List must be widely accessible to all members of the program/project team.

### 4.2.4 Risk Mitigation Plans

These 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. These plans also include the cost and schedule information required to implement the plan. The program/project determines the format for the

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.

#### **4.2.5 Risk Acceptance Records**

These records document program/project acceptance of risk (and, if a primary risk, Langley CMC concurrence). The program/project determines 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). The risk acceptance records include the risk acceptance rationale, as well as the appropriate signatures for approval, including revalidations as required.

#### **4.2.6 Risk Trends**

These consist of displays (graphical, tabular, or textual) showing changes to risk indicators over time (i.e., decreasing, staying the same, or increasing). Trends should 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. Risk trend documentation should also be consistent with other program/project metrics information.

#### **4.2.7 Risk Profile**

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). A risk profile shall be constructed (see NPR 8000.4). Initially, the projected risk profile (that part that lies in the future) shall be annotated to explain significant, but expected, changes in risk. Over the life of a program/project, the risk profile should be updated regularly, as documented in the RM Plan, to reflect actual changes in risk. Explanations for these changes should be annotated on the profile for briefing at major milestone meetings.

#### **4.2.8 Risk Communication**

a. Early in a program/project, the PM shall develop a risk communication strategy. It 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.

b. 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

a. This chapter identifies Reliability, Maintainability, Supportability, and Probabilistic Risk Assessment requirements that are a key part in providing design assurance. Analyses and assessments are to be scheduled and completed concurrently with the design effort such that the design will reflect analysis conclusions and recommendations. Each will be performed and coordinated with Program/Project design personnel beginning during the early phases of design. As more definitive information becomes available, computations shall be performed iteratively to ensure that the design requirements are equal to or exceed the Program/Project goals. 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.

b. Support provided by the LaRC Mission Assurance Branch (MAB) will include performing reliability, maintainability, supportability 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:

- (1) NASA-STD-8729.1, "Planning, Developing and Managing an Effective Reliability and Maintainability (R&M) Program."
- (2) NPR 8705.5, "Probabilistic Risk Assessment (PRA) Procedures for NASA Programs and Projects."
- (3) NPR 8705.4, "Risk Classification for NASA Payloads."
- (4) NPR 8735.1, "Procedures For Exchanging Parts, Materials, and Safety Problem Data Utilizing the Government-Industry Data Exchange Program and NASA Advisories."
- (5) 0000028493, Constellation Systems Supportability Strategy (SS).
- (6) CxP 70043, Failure Modes and Effects Analysis and Critical Items List (FMEA/CIL) Methodology.
- (7) 0000028543, Reliability, Maintainability, and Supportability Requirements Document

c. Flight projects shall utilize NPR 8705.4, "Risk Classification for NASA Payloads." This NPR 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. The establishment of the risk level early in the program/project provides the basis for program and project managers to develop and implement appropriate mission assurance and risk management strategies and requirements and to effectively communicate the acceptable level of risk.

## **5.2 DESIGN REVIEWS**

### **5.2.1 General**

a. The MAB will 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. This activity will be initiated during the conceptual design phase and may include the review of and concurrence with design specifications, drawings, and procedures prior to release. The design review schedule will be specified in the Product Assurance Plan (PAP) or Project Plan as appropriate.

b. The following sequential set of design reviews is typical for LaRC flight projects:

- (1) Systems Requirements Review (SRR).
- (2) Conceptual Design Review (CoDR).
- (3) Project Requirements Review (PRR).
- (4) Preliminary Design Review (PDR).
- (5) Critical Design Review (CDR).
- (6) Other formal reviews as established by the Program/Project.

c. The PAM will support the project in preparation for and present the status of all product assurance activities at all design reviews.

### **5.2.2 Responsibilities**

a. The Project Manager (PM) is responsible for:

- (1) Determining the design reviews to be conducted for the project.
- (2) Conducting each design review.

- b. The Product Assurance Manager (PAM) is responsible for:
  - (1) Ensuring design reviews are conducted.
  - (2) Presenting the status of the Product Assurance activities at each design review.

### **5.3 DEVIATIONS AND WAIVERS**

- a. For purposes of this document, the following definitions apply:
  - (1) 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.
  - (2) 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).

- b. The projects shall define in the appropriate project plan/documentation the process for reviewing and approving deviations and waivers. 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. Langley Form 147, "Contractor Deviation/Waiver Request," is used for contract deviations and waivers. Deviations/waivers resulting from in-house non-compliance failure reports are additionally discussed in Chapter 7.9.

### **5.4 RELIABILITY**

#### **5.4.1 Fault Tree Analysis**

Fault Tree Analysis (FTA) may be performed on systems, subsystems, and equipment. FTA can be used in both qualitative and quantitative assessments. 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. The FTA will be utilized during the initial design phase as an evaluation tool for driving the preliminary design. 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**

a. 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. 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).

b. The FMEA will be used for the following:

- (1) Identify single failure points.
- (2) Determine needs for redundancy, fail-safe design features, and/or derating.
- (3) Identify system interface problems.
- (4) Support safety and hazard analyses.
- (5) Identify quality inspection points.
- (6) Determine allowable use time or cycles.
- (7) Determine assembly, inspection, and test procedures.

#### **5.4.2.1 Approach**

a. The FMEA is initiated during the conceptual or preliminary design phase and updated as design changes are incorporated. 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.

b. 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. The process of performing the FMEA includes the following:

- (1) Describing the system and its performance requirements.
- (2) Specifying the assumptions and ground rules to be used in the analysis.
- (3) Developing block diagrams or other simple models of the system.
- (4) Developing the analysis worksheet for every identified failure mode.
- (5) Recommending and evaluating corrective actions and design improvements.
- (6) Summarizing the analysis in report form.

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c. The FMEA is based upon single component failures and provides concise statements of the failure mode and its effects. The following basic failure modes are to be imposed at the lowest level of definition:

- (1) Premature operation.
- (2) Failure to operate at prescribed time.
- (3) Failure to cease operation at prescribed time.
- (4) Failure during operation.
- (5) Degraded operation.

d. The effects of a single point of failure are to be determined at the next level of definition. Although a redundant element is considered to terminate the failure effect on the system, the failure mode and effect on the subsystem is to be identified. Analysis results and pending actions is presented during the PDR and updated for the CDR and Flight Readiness Review (FRR).

#### 5.4.2.2 Criticality Category

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. 1R#: 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., 1R3 – 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.

#### 5.4.2.3 Disposition and Justification

Single failure points are to be eliminated by the removal or redesign of the component or mitigated by graceful degradation or redundancy. 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.

#### 5.4.2.4 Critical Items List

- a. A critical items list (CIL) will be derived from the FMEA process and will identify the rationale or justification for retaining critical items. The CIL will be maintained current and presented at each design and readiness review.
- b. Utilizing the FMEA, the following classification of failure modes, as a minimum, will be entered in the CIL:
  - (1) All functional criticality category 1 and 2 items.
  - (2) All functional criticality 1R 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.
  - (3) All functional criticality category 1R and 2R items that fail one or more redundancy screens.
- c. The CIL is to contain the following information, sequenced as indicated:
  - (1) A concise statement of the purpose of the report.
  - (2) A description of the major systems contained in the CIL with general information as to what type of data is contained in the CIL.
  - (3) The rationale or justification for retaining critical items.
  - (4) A critical hardware list which provides a listing of line replaceable unit (LRU) part numbers, reference designators, LRU nomenclature, LRU highest level criticality, lower indenture level part numbers identified by the FMEA, failure mode number, quantity of items in the subsystem, and the criticality for each FMEA number.
  - (5) Individual pages describing the actual analysis results.



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#### 5.4.2.5 Responsibilities

- a. The Project personnel will:
  - (1) Perform FMEA/CIL.
  - (2) Report results at appropriate design reviews.
- b. The Mission Assurance Branch (MAB) personnel will:
  - (1) Provide guidance on performing FMEA/CILs.
  - (2) Review FMEA/CILs.
  - (3) Perform independent FMEA/CILs upon request.
- c. The Project Manager (PM) will:
  - (1) Implement the reliability assurance requirements.
  - (2) Approve FMEA/CILs.

#### 5.4.3 Reliability Prediction

- a. Reliability predictions may be performed by MAB personnel as part of design assurance to support (through quantitative analysis) trade studies, Probabilistic Risk Assessments, quantitative Fault Tree Analyses, Supportability, and Maintainability and Availability Studies.
- b. 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. This can be accomplished through utilizing heritage data, manufacturer testing, and design engineering testing (including component and integrated level testing). Bayesian techniques can be used to update initial predictions (this methodology is described in various literatures). 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).
- c. 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. In general, the parts listed in the NPSL:
  - (1) Have established procurement specifications.

- (2) Have available source(s) of supply.
- (3) Are capable of meeting a wide range of application needs.
- (4) Have been assessed for quality, reliability, and risk and found to meet the criteria for listing.
- (5) Provides easily assessable information for design engineers.

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

#### **5.4.4 Derating Analysis**

Derating analysis may be performed using information provided by design engineers, EEE parts engineers, and the MAB. 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. This analysis is typically performed by LaRC design engineers with design team (including EEE parts and MAB).

#### **5.4.5 Worst Case Analysis (WCA)**

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. 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. WCA is performed on critical flight equipment (i.e., identified in a FMEA/CIL). This analysis is typically performed by LaRC design engineers and other design team personnel (e.g., EEE parts and MAB).

### **5.5 MAINTAINABILITY AND AVAILABILITY**

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

b. Maintainability assessments will 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:

- (1) Accessibility
- (2) Interchangeability
- (3) Failure detection

- (4) Failure isolation
  - (5) Special tools and diagnostics
  - (6) Spares
- c. Information developed as part of the maintainability assessments will be utilized in other analyses (e.g., FMEA/CIL, Availability).
- d. Availability assessments will 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**

Cost and logistics trade studies and analysis, where required, will be executed and coordinated by system design engineering. However, MAB will 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)**

- a. Probability Risk Assessment (PRA) is a technique used to assess Program/Project risk by asking three basic questions:
- (1) What can go wrong?
  - (2) How likely is it?
  - (3) What are the consequences?
- b. The PRA quantifies undesired scenarios identified using risk management practices. 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.

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### 5.7.1 PRA Process

- a. The process and techniques provided in the NPR 8705.5, "Probabilistic Risk Assessment (PRA) Procedures for NASA Programs and Projects," shall be used for conducting PRAs. In addition, NPR 8705.5 cites references that provide more detailed information concerning the PRA process.
- b. As a guideline, the following table illustrates various types of Programs/Projects and the scope of PRA that is required.
- c. The PRA process is found in table 5.7.1 on the following and includes:
  - (1) objective definition
  - (2) system familiarization
  - (3) identification of initiating events
  - (4) scenario modeling
  - (5) failure modeling
  - (6) quantification
  - (7) uncertainty analysis
  - (8) sensitivity analysis
  - (9) importance ranking
  - (10) data analysis

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

Table 5.7.1, Criteria for Selecting the Scope of a Probabilistic Risk Assessment (PRA)

F is Full Scope PRA

L/S is Limited Scope PRA

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## 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 are to be reviewed for quality, application, and safety problems associated with parts and materials used by the project. Any problems encountered by the project are to be documented and reported in accordance with the GIDEP, NARS, and LLIS.

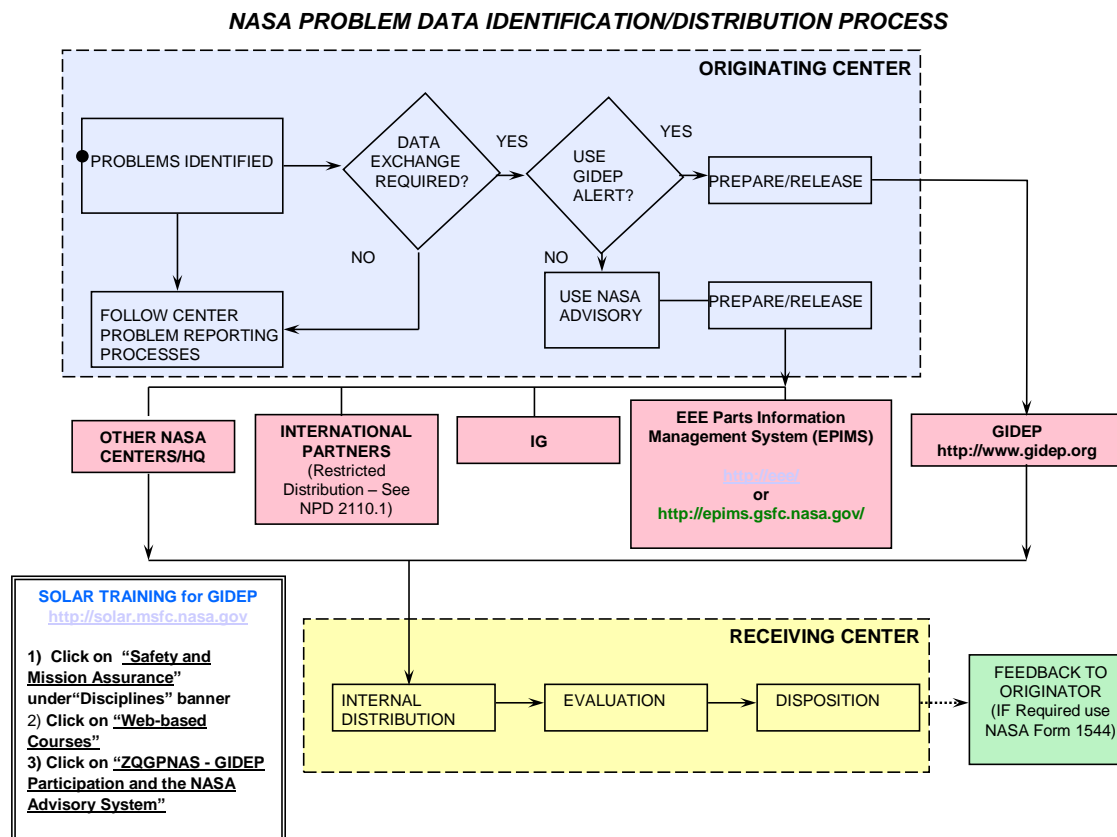


Diagram 5.8.1, NASA Problem Data Identification/Distribution Process from NPR 8715.6

### 5.8.2 Responsibilities

a. 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.

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b. 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. This process is presented in the following diagram.

a. The LaRC GIDEP representative will:

- (1) 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 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.
- (2) 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.
- (3) 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.
- (4) Submit LaRC GIDEP Utilization report to GIDEP at the end of each fiscal year per NPR 8735.1.
- (5) Utilize NASA Form 1544, "Problem Impact Statement - Parts, Materials, and Safety," as appropriate per NPR 8735.1.
- (6) 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.

b. The Product Assurance Manager (PAM) will:

- (1) 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.
- (2) Document problems found and forward to the LaRC GIDEP representative.
- (3) Review supplier procurement history.
- (4) Determine if contractor participation in GIDEP is appropriate based on the type of procurement, acquisition phase, contract cost, and criticality of equipment.

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c. The Organizational Heads/Systems Engineers/EEE Parts Engineers/Facility Safety personnel will:

- (1) 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.
- (2) Ensure that personnel aid in the preparation of reports when appropriate for GIDEP.
- (3) Ensure that reports for submittal to GIDEP are accurate and complete.
- (4) Review supplier procurement history.
- (5) 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**

a. Each mission shall conduct a formal assessment of the potential to generate orbital debris in accordance with NPD 8715.6, "Limiting Orbital Debris" and NASA-STD 8719.14, "Procedures for Limiting Orbital Debris."

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

c. 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. The following issues are to be addressed:

- (1) Debris released during normal operations.
- (2) Debris generated by explosions and intentional breakups.
- (3) Debris generated by on-orbit collisions during mission operations and orbital lifetime.
- (4) Safe disposal of upper stages and spacecraft after mission completion.
- (5) Structural components impacting the Earth following post-mission disposal by atmospheric reentry.



## **Chapter 6**

### **PARTS AND MATERIALS**

#### **6.1 GENERAL**

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. The parts and materials (P&M) section of the PAP is to be developed from the requirements of this chapter.

All mechanical and EEE parts and components are to be identified on a Parts Inventory Report (PIR). Sufficient spares are to be procured to ensure the replacement of defective parts and parts required for destructive testing.

#### **6.2 MECHANICAL PARTS**

Mechanical parts and components include structural and mechanical piece parts, fasteners (all types), mechanical devices, and springs. All fasteners received at LaRC shall be verified by the Quality Assurance Branch (QAB), as specified on the PO. Upon acceptance, fasteners and their associated certification documentation will be maintained in the appropriate bonded stores area (see Chapter 7.11).

#### **6.3 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL PARTS**

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

##### **6.3.1 Implementation**

The LaRC EEE Parts Manager (EPM) will coordinate the NASA Electronic Parts and Packaging Program (NEPP) with the NASA Parts Project Office of NASA Headquarters and MAB. The EPM will develop and implement the EEE Parts Plan in accordance with LMS-OP-5515, "Electric, Electronic, Electromechanical (EEE) Parts Assurance," for LaRC internal projects. The EEE Parts Plan shall be submitted to and approved by the MAB prior to the PDR.

##### **6.3.2 Standard Parts**

Parts selected and procured from the NASA Parts Selection List (NPSL) or Goddard Space Flight Center (GSFC) Preferred Parts List are identified as "standard parts" and are to be used as a first order of preference. 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. The EPM will ultimately approve all EEE parts.

### **6.3.3 Nonstandard Parts**

Parts that do not meet the criteria of “standard parts” are identified as “nonstandard parts.” The EEE Parts Plan shall identify qualification-testing requirements for all “nonstandard parts.” The Electronic Systems Branch will perform qualification testing of EEE parts. Any nonstandard parts require the submittal of NASA Langley Form 170, “Nonstandard Part Approval Request (NSPAR),” with supporting data package for LaRC consideration and approval.

## **6.4 MATERIALS**

### **6.4.1 Selection**

- a. Flammability, stress corrosion, outgassing, and offgassing requirements for materials, including mechanical parts and components, shall be based upon payload cleanliness goals and any specific launch vehicle requirements.
- b. 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,” may be used for guidance in determination of material requirements.
- c. 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 offgassing requirements. The MUA is to be routed through the MAB to the integrator’s approving organization.

### **6.4.2 Composites**

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

### **6.4.3 Limited Life Items**

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

#### **6.4.4 Materials List**

A listing of selected materials is to be developed and maintained current. The Materials List (ML) shall contain a reference to the document from which acceptability was ascertained.

#### **6.5 RESPONSIBILITIES**

- a. The Project Manager (PM) is responsible for:
  - (1) Material selection and procurement.
  - (2) Preparation of the PIR and ML.
  - (3) Initiating the MUA process.
- b. The Product Assurance Manager (PAM) is responsible for:
  - (1) Verifying material compliance through review and approval of MLs and MUAs.
  - (2) Verifying parts compliance through review and approval of PIRs, EEE Parts Plans, CMQPs, and limited life items.
- c. The EEE Parts Manager (EPM) is responsible for:
  - (1) Coordinating the NASA Standard Parts Program with the NASA Parts Project Office of NASA Headquarters and the MAB.
  - (2) Developing and implementing the EEE Parts Plan for LaRC internal projects.
- d. The Electronic Systems Branch is responsible for:
  - (1) Qualification testing of nonstandard EEE parts.
- e. The Quality Assurance Branch (QAB) is responsible for:
  - (1) Verifying fasteners received at LaRC are as specified on the PO.

## **Chapter 7**

### **QUALITY ASSURANCE**

#### **7.1 GENERAL**

- a. This chapter identifies the quality assurance (QA) requirements for the fabrication, assembly, disassembly, integration, testing, handling, preservation, and shipping of flight products. The QA section of the PAP is to be developed in accordance with the requirements of this chapter.
- b. The Quality Assurance Branch (QAB) maintains quality assurance cognizance of flight hardware during fabrication. The Mission Assurance Branch (MAB) will initiate and maintain quality assurance cognizance of flight hardware and Ground Support Equipment (GSE) upon delivery to the project.

#### **7.2 INSTITUTIONAL SAFETY INTERFACE**

##### **7.2.1 General**

- a. All flight product and associated GSE fabrication, assembly, disassembly, and test operations are to comply with established LaRC safety policies and the following:
  - (1) Work shall be terminated when any unsafe condition exists that could cause injury to personnel or damage to hardware, software, and associated GSE.
  - (2) All assembly, disassembly, and test operations are to be conducted in accordance with written procedures approved by personnel designated in the PAP.
  - (3) Any operations designated as hazardous (i.e., risks personnel injury and/or illness and/or property damage/destruction) are to be conducted in accordance with written procedures approved by personnel designated in the PAP and the LaRC Safety Manager.
  - (4) Changes to hazardous operations procedures are to be approved prior to implementation.
- b. All personnel are responsible for reporting unsafe conditions or situations to the Designated Project Engineer (DPE), Facility Coordinator, or PAM. Anyone observing an action which creates an imminent danger or hazard to personnel or equipment has the authority to have such action terminated. In such instances, the LaRC Safety Manager must be immediately notified.

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### **7.2.2 Responsibilities**

- a. The Project Manager (PM) is responsible for:
  - (1) Implementation of the LaRC Safety Program for the project.
- b. The assigned QAB Quality Assurance Specialist (QAS) or the MAB Quality Assurance Specialist (MAB QAS) is responsible for:
  - (1) Assuring that neither the flight hardware nor operational personnel associated with its fabrication, assembly, testing, or handling are exposed to hazards which could cause damage to the hardware or injury to personnel.
  - (2) Coordinating resolution of safety concerns with both institutional safety and project management.
- c. The LaRC Safety Manager is responsible for:
  - (1) Approving all hazardous procedures and subsequent changes for hazardous operations.
- d. All LaRC personnel are responsible for:
  - (1) Reporting unsafe conditions or situations to the DPE. Further, if any employee observes an action, which creates an imminent danger or hazard to personnel or equipment, that employee has the authority to have such action terminated. In such instances, the LaRC Safety Manager, extension 4-7233, must be immediately notified.

### **7.3 SOFTWARE**

The PAP shall require compliance with LMS-CP-5528, "Software Planning, Development, Acquisition, Maintenance, and Operations."

### **7.4 METROLOGY**

Procedures for the calibration and control of laboratory standards, precision measurement instruments, and test equipment used to support fabrication, assembly, and test activities are to be in accordance with LMS-CP-0506, "Selection, Use and Control of Inspection, Measuring, and Test Equipment (IM&TE)," and LMS-CP-0510 "Procurement of Inspection, Measuring and Test Equipment (IM&TE)."

## **7.5 RECEIVING AND INSPECTION**

Shipping and receiving personnel are to inspect flight product packages for external damage only. Packages are not to be opened. As specified on the PO, undamaged packages are to be delivered to the Quality Assurance Branch (QAB). The QAB will assure that the acceptance criteria stated on the procurement specifications are satisfied in accordance with LMS-CP-4758, "Receipt Inspection for Safety-Critical Products."

### **7.5.1 Certification**

a. Certification requirements for all metallic and nonmetallic materials, including fasteners and weld filler material, are to be specified in the PO via information contained on LF 188, "Contract/Purchase Order /Solicitation Quality Assurance Requirements Form." Documentation received with products is to be retained for traceability to the manufacturer. As a minimum, this documentation shall include the following:

- (1) LaRC PO number.
- (2) Date shipped by supplier.
- (3) Supplier's name and address.
- (4) Part number.
- (5) Raw material identification information.
- (6) Quantity accepted.
- (7) Contractor's inspector acceptance stamp.

b. A sample of the product's "parent" material (verification coupon) may be requested as part of the certification requirements.

### **7.5.2 Verification**

a. The physical properties and chemical composition of materials are to be verified by the Quality Assurance Branch (QAB) as specified on the PO. Evidence of the following required supplier's inspections and tests, if applicable, are to be verified during receiving inspection:

- (1) Material certification test report.
- (2) Evidence of supplier inspection acceptance.
- (3) Certification that end-items is from material furnished.

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- (4) Test data.
  - (5) Inspection reports.
  - (6) Other documentation as specified in the PO.
- b. Verification coupons, if required, are to be spectrochemically analyzed to verify their composition. Heat-treated materials are to be hardness tested to verify specified heat treatment.
- c. Fasteners (including bolts/nuts, screws, washers, rivets, and welding rods) are to be verified from lot samples as specified by the Quality Assurance Branch (QAB) and the PO. Any fastener identified as “fracture critical” is to be verified at 80 percent of its specified yield strength.

### **7.5.3 Rejection of Received Articles**

Articles which do not conform to drawings, specifications, or purchase order acceptance criteria or do not have adequate or correct data are to be documented in the LaRC Nonconformance Failure Report (NFR) Web System, and held for MRB disposition (see Chapter 7.9).

### **7.5.4 Responsibilities**

- a. The Quality Assurance Branch (QAB) is responsible for:
- (1) Verifying parts and materials received, as specified on the PO, comply with procurement specifications by performing mechanical testing, chemical analysis, microscopic examination, and destructive testing.
  - (2) Documenting any nonconformance on a test report, and reporting it to the Technical Initiator of the Purchase Request and to Contracting Officer.
- b. Shipping and Receiving personnel are responsible for:
- (1) Inspecting flight product packages for external damage only.
  - (2) Delivering undamaged packages to the QAB as specified in the PO.

## **7.6 FABRICATION PLANNING**

Fabrication, assembly, disassembly, test, and inspection operations of all flight products and associated GSE performed at LaRC facilities are to be accomplished in accordance with CID-5640, “Requesting, Performing, and Closing Fabrication Services Requests.” Contractor sites or subcontractor sites must utilize approved drawings and a documentation system equivalent to that identified in this chapter.

### **7.6.1 Fabrication Work Request**

A completed NASA Langley Form 133, "Fabrication Work Request," (FWR) with Fabrication Representative (FR), the person receiving the work, approval, is required to initiate fabrication activities. All flight product FWRs are to be marked as "Formal" and signed by the requestor or project representative.

### **7.6.2 Fabrication and Inspection Operations Sheet**

A NASA Langley Form 136, "Fabrication Inspection and Operations Sheet," (FIOS) is to be prepared for each serialized part, group of parts, or subassembly as per CID-5640, "Requesting, Performing, and Closing Fabrication Services Requests." All FIOS's require approval by the QAS, FR, and requestor or the project representative.

### **7.6.3 Fabrication Processes**

a. Process specifications are required for certain fabrication and assembly operations when any of the following conditions exist:

- (1) The final result or completion operation is not inspectable or testable.
- (2) The operation is sufficiently complex such that an experienced operator cannot successfully perform the operation with repeatable results.
- (3) The operation is potentially destructive to hardware or personnel.
- (4) The operation can generate destructive by-products, such as contamination, not apparent to the operator.

b. Existing proven processes (i.e., soldering, welding, heat treatment, coatings, etc.) are to be used on qualification and flight hardware and performed by qualified personnel.

c. All process specifications are to be submitted by the QAB QAS to the project representative for concurrence with adequacy and compliance to design requirements. Process documentation is to be available for review at the facility where the process is implemented. Processes are to be identified by number and revision and placed under configuration control.

### **7.6.4 First Article Inspection**

The purpose of the First Article Inspection (FAI) is to give objective evidence that all engineering, design, and specification requirements are correctly understood, accounted for, verified, and recorded. During preparation of the FIOS, first article inspection requirements shall be identified. The FIOS shall require the appropriate inspection, verification, and documentation of a representative item from the first production run of a new part or following any subsequent changes that invalidates the



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previous first article inspection result. Any change to First Article Inspection requirements shall be negotiated with the customer and clearly defined in the PAP.

### **7.6.5 Responsibilities**

- a. The Fabrication Representative (FR) will:
  - (1) Review and approve the FWR.
  - (2) Review and approve the FIOS.
- b. The QAB Quality Assurance Specialist (QAB QAS) will:
  - (1) Review and approve FIOS.
  - (2) Identify QAS inspection points on the FIOS.
  - (3) Verify required inspections are performed.
  - (4) Assist the DPE in preparing the FIOS.
  - (5) Assure all fabrication process steps are performed and signed off in sequence.
- c. The Designated Project Engineer (DPE) will:
  - (1) Initiate NASA Langley Form 133.
  - (2) Prepare the FIOS.
  - (3) Review and concur that process specifications are adequate and comply with design requirements.

### **7.7 WORKMANSHIP STANDARDS**

- a. All flight work performed shall meet the following Agency Workmanship standards:
  - (1) NASA-STD-8739.1, "Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies."
  - (2) NASA-STD-8739.2, "Workmanship Standard for Surface Mount Technology."
  - (3) NASA-STD-8739.3, "Soldered Electrical Connections."
  - (4) NASA-STD-8739.4, "Crimping, Interconnecting Cables, Harnesses, and Wiring."

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- (5) NASA-STD-8739.5, "Fiber Optics Terminations, Cable Assemblies, and Installation."

b. Alternate standards may be used when approved by the Project and the Mission Assurance Branch and shall be stated in the Product Assurance Plan. Suppliers shall submit for review and acceptance as required in the contract, any alternate standards. In such alternate standards, the supplier shall stipulate the differences between the alternative standards and the required standard prior to approval.

c. In order to meet the requirements of ANSI/ESD S20.20, the Langley Research Center has adopted the Goddard Space Flight Center's Workmanship Manual for Electrostatic Discharge Control, GSFC-WM-001A. Training is offered at the NASA Manufacturing Technology Transfer Center (NMTTC) or by a LaRC level B instructor.

### **7.7.1 Worker Certification**

Upon completion of the Workmanship Standards training, operators and inspectors are required to have a Certificate of Certification signed by their supervisor. The line organization determines any additional requirements (in-addition to the class training), such as, on-the-job training, hours/jobs worked, be necessary to be certified. The line organization is responsible for maintaining records and workers certification status as necessary. The MAB is allowed to audit/review a worker's status and/or records as required.

## **7.8 HARDWARE IDENTIFICATION**

### **7.8.1 Identification Number**

a. Parts and assemblies are to be identified by an Identification (ID) Number consisting of a Part Number (PN) and a Serial Number (SN). Exceptions are as follows:

- (1) Parts which are permanently attached to other parts or assemblies (i.e., by welding, riveting, brazing, soldering, etc.).
- (2) Batch or lot controlled parts manufactured or processed in one operation do not require serial numbers.
- (3) Parts or assemblies specifically exempted as specified on drawings.

b. The PN identifies the LaRC drawing number from which the article was fabricated, the article drawing dash number, and the article drawing revision. A SN is added to the PN when like articles are to be manufactured with multiple operations.

c. The beginning SN, "001," is to be assigned to the first article manufactured regardless of type (i.e., prototype, qualification unit, etc.) and will be consecutive through all configuration changes.

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- d. In general, the ID number sequence is illustrated as follows:

PN			SN	
XXXXXXXX	-	XXX	X	XXX
A	B	C	D	E

Where,

A = Seven figures (maximum) for identifying LaRC drawing number from which the article is fabricated.

B = Dash for separating article's drawing number from its drawing dash number.

C = Three figures for article's drawing dash number.

D = One letter noting article's drawing revision (if drawing revision is not applicable, a dash will be used in lieu of a letter).

E = Three figures starting with "001" for the first of multiple parts and assemblies.

Example: 1023907-001A001

- e. Fabrication technology personnel are to identify hardware as specified on engineering drawings. When no Identification (ID) Number is specified, the Tracking Number on the FIOS is to be used.

### 7.8.2 Identification Number Location

- a. The ID Number is to be marked directly on the article, whenever possible, as follows:

- (1) Location of the ID Number on the article is to be specified on the article drawing.
- (2) The ID Number is to be legible after installation or assembly whenever possible.
- (3) The ID Number of assemblies is to be visible under normal vision and lighting conditions.

- b. Articles having unsuitable or insufficient surfaces for direct marking (i.e., small springs, glass, plastic, optical elements, wire harnesses, etc.) or drawings which specify "NO MARKING PERMITTED" are to be identified by an ID Number on an attached

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identification tag (NASA Langley Form 183, "Hardware Identification Tag," or equivalent).

c. Articles which cannot be marked by other means, or where individual tagging is not practical (i.e., small electrical or electronic parts, attaching hardware, parts having dielectric properties, etc.) will be "bagged and tagged" as follows:

- (1) Articles are to be "bagged" in boxes, envelopes, bags, or other appropriate containers.
- (2) Containers are to be "tagged" by affixing an identification tag (NASA Langley Form 183 or equivalent)

d. Contents of the container are to be verified by a QAB QAS with appropriate quality stamping (see Chapter 7.10).

### **7.8.3 Identification Number Marking**

a. The ID Number marking method (determined by contamination control requirements, size of the part, surface properties, etc.) is to be specified on drawings. Standard acceptable methods of marking are ink, electrochemical etching, chemical etching, and dot peening.

b. Dot peening, the preferred method, is a programmable marking system which utilizes a direct contact stylus. This method is capable of producing a wide variety of markings on all types of materials and surfaces.

c. Articles, which contain optical elements subject to condensable volatile contamination, require special marking processes. These special processes shall be identified in the PAP.

d. Ink markings are to be applied directly on articles or identification tags with direct type stamps, indirect type stamps, or stencils available in small typeface (3/32" height) or large typeface (1/8" height). Markem Ink Company 7224 ink, or equivalent, is to be used in white, black, or green colors. Identification tags shall be NASA Langley Form 183 or equivalent.

e. When a non-injurious method is required for permanent marking of bare metallic or conductive surfaces, electrochemical etching will be used in preference to ink marking. Electrochemical etching is accomplished by use of the LECTROETCH Company power unit, or equivalent, in accordance with the manufacturer's recommendations (including electrolyte and cleaner specified) unless otherwise specified on drawings. The resulting etchings and the surrounding area are to be thoroughly cleaned to remove corrosive chemicals after use.

f. Etching depth is subject to operation variables. If the depth of the etch is critical (e.g., fatigue life), samples are to be prepared at various voltages and application

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duration to determine those variables necessary to achieve an acceptable depth of etch.

g. The ID Number marking for printed circuit boards is limited to chemical etching. The PN is chemically etched as part of the fabrication process. If more than one board of the same drawing is fabricated, the SN will be silk screened using glass baking epoxy ink (NAZ-DAR-BE-112 White or BE-111 Black). After application, the board is to be baked at 250 °F for one hour to cure the ink.

#### **7.8.4 Identification Removal**

Upon removing the articles for final use, the identification tag is placed in the appropriate logbook (see Chapter 7.12) and the ID Number recorded on NASA Langley Form 154, "Configuration Record," by the MAB QAS.

#### **7.8.5 Responsibilities**

- a. The Designated Project Engineer (DPE) is responsible for:
  - (1) Providing the ID number, ID number location, and ID number marking method on engineering drawings.
- b. Fabrication Technology personnel are responsible for:
  - (1) Marking and tagging of articles.
- c. The QAB QAS is responsible for:
  - (1) Verifying contents of "Bag and Tag" containers by quality status stamping identification tags.
- d. The MAB QAS is responsible for:
  - (1) Placing the identification tag in the appropriate logbook and recording ID Number on NASA Langley Form 154.

### **7.9 NONCONFORMANCE AND FAILURE REPORTING**

- a. Nonconformances and failures are required to meet specific reporting, disposition, documentation, verification, and close out requirements as specified below.
- b. For purposes of this document, the following definitions apply:
  - (1) Nonconformance: A condition or characteristic of any hardware or software item that does not conform to drawings or other specifications.

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- (2) Failure: The inability of a system, subsystem, component, or part to perform in accordance with a specified functional test or operating requirement.

### 7.9.1 Reporting

a. All nonconformance and failures associated with flight products are to be documented in the LaRC Nonconformance/Failure Reporting (NFR) Web System. The URL for the system is <http://nfr-anomaly.larc.nasa.gov>. The help section of the Web System will give instructions for the use of the system. The proper project personnel are added to the system as new projects are established by Mission Assurance Branch (MAB) personnel. Passwords are obtained from the MAB. Paper copies are to be printed from the Web system to be placed in work order packages and logbooks. The official records reside in the electronic database. A paper copy of the form can be used in the field if no access to the computer system is available, but must be added to the database as soon as practical.

b. If the reported nonconformance or failure poses a safety hazard to personnel or equipment, operations are to be discontinued in an orderly manner. Operation will resume pending proper documentation and disposition of the nonconformance or failure as authorized by the Material Review Board (see Disposition chapter).

### 7.9.2 Disposition

a. The cognizant engineer is only authorized to return the discrepant item for completion of work to be performed, for return to supplier, or for scrap. Other dispositions require the approval of a Materials Review Board (MRB). A project MRB is to be established with authority to make dispositions. The project MRB is a technical team comprised of the DPE, QAB QAS or MAB QAS, and a representative from project management. The MAB QAS is to maintain a current list of MRB membership and other technical experts as appropriate. The project manager shall provide the MAB with a list of all personnel authorized to make NFR disposition decisions and then respective functional designations. The MAB QAS shall input the names into the NFR system in the appropriate function and maintain current. All NFR dispositions are to be compatible with specified design, performance, interface, reliability, and safety requirements and not unduly be driven by the impact upon costs and schedules.

b. Unanimous agreement by the MRB is required to make a disposition. If unanimous agreement cannot be reached, the Project Manager is to authorize an appropriate disposition. The designated QAB QAS or MAB QAS shall notify the Head of the MAB if unable to concur with the disposition. In all cases, the project representative cannot be the DPE or cognizant engineer providing the disposition.

c. In developing the disposition, the MRB shall evaluate whether a waiver is required and/or what level of Center/Customer approval is required per LMS-CP-5507, "Reporting and Disposition of Nonconforming Aerospace Hardware Items and Products." The use of "use as-is" or repair dispositions shall not be used unless specifically authorized by the customer if the product is produced to a customer design.

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or the nonconformity results in a departure from the customer requirements. If outside approval is required, the Project will initiate and follow through accordingly and note on the disposition of the NFR.

### 7.9.3 Scrap

a. Nonconforming parts and materials identified as scrap shall be rendered into a condition to ensure they are unusable for their original application and incapable of being reworked or camouflaged to provide the appearance of being serviceable. Scrap parts and materials will be segregated from conforming materials by storing them in a controlled storage area until disposal. Items too large to be easily moved or placed in the controlled area shall be tagged and/or marked in place to identify it as scrap. Marking of scrap parts and materials shall be performed in any of the following manners: Ink Marking; electrochemical etching; chemical etching; dot peening; tagging; etc. Effective disposal may be accomplished by, although not limited to, one or a combination of the following methods:

- (1) Grinding.
- (2) Burning.
- (3) Removal of a major integral feature.
- (4) Permanent distortion of parts and materials.
- (5) Cutting a significant size hole with a cutting torch or saw.
- (6) Melting.
- (7) Sawing into many small pieces.
- (8) Removing manufacturer identification, part, lot, batch, and serial number.

b. There are several suitable disposal containers marked for metallic parts emptied by a contractor at the Center. Parts can be placed in these locations after implementing one of the above disposal methods.

c. Quality assurance personnel shall witness the part being rendered unusable, and signature on the close out of the NFR will designate that such witnessing took place.

### 7.9.4 Documentation

a. All NFRs generated during the fabrication process are to be logged and maintained on the appropriate FIOS. A paper copy of all NFRs generated will be included in the Work Order Package.

b. A paper copy, printed from the NFR Web System, for each NFR is to be included in the logbook. Logbooks are to be maintained by the DPE.



### 7.9.5 Verification and Closeout

The completion of all quality actions and dispositions require verification by the designated QAS/Quality Assurance Representative (QAR) to close an NFR. The MAB QAS will verify closure of all NFRs. A paper copy of the NFR is to be printed from the Web System and maintained in the project logbooks.

### 7.9.6 Responsibilities

- a. The originator of a NFR will:
  - (1) Complete Part A of NASA Langley NFR Web form. Distribution to the Designated Project Engineer by e-mail will occur once Part A has been completed and approved.
- b. The Designated Project Engineer (DPE) will:
  - (1) Make technical decisions and recommendations for disposition compatible with design/performance requirements, specifications, reliability, and safety.
  - (2) Complete Part B of NASA Langley NFR Web form or convene the MRB.
  - (3) Provide appropriate details of engineering analyses as required or as requested by other MRB members.
  - (4) Prepare necessary detailed instructions for implementing disposition activities directed by the MRB on Part C of NASA Langley NFR Web form.
  - (5) Approve the MRB disposition (Part D on paper form).
- c. The QAB Quality Assurance Specialist (QAB QAS) or the MAB Quality Assurance Specialist (MAB QAS) will:
  - (1) Assure that reliability, quality, and safety is adequately considered in determining the disposition of the NFR.
  - (2) Approve the MRB disposition to indicate concurrence with the MRB disposition (Part D on paper form).
  - (3) Verify that dispositions are satisfactorily completed for closeout, Part E of NASA Langley NFR Web form.
  - (4) Defer to next highest level of line management if unable to concur with any NFR disposition considered incompatible with design/performance requirements, interface specifications and/or quality/reliability requirements, or considered beyond scope of responsibility.



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- (5) QAB QAS will perform above functions for all NFRs generated during fabrication of flight hardware.
- d. The MAB Quality Assurance Specialist (MAB QAS) will:
  - (1) Maintain current list of MRB membership.
  - (2) Enter Project data into the NFR Web system as required for existing or new projects.
  - (3) Perform final closeout of all NFRs on the Web System.
  - (4) Participate in MRB actions as required.
  - (5) Defer to Project Manager if unanimous agreement cannot be reached by the MRB.
- e. The Project Manager (PM) will:
  - (1) Insure the project adheres to the NFR requirements.
  - (2) Participate in MRB dispositions as required.
  - (3) Arbitrate MRB action when unanimous agreement cannot be reached, and approve Part D of MRB as required.
  - (4) Assign project representative when deemed necessary.
- f. The Project Representative will:
  - (1) Represent the Project Manager as requested.
  - (2) Perform all duties of the project manager as directed with the exception of approving MRB activities when a unanimous agreement cannot be reached.

## **7.10 QUALITY STATUS STAMPS**

- a. Quality Status Stamps (QSS) provide functional accountability for the quality status of products through the identification of quality assurance personnel by number. Every stamped impression is to be accompanied by a handwritten date. QSS are required to meet specific criteria, application, procedures, and issuance and control.
- b. An authorized QSS user log will be maintained by the MAB. Inappropriate and unauthorized use of stamps could lead to disciplinary action.
- c. QSS issued to NASA Langley Civil Servants can be utilized as a means of verifying quality status of flight related products, documentation, containers, and other articles as follows:

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- (1) Conformance Stamp: A triangular shaped stamp used to indicate that items satisfy requirements and conform to prescribed criteria.
- (2) Nonconformance Stamp: A hexagonal shaped stamp used to indicate that items have been inspected and/or tested, but do not conform to requirements. Such items are subject to further corrective actions, inspections, tests, investigations, processing, or contract action.
- (3) Void Stamp: A "D" shaped stamp used to indicate that previous inspections, tests, and accompanying documents are void.

d. QSS issued to NASA Langley on-site contractors can also be utilized as a means of verifying quality status of flight related products, documentation, containers, and other articles.

- (1) Honeywell QA representatives utilize NCAS Quality Status Stamps as follows:
  - (a) Conformance Stamp - a rectangle with the words "NCAS Accepted" and the stamp number in black ink.
  - (b) Nonconformance Stamp – a circle with the words "NCAS Rejected R" and the stamp number in red ink.
- (2) Mainthia Technology Incorporated (MTI) QA representatives utilize government-purchased contractor Quality Status Stamps as follows:
  - (a) Conformance Stamp – a circle with the words "QA Accepted" and the stamp number in black ink.
  - (b) Nonconformance Stamp – a circle with the words "QA Rejected" and the stamp number in red ink.

### 7.10.1 Quality Status

Quality status is to be controlled and maintained as follows:

- a. All independent entries, steps, tasks, etc. delineated on equipment history records, test procedures, fabrication work documents, etc. satisfactorily accomplished and witnessed, inspected and/or verified by QA personnel are to be "CONFORMANCE" stamped.
- b. When any previously stated condition is unsatisfactory or nonconforming, it is to be "NONCONFORMANCE" stamped and identified by referring to an NFR.
- c. Whenever a previously accepted entry, step, task, etc. no longer conforms to requirements, it is to be voided by using a "VOID" stamp interlocking to the right of the

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original "CONFORMANCE" stamp. An assembly history note is to be written to refer to the report, which documents the reason for voiding.

d. When the reasons for voiding are corrected, a "CONFORMANCE" stamp is applied to the right of the "VOID" stamp.

e. "NONCONFORMANCE" stamps are cleared (overridden or superseded) by the placement of a "CONFORMANCE" stamp to the right of and interlocking with the "NONCONFORMANCE" stamp.

### 7.10.2 Application

QSS may be applied directly to hardware, except when the quality of the article would be degraded by the direct application of ink and/or the size or shape of the article would preclude direct application. In such instances, QSS are to be applied to the related documentation.

### 7.10.3 Procedures

Accepted LaRC QSS procedures are as follows:

a. When a part permanently marked for "TEST USAGE" is returned for completion of operation by a MRB action, the accompanying documentation is to be "NONCONFORMANCE" stamped and the NFR number is to be permanently marked next to the test usage marking as indicated:

---

**TEST USAGE ONLY**  
**NFR 4488**

b. All written entries requiring QSS for validation are to be in ink.

c. Apply QSS to documentation upon completion of inspection.

d. Apply only one stamp for each acceptance or rejection.

e. Date all stamped entries when applied.

f. If any additional written entry is made after validation by QSS, all related subsequent test and inspection points previously validated are to be "VOID" stamped.

g. To cancel a QSS impression made in error, it is to be "VOID" stamped across the face of the erroneous impression and dated with stated reason for cancellation.

h. To indicate partial inspection conformance of an article or a test, apply the QSS to the left of the "Acceptance" block on the applicable record and denote existing

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condition which requires subsequent inspection. If and when the inspection has been completed, the QSS can be moved into the "Acceptance" block.

- i. When an erroneous data entry has been made on an inspection record, draw a single line through it. Enter the correct information, and apply the QSS and date next to correction.
- j. Interlock QSS from left to right to indicate the sequence in which the stamping occurred.
- k. QSS are to be applied to the container or tags attached to the bag or bundle for accepted articles such as "O" rings, fasteners, connectors, packaging materials, electrical and electronic components, and optical components.
- l. Stamped containers or tags are not to be separated from items prior to installation.

#### **7.10.4 Issuance and Control**

- a. QSS are to be traceable to the individual responsible for verifying the quality of the items as follows:
  - (1) NASA Langley Form 142, "Quality Status Stamp Request Receipt/Return," is to be used for requesting and acknowledging receipt of a set of QSS, and returning a set of QSS (for disposition by the QSS Control Authority – as described below).
  - (2) NASA Langley Form 450 "Quality Status Stamp Yearly Inventory," is to be used for a yearly inventory control and inspection of all QSS in use by civil servants or on-site contractors.
  - (3) Only one set of QSS (one stamp of each design and size) is to be assigned to a given individual (3 stamps for civil service, 2 stamps for on-site contractors).
- b. The Mission Assurance Branch (MAB) is to maintain a control system for the traceability of QSS by performing the following:
  - (1) Issue QSS sets and record names of individuals to whom sets are issued.
  - (2) Issue replacement QSS when worn or damaged.
  - (3) Control re-issue of QSS upon termination or transfer of personnel (QSS numbers are to be withheld from use for a period of one year before reissue to another individual).
  - (4) Record lost QSS, and investigate circumstances.

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- (5) Perform inventory and verify records, at least once a year, of all QSS issued and in stock. Use NASA Langley Form 450 to record stamp imprints and reject stamps if necessary for appropriate reasons such as damage, wear, or lost stamps.
- (6) If QSS are no longer required, damaged or worn due to illegibility, they must be returned.
- (7) Selecting a civil servant to serve as the Langley QSS Control Authority.

c. QSS assignees are to complete NASA Langley Form 450 for the Annual Inventory of QSS (as described above). The QSS Control Authority will inspect each imprint recorded on NASA Langley Form 450 and approval or disapprove (Y or N) the continued use of the complete QSS set. Stamp sets disapproved for continued use must be recorded using the Return section of NASA Langley Form 142.

#### **7.10.5 Responsibilities**

a. The Mission Assurance Branch (MAB) is responsible for:

- (1) Maintaining a control system for quality status stamps.
- (2) Issuing stamp sets and recording names of individuals to who stamps are issued.
- (3) Issuing replacement stamps.
- (4) Controlling reissue of stamps upon termination or transfer of personnel.
- (5) Recording lost stamps, and investigating circumstances.
- (6) Inventorying, at least once a year, stamps issued and in stock, including verification of records.

b. Quality Status Stamp Requesters are responsible for:

- (1) Completing the request portion of NASA Langley Form 142, and mailing to the Head of the MAB, Mail Stop 305.
- (2) Completing the receipt portion of NASA Langley Form 142 when accepting quality status stamps.

c. Quality Status Stamp Assignees are responsible for completion of NASA Langley Form 450 for the Annual Inventory of QSS. Assignees will provide QSS imprints on the NASA Langley Form 450 and will surrender damaged or worn QSS back to the QSS Control Authority if requested to do so.

d. Individuals who must return Quality Status Stamps (i.e. Returners) are responsible for:

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- (1) Completing the return portion of the NASA Langley Form 142 when relinquishing control of their QSS.
- (2) The QSS Control Authority will receive returned QSS sets and dispose of them upon receipt to prevent reuse or misuse.

## **7.11 BONDED STORES**

Bonded stores are to be established as per LMS-CP-4892, "Bonded Storage," when assembling flight hardware that must be closely controlled to ensure safety and product quality. The objective of bonded stores as established by LMS-CP-4892 is to provide control and accountability of materials, hardware, and associated equipment used to build LaRC's products; thereby ensuring safety, reliability, and functionality.

## **7.12 LOGBOOKS**

Logbooks shall be used to provide traceability and verification of hardware, software, and associated GSE during assembly, test, and launch operations. The logbook will provide a record of work, inspections, and NFRs. QSS are to be used when making entries in logbooks. As a minimum, logbook entries are to chronologically contain date, time, description of event or activity, and name of individual performing the activity. Logbooks are to remain within the designated work area or with the assigned hardware.

### **7.12.1 Issue**

Project personnel are required to obtain and maintain appropriate logbooks from the MAB QAS when two or more parts are to be assembled after release from the QAB. The assigned QAS is to issue and maintain accountability of all logbooks and assure logbooks are maintained current by the requester.

### 7.12.2 Component Logbook

- a. A component logbook is to be issued when two or more parts are assembled which perform a distinctive function.
- b. Component logbooks are to contain the following:
  - (1) NASA Langley Form 132, "Record of Weight," entered as generated.
  - (2) NASA Langley Form 138, "Time/Cycle Log."
  - (3) A paper copy of the "Nonconformance-Failure Report (NFR)" entered as generated.
  - (4) NASA Langley Form 146, "Nonconformance - Failure Report (NFR) Summary."
  - (5) NASA Langley Form 154, "Configuration Record," maintained current.
  - (6) NASA Langley Form 155, "Assembly History Record," containing entries for all activities performed on the component including assembly, test, calibration, disassembly, etc.
  - (7) "As-Run" assembly and test procedures.
- c. Component logbooks are to remain with the hardware until integration of the component into the next level of assembly. Any open NFRs are to be transferred into the subsystem logbook. After integration is complete, component logbooks are to be stored in a centrally accessible location until completion of the project.

### 7.12.3 Subsystem Logbook

- a. A subsystem logbook is to be issued when components or parts are assembled to form a major functioning entity within a system (i.e., ignition, fluid, radar, etc.). This logbook integrates the appropriate component logbooks into one logbook and provides a record of work, inspection, and NFRs incurred during assembly and test of the subsystem.
- b. Subsystem logbooks are to contain the following:
  - (1) NASA Langley Form 132, "Record of Weight," entered as generated.
  - (2) NASA Langley Form 138, "Time/Cycle Log," continued from the component logbook.
  - (3) A paper copy of the "Nonconformance-Failure Report (NFR)" entered as generated.
  - (4) NASA Langley Form 144, "Connector Log."

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- (5) NASA Langley Form 146, "Nonconformance - Failure Report (NFR) Summary," continued from component logbook.
- (6) NASA Langley Form 154, "Configuration Record," continued from the component logbook.
- (7) NASA Langley Form 155, "Assembly History Record," continued from the component logbook.
- (8) "As-Run" assembly and test procedures.

c. Subsystem logbooks are to remain with the hardware until integration of the subsystem into the system. Any open NFRs are to be transferred into the system logbook. After integration is complete, subsystem logbooks are to be stored in a centrally accessible area until completion of project.

#### **7.12.4 System Logbook**

a. A system logbook is to be issued when subsystems are integrated into one of the principal functioning entities comprising the hardware, software, and related operational services within a project or flight mission (i.e., thermal protection, propulsion, control, etc.). This logbook integrates the appropriate subsystem logbooks into one logbook and provides a record of work, inspection, and NFRs incurred during assembly and test of the system.

b. System logbooks are to contain the following:

- (1) NASA Langley Form 132, "Record of Weight," entered as generated.
- (2) NASA Langley Form 138, "Time/Cycle Log," continued from the subsystem logbook.
- (3) NASA Langley Form 139, "Removal/Installation Log," initiated only after completion of system integration.
- (4) A copy of the "Nonconformance-Failure Report (NFR)" entered as generated.
- (5) NASA Langley Form 144, "Connector Log," continued from the subsystem logbook.
- (6) NASA Langley Form 146, "Nonconformance - Failure Report (NFR) Summary," continued from the subsystem logbook.
- (7) NASA Langley Form 154, "Configuration Record," continued from the subsystem logbook.
- (8) NASA Langley Form 155, "Assembly History Record," continued from the subsystem logbook.

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- (9) "As-Run" assembly and test procedures.
- c. System logbooks are to remain with the DPE until archived with other project documentation.

#### **7.12.5 Ground Support Equipment (GSE) Logbook**

- a. A ground support equipment (GSE) logbook is to be issued when any GSE is required during assembly, test, and launch operations. This logbook is to provide a record of work, inspection, and NFRs incurred during use of the GSE. The GSE logbook is to remain with the equipment throughout its use.
- b. GSE logbooks are to contain the following:
  - (1) A copy of the "Nonconformance-Failure Report (NFR)" entered as generated.
  - (2) NASA Langley Form 146, "Nonconformance Failure Report (NFR) Summary."
  - (3) NASA Langley Form 154, "Configuration Record."
  - (4) NASA Langley Form 155, "Assembly History Record."
  - (5) Calibration and maintenance records.
  - (6) Handling and lifting equipment certifications.

#### **7.12.6 Numbering System**

All logbooks are to be identified and numbered on NASA Langley Form 184, "Identification Card." Logbook numbers are to consist of the first three letters of the project name, a sequential three-digit number beginning with "001," and a three-letter abbreviation denoting the type of logbook as follows:

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

Example: HAL-001-COM.

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### **7.12.7 Responsibilities**

- a. Project system/subsystem managers and other designated project personnel will:
  - (1) Request appropriate logbooks from the MAB.
  - (2) Maintain required logbooks.
- b. The Mission Assurance Branch (MAB) will:
  - (1) Issue and maintain accountability of all logbooks.
  - (2) Conduct periodic audits to assure logbooks are properly maintained.

### **7.13 ASSEMBLY AND INTEGRATION**

All flight product and associated ground support equipment are to be assembled or disassembled using approved drawings and/or procedures. All assembly or disassembly is to be verified by MAB personnel. MAB personnel are to be present during all critical inspection activities identified in the assembly procedure.

#### **7.13.1 General**

- a. Line organization engineers and technicians are to be assigned to each flight project for the purpose of planning and conducting activities within their jurisdiction. When more than one line organization is involved in the assembly, the project manager is to provide overall coordination of organizations. Organizational guidelines are to be utilized to the maximum extent possible when preparing assembly plans and procedures.
- b. When a nonconformance or failure is encountered that poses a safety hazard to personnel or flight hardware, the affected procedure or operation is to be discontinued in an orderly manner. Any resumption of a discontinued operation is to be accomplished using approved documented procedures.
- c. All equipment used in assembly (i.e., torque wrenches, voltmeters, etc.) are to be in current calibration.
- d. Handling and lifting GSE (i.e., slings, hoists, tables, carts, etc.) are to be certified in accordance with applicable safety requirements of the assembly facility. Evidence of current calibration shall be visibly affixed.
- e. Project logbooks are to be initiated and maintained during assembly of all flight products and GSE.

### 7.13.2 Assembly Procedures

Project personnel shall generate an assembly procedure when the drawing does not provide adequate detail for assembly. The assembly procedure shall outline the scope, technical intent, equipment required, and detailed assembly instructions. The assembly procedure is to be submitted to the MAB for approval.

### 7.13.3 Procedures

- a. All assembly or disassembly is to be performed in accordance with written procedures approved by the PAM. The degree of detail is to be sufficient to clearly convey information needed for the performance of all tasks.
- b. Procedures are to include, but are not limited to, the following:
  - (1) Cover sheet.
  - (2) Approval "signoff" page.
  - (3) Personnel required to accomplish the task.
  - (4) Detailed objectives.
  - (5) Item description and identification.
  - (6) Facility environmental requirements, cleanliness category, etc.
  - (7) Reference documents, specifications, drawings, schematics, etc.
  - (8) Hardware configuration list.
  - (9) Video and/or photographic requirements.
  - (10) List of required equipment.
  - (11) Sequential detailed steps describing the task to be performed with signature and date line to be completed by individual performing task.
  - (12) Tasks potentially hazardous to personnel or equipment are to be pre-approved by designated safety personnel. These tasks are to be preceded by a warning or caution note easily distinguishable from other text.
  - (13) Tasks requiring inspection or verification are to be quality stamped and dated by the appropriate QAS.
- c. Changes to approved procedures may be "red lined," but must be initialed and dated by the DPE and QAS.

#### **7.13.4 Responsibilities**

- a. The Designated Project Engineer (DPE) is responsible for:
  - (1) Preparing the individual procedures.
  - (2) Approving “red lines” to drawings and procedures.
- b. Mission Assurance Branch (MAB) personnel are responsible for:
  - (1) Review and approval of all assembly procedures.
  - (2) Verification and signoff of procedures.
  - (3) Verification of calibration/certification of handling and lifting GSE.
  - (4) Maintaining safety oversight of procedures.
- c. Facilities personnel are responsible for:
  - (1) Performing tasks outlined in procedures and on drawings.

#### **7.14 TESTING**

Functional and environmental testing of flight products and associated GSE for purposes of flight acceptance are to be conducted according to written and approved plans and procedures. All testing activities are to be verified by MAB personnel. MAB personnel are to be present during all critical inspection activities identified in the Integrated Test Plan (ITP).

##### **7.14.1 General**

- a. Line organization test engineers and technicians are to be assigned to each flight project for purposes of planning, scheduling, and conducting test activities within their jurisdictions. When more than one line organization is involved in the conduct of testing activities, a project test manager is to be designated by the project manager to provide overall coordination of project related testing activities. Organizational guidelines are to be utilized to the maximum extent possible when preparing test plans and procedures.
- b. All equipment used in testing (i.e., scopes, power supplies, torque wrenches, etc.) is to be in current calibration. All software used for test and measurement purposes is to be in a known and controlled configuration.
- c. Handling and lifting GSE (i.e., slings, hoists, tables, carts, etc.) are to be certified in accordance with applicable safety requirements of the test facility. Evidence of current certification shall be visibly affixed.

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- d. Project logbooks, initiated during the initial assembly phase, are to be maintained during testing operations.

#### **7.14.2 Integrated Test Plans (ITPs)**

- a. Project personnel shall generate an Integrated Test Plan (ITP). The ITP shall outline the scope, technical intent, and success criteria of the overall project-testing program. The ITP is to be submitted to the MAB for approval. Requirements and conditions necessary to accomplish component, subsystem, system, payload, GSE, and associated software testing, as appropriate, are to be included in the ITP.
- b. As a minimum, the following are to be provided for each test:
  - (1) Overall test objectives.
  - (2) Overall test requirements.
  - (3) General testing rules.
  - (4) Test sequence flow diagram.
  - (5) Summary matrix (indentured list of test items versus the type of test in each category).
  - (6) Identification of organizations responsible for the development, implementation, and approval of test plans, specifications, and procedures.
  - (7) Description of test facilities and major support equipment.
  - (8) Disposition of test data.
  - (9) QA requirements.

#### **7.14.3 Procedures**

- a. All testing is to be performed in accordance with written procedures approved by the PAM. The degree of detail is to be sufficient to clearly convey information needed for the performance of all tasks.
- b. Procedures are to include, but not limited to, the following:
  - (1) Cover sheet (with title, date, and test number).
  - (2) Approval "sign-off" page.
  - (3) Telephone numbers of designated personnel to be contacted in an emergency.

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- (4) Personnel required to accomplish test.
  - (5) Detailed test objectives.
  - (6) Test item description and identification.
  - (7) Expected results with “pass/fail” criteria.
  - (8) Data measurement, recording, and analysis requirements.
  - (9) Facility environmental requirements, cleanliness category, power levels, etc.
  - (10) Reference documents, specifications, drawings, layouts, schematics, etc.
  - (11) Hardware and software configuration checklist.
  - (12) Video and/or photographic requirements.
  - (13) List of required equipment including special purpose test equipment and simulator software with provisions for recording serial numbers, calibration due dates, and software version numbers.
  - (14) Sequential detailed steps describing the task to be performed with signature and date line to be completed by individual performing task (includes setup of special equipment, entry of parameters into software tables, and preliminary calibrations and operational checks).
  - (15) Tasks potentially hazardous to personnel or equipment are to be pre-approved by designated safety personnel. These tasks are to be preceded by a warning or caution note easily distinguishable from other text.
  - (16) Tasks requiring inspection or verification are to be quality stamped and dated by the appropriate QAS.
  - (17) Tasks requiring manual recording of data are to include a formatted table or chart such that the expected values and allowable tolerances are adjacent to the data being recorded.
  - (18) Detailed sequential steps for all identified emergency “shut-down” conditions.
- c. Changes to approved procedures may be “red-lined,” but must be initialed and dated by the DPE and QAS.
- d. When a nonconformance or failure is encountered that poses a safety hazard to personnel, test equipment, or flight hardware, the affected procedure or operation is to

be discontinued in an orderly manner. Any resumption of a discontinued test is to be accomplished using approved documented procedures.

#### **7.14.4 Reporting**

a. On completion of each test (including failed and aborted tests), the test engineer prepares a copy of a Quick-Look Test Report (QLTR) to be forwarded to the project manager. The QLTR consists of test objectives, results summary, any assigned open issues (with dates of expected resolution), and the “as-run” test procedure.

b. Once determination is made that the test objectives were satisfied, a Final Test Report (FTR) is to be prepared and forwarded to the project manager. The FTR will describe in detail the degree to which objectives were satisfied, how well the mathematical models were validated, and other pertinent test related information as follows:

- (1) A chronological listing of the significant activities and related events that occurred during the performance of the test.
- (2) Detailed discussions of any procedural changes and failures.
- (3) Data generated by the test.
- (4) Status and reporting plans for performance data.
- (5) Post-test status of test article.
- (6) Changes to test article during test.
- (7) List of NFRs.
- (8) List of authorized activities (i.e., troubleshooting) not originally planned, with approved procedures.
- (9) Copy of the “as-run” test procedure.

#### **7.14.5 Responsibilities**

a. Project personnel are responsible for:

- (1) Preparing the ITP and individual test procedures.

b. The Test Engineer is responsible for:

- (1) Performing the test in accordance with the procedures.
- (2) Preparing the Quick-Look Test Report.
- (3) Preparing the Final Test Report.

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- c. Mission Assurance Branch (MAB) personnel are responsible for:
  - (1) Participating in test operations to monitor or witness, as necessary, to verify compliance to approved procedures.
  - (2) Verifying current calibration and/or certification of handling and lifting GSE.
- d. The Product Assurance Manager (PAM) is responsible for:
  - (1) Approving test procedures.

## **7.15 ELECTROSTATIC DISCHARGE (ESD)**

a. The transfer of an electrostatic charge (static electricity) between bodies at different electrostatic potentials, caused by direct contact or induced by an electrostatic field, is termed an electrostatic discharge (ESD). 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 or in the future as a latent defect. Many failures of undetermined origin are probably a result of ESD. Assemblies and equipment containing these parts are also susceptible to damage when an ESD occurs at their terminals or when they are exposed to electrostatic fields.

b. Electrical and electronic parts, assemblies, and equipment sensitive to ESD voltages of 15,000 volts or less are to be designated as ESD sensitive (ESDS) and identified as such on drawings and parts lists. ESDS items are to be designed and handled in accordance with ANSI/ESD S2020, "Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)."

### **7.15.1 Design**

Protection against ESD is to be considered when designing electrical circuits. Design techniques are to be utilized which reduce the susceptibility of parts and assemblies to ESD.

### **7.15.2 Handling**

a. Personnel handling ESDS items shall be trained and certified in ESD precautionary measures in accordance with ANSI/ESD S2020. Precautions are to be taken throughout the life cycle of ESDS devices to prevent damage during handling, packaging, inspection, shipping, storage, assembly, testing, installation, or maintenance.



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b. The following precautions, as a minimum, are to be employed while handling ESDS devices:

- (1) All ESDS devices are to be stored or transported in anti-static material, preferably with the exposed leads at a common potential.
- (2) Prior to removing ESDS devices from anti-static material, the device is to be placed on an anti-static work surface.
- (3) A conductive wrist strap, tied to a soft ground common to the work surface, is to be worn by the operator. Personnel without a wrist strap are to be restricted from the ESDS area.
- (4) Tools are to consist of conductive or static dissipative materials.
- (5) Equipment used in an ESDS area is to be grounded.
- (6) Soldering operations are to be performed using a grounded tip soldering iron.
- (7) 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.) are to be removed.
- (8) Direct contact between street clothing and ESDS devices is to be avoided.

### 7.15.3 Work Stations

a. ESDS items, when removed from their protective packaging, are to be handled with ESD protective devices only at an ESD work station. The QAS will use diagnostic equipment to verify that personnel and flight products are properly grounded when ESDS items are removed from their protective packaging during payload build-up.

b. As a minimum, a typical work station will consist of the following items:

- (1) Personnel ground strap.
- (2) ESD protective work surface.
- (3) Air ionizer.
- (4) Humidity control.
- (5) ESD caution signs.

#### **7.15.4 Responsibilities**

- a. Project personnel will:
  - (1) Consider ESD protection in designs.
- b. The technicians will:
  - (1) Comply with the ESD requirements.
- c. The MAB Quality Assurance Specialist (MAB QAS) will:
  - (1) Assure compliance with ESD requirements.
  - (2) Assure personnel are properly certified as per ANSI/ESD S2020.

#### **7.16 CONTAMINATION CONTROL**

Contamination control consists of controlling two aspects of the fabrication, assembly, integration, and testing of flight hardware. The first aspect is the control of Foreign Object Debris (FOD) to prevent damage to aerospace flight hardware and/or aerospace vehicles. The second aspect is overall cleanliness levels specified for flight hardware generally discussed in terms of a certain class clean room requirement.

##### **7.16.1 Foreign Object Debris (FOD)**

- a. Foreign Object Debris (FOD) is defined as any foreign object that can potentially cause damage to, or malfunction of, a launch vehicle or payload. FOD may cause material or actual damage or it may make the system or equipment inoperable, unsafe, or less efficient. FOD can occur internally and externally. Internal FOD is used to refer to damage or hazards caused by foreign objects inside aircraft, space craft, or other flight systems. Internal FOD may be an object left behind after assembly, repair or maintenance activities. FOD may be trapped behind a panel or floorboard or may even be part of an airplane or spacecraft that was not returned to its proper place. External FOD refers to damage or hazards caused by foreign objects outside of the vehicle. External FOD may be nothing more than a small rivet or other object on the ramp or runway. Tire punctures are common with runway FOD. Other examples are blowing sand or dust and other wildlife on or near runways.
- b. Use of a FOD prevention program at Langley Research Center will minimize the possibility of damage or loss of flight hardware, mission, or injury to personnel due to lost items within the flight hardware elements. The primary goals of the FOD program are to:
  - (1) Provide a standardized approach, maintaining awareness, prevention, compliance, and continued reinforcement.

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- (2) Ensure operational processing areas maintain a safe, clean, FOD-Free environment.

c. FOD prevention shall be considered as early as the design phase by considering such items as identifying sensitive parts, assemblies, surfaces and areas; identifying and eliminating foreign object entrapment areas; using blind fasteners or other self-retaining features; and installing screens. Additionally, assembly operations, test cell environments, remove for flight items, and field operations are other sources of FOD and can be planned for accordingly.

d. Additionally, each project shall incorporate the following preventive practices to ensure proper FOD prevention taking into account the relative complexity of, and the risk to, the hardware:

- (1) Follow procedures.
- (2) Practice good housekeeping, "Clean-As-You-Go."
- (3) Account for all tools, hardware, and equipment at specific intervals.
- (4) Consider controlled access points where loose objects are removed prior to entry.
- (5) Provide worker awareness to FOD causes.
- (6) Establish designated storage areas for ladders, hoses, toolboxes, and other work aids.

e. Any time an item is lost during assembly, manufacturing, or maintenance task, cease activity in the affected area and initiate a search for the item. Continue the search until the item is found or adequate assurances are made that the item is not in the aerospace vehicle or assembly. Searching for such items may require de-paneling or non-destructive inspections, including bore scope and/or x-ray. If an item cannot be located after a search has been completed, annotate an NFR with a description of the item and search procedure followed.

#### **7.16.2 Class 100 Clean Room/Work Station**

Requirements for contamination control of Class 100 clean rooms and work stations are as follows:

- a. No particles over 4.0 microns are permitted.
- b. Total particle count is not to exceed 100 particles of a size .5um or larger per cubic foot.

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- c. For particles 0.5 micron and larger, equipment employing light scattering principles is to be used for measurement.
- d. Measurement equipment is to provide particle quantity and size data.

### **7.16.3 Class 10,000 Clean Room/Work Station**

Requirements for contamination control of Class 10,000 clean rooms and work stations are as follows:

- a. No particles over 35 microns are permitted.
- b. Total particle count is not to exceed 10,000 particles of a size .5um or larger per cubic foot.
- c. For particles 0.5 micron and larger, equipment employing light scattering principles is to be used for measurement.
- d. Microscopic counting of particles collected on a membrane filter, through which a sample of air has been drawn, may be used for measurement of particles 5.0 microns and larger.
- e. Measurement equipment is to provide particle quantity and size data.

### **7.16.4 Class 100,000 Clean Room/Work Station**

Requirements for contamination control of Class 100,000 clean rooms and work stations are as follows:

- a. No particles over 100 microns are permitted.
- b. Total particle count is not to exceed 100,000 particles of a size .5um or larger per cubic foot.
- c. For particles 0.5 micron and larger, equipment employing light scattering principles is to be used for measurement.
- d. Microscopic counting of particles collected on a membrane filter, through which a sample of air has been drawn, may be used for measurement of particles 5.0 microns and larger.
- e. Measurement equipment shall provide particle quantity and size data.

### **7.16.5 General Operations**

- a. The organizations responsible for the operation of clean rooms and work stations shall conduct appropriate training classes for all personnel using their facilities. Certification of completed training shall be provided.

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b. Compliance with the following provisions is essential for the successful operation of clean rooms and work stations:

- (1) Equipment used to control, monitor, and record clean room and clean work station conditions is to be calibrated as specified by the manufacturer.
- (2) All equipment is to be cleaned and decontaminated before being passed into the clean environment by dusting, vacuuming, washing, dunking, or other suitable means compatible with the equipment involved.
- (3) Environmental conditions such as temperature and humidity are to be controlled, continuously recorded, and reviewed as specified. Noise levels should be kept as low as possible for personnel comfort. However, a maximum noise level of 85 dBA is not to be exceeded without proper protection and controls.
- (4) An air pressure of 0.05 inches of water above that of surrounding areas is to be maintained in clean rooms to assure an outward flow of air.
- (5) Gloves, tweezers, or other mechanical barriers to prevent contact between skin and hardware are to be used while working with or handling sensitive parts.
- (6) Exhaust systems for grinding, welding, soldering, machining, or other related operations are to be installed in accordance with the "Industrial Ventilation Manual" published by the American Conference of Government Industrial Hygienists.
- (7) Equipment used to maintain the cleanliness of the clean area is to be stored within the clean area in a manner to prevent accumulation or dispersion of particulates or microbiota on the surfaces.
- (8) Vacuum hoses, electrical cables, and other flexible conductors are to be stored on reels or racks off the floor of the clean room. Use of bristle brushes, steel wool, and other particle shedding material is not permitted.

#### **7.16.6 Responsibilities**

a. The Project Manager (PM) is responsible for:

- (1) Establishing the level of cleanliness requirements.
- (2) Developing the Contamination Control Plan (CCP).

b. The Product Assurance Manager (PAM) will:

- (1) Review and approval the CCP.

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- c. The MAB Quality Assurance Specialist (MAB QAS) will:
  - (1) Audit to ensure compliance with the CCP.
- d. The line organization responsible for the operation of clean rooms and work stations will:
  - (1) Conduct appropriate training classes for all personnel using their facilities.
  - (2) Provide certification of completed training.
  - (3) Maintain the specified levels of cleanliness.

## **7.17 INTEGRATED DATA PACKAGE**

### **7.17.1 General**

- a. An Integrated Data Package (IDP) is to be provided at the point of delivery to an integrated test facility or launch site, which documents the configuration, functional characteristics, and flightworthiness of all deliverable flight products, GSE, and associated spares.
- b. The IDP shall comply with all integrated test facility or launch site specific requirements.
- c. The IDP will reflect the status of each applicable hardware and software item at the time of the Systems Acceptance Review (SAR) and is to be delivered concurrent with the hardware and software.
- d. As a minimum, the following is to be included in the IDP:
  - (1) Index of included items.
  - (2) Notes/Documents (customer's option).
  - (3) All Deviations/Waivers (both open and closed).
  - (4) List of shortages.
  - (5) Closed NFRs affecting LaRC.
  - (6) Open NFRs affecting integration activities.
  - (7) Listing of unplanned/deferred work.
  - (8) Identification (as-built configuration/drawings).
  - (9) Limited operating life/age sensitive items.

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- (10) Pyrotechnic data.
- (11) All installed non-flight items identified.
- (12) Current certification of proof-load and calibration of GSE to be turned over.
- (13) Operating test procedures.
- (14) List of open items from Phase III Ground Safety Review (see Chapter 8.5).

e. For Human-rated flight hardware/software, the following items are required in addition to the above list:

- (1) Preplanned/Assigned work
- (2) Nonstandard Calibration information
- (3) Repair Limitations
- (4) Pressure vessel data
- (5) Certification
- (6) MSDS
- (7) Acceptance requirements
- (8) Historical Log/Notes/Comments
- (9) Operating Time/Cycle

### **7.17.2 Responsibilities**

- a. The Project Manager (PM) will:
  - (1) Identify and compile documentation for incorporation into the IDP.
- b. The Mission Assurance Branch (MAB) will:
  - (1) Assist the PM in establishing the IDP requirements for LaRC fabricated flight hardware and GSE.
  - (2) Prepare the IDP requirements jointly with project system/subsystem manager for flight hardware contracts.
  - (3) Review the IDP for compliance with requirements of this instruction.
  - (4) Participate in the preparation of the IDP.

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## **7.18 HANDLING, PRESERVATION, AND SHIPPING**

- a. Handling, preservation, and shipping of flight hardware is to be in accordance with LMS-CP-4756, "Handling, Preservation, Storage, and Shipping of Space Flight Hardware." Hazardous material handling, preservation and shipping shall also follow applicable LMS-CP-4759, "Acquisition of Hazardous Materials" requirements.
- b. The PAP is to specify requirements for the handling, preservation, and shipping of all flight products. Implementing instructions are to be identified on drawings and/or procedures.

### **7.18.1 Handling**

- a. Special handling instructions (e.g., ESDS items) are to be provided for items during all phases of fabrication and processing when requirements of standards are not sufficient.
- b. Evidence of proof load testing is to be attached to handling equipment such as slings, hoists, cables, carts, etc. Handling equipment is to be in compliance with specified site requirements.

### **7.18.2 Preservation**

- a. Protective measures are to be identified and implemented to prevent deterioration from potentially damaging environmental conditions such as moisture, molecular and attached particulates, condensable volatiles, salt spray, sunlight, and temperature.
- b. Additional protective measures are to be identified and implemented to prevent contamination of optics from anti-static packing materials.

### **7.18.3 Shipping**

All items to be shipped are to be classified and identified on NASA Langley Form 52, "Shipping/Transfer Document." Packaging procedures for hazardous materials are to be approved by the DPE, MAB QAS, and the LaRC Safety Manager. Procedures for packaging pyrotechnics require the additional approval of the LaRC Pyrotechnic Support Engineer. ESDS items are to be packaged and shipped in approved ESD protective material.

### **7.18.4 Storage**

- a. Articles and materials to be stored are to be protected against deterioration and damage. Items requiring special internal environments, such as inert gases, to prevent degradation are to be identified and maintained accordingly. Containers are to be labeled with appropriate warnings (i.e., CAUTION-HAZARDOUS MATERIAL, GLASS, THIS END UP, FRAGILE, HANDLE WITH CARE, etc.).



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- b. Packaged articles are to have an affixed packing list containing the name and identification number of contents.

### **7.18.5 Responsibilities**

- a. The Project Manager (PM) is responsible for:
  - (1) Preparing NASA Langley Form 52 and obtaining the necessary approvals.
  - (2) Determining the appropriate “levels of packaging and classes of shipping” required for compliance with NPR 6000.1G, “Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems, Equipment, and Associated Components.”
  - (3) Identifying the handling, preservation, packaging, shipping, and storage requirements on drawings or procedures.
- b. The MAB Quality Assurance Specialist (MAB QAS) is responsible for verifying:
  - (1) Procedures and instructions are in compliance with established requirements.
  - (2) The IDP is complete, and the inspection status is identified by appropriate QSS.
  - (3) The article is traceable to the “as-built drawing,” and any open items are identified.
  - (4) All articles and materials are properly identified and marked.
  - (5) Articles and materials are prepared and packaged in accordance with written and approved procedures and instructions.
  - (6) NASA critical item labels are affixed to the shipping containers.
  - (7) Shipment routing and routing requests include special handling and monitoring instructions.

## **Chapter 8**

### **SYSTEM SAFETY**

#### **8.1 GENERAL**

- a. This chapter 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.
- b. The System Safety section of the Product Assurance Plan (PAP) shall be developed in accordance with the requirements of this chapter for aerospace products launched or used by Exploration and Constellation developed vehicles, the National Space Transportation System (NSTS), expendable launch vehicles (ELVs), and hypersonic and subsonic vehicles.
- c. Support provided by the LaRC Mission Assurance Branch (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**

- a. A System Safety Plan (SSP) shall be prepared for each flight product by the integrating organization. When LaRC is the Initiating Organization (I.O.), the SSP will be submitted under separate cover or included in the System Safety Section of the PAP. In all instances, the SSP requires MAB approval.
- b. The SSP is to address the following items for the appropriate launch system and site:
  - (1) Organizational responsibilities, authority, and interrelationships as related to system safety.
  - (2) Orbital debris assessment (see Chapter 5.9).
  - (3) Required system safety analyses.
  - (4) Internal and external safety review processes.
  - (5) Hazardous operation surveillance.
  - (6) Accident investigation and reporting.
  - (7) Operator training and certification.
  - (8) Required Safety Compliance Data Package documentation.

- c. The PAM is to 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**

- a. A Safety Compliance Data Package (SCDP) is to be submitted to the applicable Safety Review Panel. If an established safety review process does not exist for a particular launch system or site, the PAM is to establish and implement an independent review process for the SCDP.
- b. The SCDP is to provide information and data which assures all subsystem and system hazards have been identified, controlled by appropriate methods, and that control methods are verifiable.
- c. The SCDP is to include the following for the appropriate launch system and site:
- (1) Mission overview.
  - (2) List of applicable documents.
  - (3) Payload description.
  - (4) Safety overview.
  - (5) Flight safety analyses with hazard reports.
  - (6) Ground safety analyses with hazard reports.
  - (7) Supplemental analyses.
  - (8) Approved deviations and waivers.
  - (9) Payload safety noncompliance reports.

### **8.4 FLIGHT SAFETY ANALYSIS**

- a. A Flight Safety Analysis (FSA) is to be prepared for aerospace products and updated throughout the various product life cycle including design, fabrication, test, transportation, integration, and launch. The FSA is to include the following:
- (1) A description of the potential hazard.
  - (2) Identification of the cause of the potential hazard.
  - (3) The control or technical explanation demonstrating that the potential hazard does not pose a catastrophic or critical condition for the launch system.

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- (4) Method of verification of control.
- (5) Current status of hazard control and verification.
- b. A separate payload hazard report, similar to Johnson Space Center (JSC) Form 542, "Payload Hazard Report," is to be generated for each specific hazard identified. NSTS payload "STANDARD HAZARDS," with their appropriate controls, is identified on JSC Form 1230, "Flight Payload Standardized Hazard Control Report."

## **8.5 GROUND SAFETY ANALYSIS**

A Ground Safety Analysis (GSA) is to 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. The GSA is to include the following:

- a. 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**

- a. All safety reviews are to be held according to the following phased system:
  - (1) Phase 0: Requires potential hazards, hazard causes, and applicable safety requirements be identified and is held after the conceptual design has been established.
  - (2) Phase I: Requires the methods of hazard control or elimination be provided and is held after the preliminary design has been established.
  - (3) 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.

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- (4) 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.
- b. 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**

All safety analyses are to be approved by safety review panels established and chartered by Johnson Space Center (JSC) and Kennedy Space Center (KSC) management. 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 chapter are applicable to both the Eastern and Western Ranges.

### **8.7.1 Launch Services and Mission Orientation Briefing**

- a. Launch Services and Mission Orientation Briefing (LSMOB) will be conducted by the Range User for the Range Safety Organization approximately 45 days after project approval or contract award. The LSMOB will cover the following topics, as appropriate:
  - (1) Changes to the launch vehicle.
  - (2) Changes to the payload bus.
  - (3) Planned payload additions for the mission.
  - (4) Changes to hazardous systems and operations.
- b. Range Safety concurrence for mission concept and proposed schedule will be provided within 14 days after briefing.

### **8.7.2 System Safety Program Plan**

Range Users will submit a System Safety Program Plan (SSPP) for Eastern and Western Ranges safety purposes. Such a program is consistent with MIL-STD-882, "System Safety," for DoD programs and the requirements of AFI 91-202 for Air Force programs. The program includes the corresponding requirements for a Range User SSPP described in AFSPCMAN 91-710 and identifies hazard analysis and risk assessment requirements. The Range User shall submit a draft SSPP to Range Safety

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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**

A payload Missile System Prelaunch Safety Package (MSPSP) shall be delivered to Range Safety by the Range User approximately 12 months before launch and 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. However, for commercial payloads, the payload MSPSP is normally submitted to Range Safety through the launch vehicle contractor. 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**

a. The Range User shall perform and document an operating and support hazard analysis (O&SHA) to examine procedurally controlled activities. 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. The O&SHA identifies and evaluates hazards resulting from the implementation of operations or tasks performed by persons, considering the following criteria:

- (1) planned system configuration and/or state at each phase of activity
- (2) facility interfaces
- (3) planned environments or the ranges thereof
- (4) supporting tools or other equipment including software controlled automatic test equipment specified for use
- (5) operational and/or task sequence, concurrent task effects and limitations
- (6) biotechnological factors, regulatory or contractually specified personnel safety and health requirements
- (7) potential for unplanned events including hazards introduced by human errors.

b. 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. This supplement is required only if changes have been made to operations and procedures that affect hazardous levels or risks

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- c. Range Safety will provide responses within 45 days after receipt of the GOP supplement.

### **8.7.5 Mission Approval Safety Review**

- a. A Mission Approval Safety Review (MASR) is to be conducted approximately 120 days prior to launch. The MASR will provide approval for the following activities:

- (1) Launch vehicle processing.
- (2) Payload processing.
- (3) Transport to payload launch pad.
- (4) Payload launch vehicle mating.
- (5) Launch pad payload processing.

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

### **8.7.6 Final Launch Approval**

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. 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**

- a. The Project Manager (PM) is responsible for:
- (1) 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.
  - (2) Developing provisions for verifying safety requirements that are satisfied by inspection and/or tests.

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- (3) Supporting the PAM in the coordination and preparation of required technical analyses.
  - (4) Presenting technical discussions of safety analyses to the JSC and KSC safety review panels or the Eastern/Western Range.
  - (5) Supporting MAB in post safety panel review activities.
- b. The Product Assurance Manager (PAM) is responsible for:
- (1) Preparation of the SSP.
  - (2) 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).
  - (3) Preparation of the SCDP.
  - (4) Tailoring of the safety requirements based on the program/project (e.g., Shuttle, Constellation, ELV, and ISS).
  - (5) 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.
  - (6) Monitoring/verifying close out of all safety items identified in safety verification tracking lists.



## APPENDIX A

### ACRONYMS

ANSI	American National Standards Institute
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
COTR	Contracting Officer's Technical Representative
CP	Center Procedure
DA	Delegated Agency
DoD	Department of Defense
DPE	Designated Project Engineer
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
ESD	Electrostatic Discharge
ESDS	ESD Sensitive
ER	Eastern Range
EWR	Eastern Western Range
FAI	First Article Inspection
FAR	Federal Acquisition Regulation
FIOS	Fabrication and Inspection Operations Sheet
FMEA	Failure Modes and Effects Analysis
FOD	Foreign Object Debris
FR	Fabrication Representative
FRR	Flight Readiness Review
FSA	Flight Safety Analysis
FTA	Fault Tree Analysis
FTR	Final Test Report
FWR	Fabrication Work Request

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GIDEP	Government-Industry Data Exchange Program
GOP	Ground Operations Plan
GSA	Ground Safety Analysis
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
ID	Identification
IDP	Integrated Data Package
IM&TE	Inspection, Measuring, and Test Equipment
IO	Initiating Organization
ISO	International Organization of Standardization
ISS	International Space Station
ITP	Integrated Test Plan
JSC	Johnson Space Center
KSC	Kennedy Space Center
LaRC	Langley Research Center
LAPD	Langley Policy and Directives
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	Mission Assurance Branch Quality Assurance Specialist
MAP	Mission Assurance Program
MASR	Mission Approval Safety Review
MIL-HDBK	Military Handbook
MIL-STD	Military Standard
ML	Materials List
MRB	Material 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

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NASA	National Aeronautics and Space Administration
NEPP	NASA Electronic Parts and Packaging Program
NEPAG	NASA EEE Parts Assurance Group
NFR	Nonconformance Failure Report
NMTTC	NASA Manufacturing Technology Transfer Center
NPSL	NASA Parts Selection List
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
PA	Product Assurance
P&M	Parts and Materials
PAP	Product Assurance Plan
PAM	Product Assurance Manager
PAR	Product Assurance Requirements
PDR	Preliminary Design Review
PIR	Parts Inventory Report
PM	Project Manager
PN	Part Number
PO	Purchase Order
PR	Purchase Request
PRR	Project Requirements Review
QA	Quality Assurance
QAB	Quality Assurance Branch
QAB QAS	Quality Assurance Branch Quality Assurance Specialist
QAR	Quality Assurance Representative
QAS	Quality Assurance Specialist
QLTR	Quick-Look Test Report
QRAS	Quantitative Risk Assessment System
QSS	Quality Status Stamps
RFP	Request for Proposals
RG	Reliability Goal
SAP	Software Acquisition Plan
SAR	Systems Acceptance Review
SCDP	Safety Compliance Data Package
SMAO	Safety and Mission Assurance Office
SN	Serial Number

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SOW	Statement of Work
SRR	Systems Requirements Review
SSP	System Safety Plan
SSP	System Safety Program Plan
STD	Standard

TRL	Technology Readiness Level
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UVA	Unmanned Aerial Vehicle
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WCA	Worst Case Analysis
WFF	Wallops Flight Facility

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## **APPENDIX B**

### **APPLICABLE DOCUMENTS**

#### **Section 1: Program and Project Management Documents**

- a. NPD 7120.4, "Program/Project Management."
- b. NPR 7120.5D, "NASA Space Flight Program and Project Management Requirements."
- c. LAPD 1000.1, "Langley Management System (LMS) Policy Manual."
- d. LAPD 5300.1, "Program/Product Assurance."

#### **Section 2: Product Assurance Plans**

#### **Section 3: Acquisition Quality Assurance**

- a. NASA FAR Supplement (Paragraph 18-42.202-70).
- b. LMS-CP-4759, "Acquisition of Hazardous Materials."

#### **Section 4: Configuration Management**

- a. NPR 7120.5D, "NASA Space Flight Program and Project Management Requirements."
- b. LPR 7320.1, "Engineering Drawing System."

#### **Section 5: Design Assurance**

- a. NPR 8715.6, "NASA Procedural Requirements for Limiting Orbital Debris."
- b. NASA-STD-5001, "Structural Design and Test Factors of Safety for Spaceflight Hardware."
- c. NASA-STD-5002, "Load Analyses of Spacecraft and Payloads."
- d. NASA-STD-7001, "Payload Vibroacoustic Test Criteria."

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- e. NASA-STD-7002, "Payload Test Requirements."
- f. NASA Space Transportation System (NSTS) 22206, "Requirements for Preparation and Approval of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)."
- g. NSS 1740.14, "Guidelines and Assessment Procedure for Limiting Orbital Debris."
- h. MIL-HDBK-217, "Reliability Prediction of Electronic Equipment."

## **Section 6: Parts and Materials**

- a. NPD 8730.2, "NASA Parts Policy."
- b. LAPD 5330.3, "Langley Research Center (LaRC) Standards for the Acquisition of Threaded Fasteners (Bolts)."
- c. MSFC-HDBK-527, "Materials Selection List for Space Hardware Systems"
- d. NASA/ Goddard Space Flight Center (GSFC)-Preferred Parts List (PPL) -21, "Preferred Parts List."

## **Section 7: Quality Assurance**

- a. LPR 1740.2, "Facility Safety Requirements."
- b. LMS-CP-0506, "Selection, Use and Control of Inspection, Measuring, and Test Equipment (IM&TE)."
- c. LMS-CP-0510, "Procurement of Inspection, Measuring and Test Equipment (IM&TE)."
- d. LMS-CP-4703, "Review of Purchase Requests by the Safety and Mission Assurance Office (SMAO)."
- e. LMS-CP-4706, "Monitoring and Reporting of Materials Analysis and Quality Assurance Testing Results Performed by the Materials Analysis and Quality Assurance Lab."
- f. LMS-CP-4750, "Develop Product Assurance Plans."

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- g. LMS-CP-4751, "Response to Requests for Mission Assurance Support in Proposal or Contract Development."
- h. LMS-CP-4754, "Quality Assurance (QA) for Software Development and Acquisition."
- i. LMS-CP-4756, "Handling, Preservation, Storage, and Shipping of Space Flight Hardware."
- j. LMS-CP-4758, "Receipt Inspection of Safety-Critical Products."
- k. LMS-CP-4892, "Bonded Storage."
- l. LMS-OP-5515, "Electric, Electronic, and Electromechanical (EEE) Parts Assurance."
- m. LMS-CP-5528, "Software Planning, Development, Acquisition, Maintenance and Operations."
- n. LMS-CP-5640, "Requesting, Performing, and Closing Fabrication Services Requests."
- o. GEVG-LaRC/SED, "General Environmental Verification Guidelines for STS and ELV Payloads, Subsystems and Components."
- p. JSC-SN-C-0005, "Space Shuttle Contamination Control Requirements."
- q. Kennedy Handbook (KHB) 1700.7, "Space Shuttle Payload Ground Safety Handbook."
- r. Federal-Standard-209, "Clean Room and Work Station Requirements, Controlled Environment."

## **Section 8: System Safety**

- a. Eastern Western Range (EWR) 127-1, "Eastern and Western Range Safety Requirements."
- b. JSC 26943, "Guidelines for the Preparation of Payload Flight Safety Data Packages and Hazard Reports."
- c. KHB 1700.7, "Space Shuttle Payload Ground Safety Handbook."

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- d. NASA-STD-5003, "Fracture Control Requirements for Payloads Using the Space Shuttle."
- e. NASA-STD-5005, "Ground Support Equipment."
- f. NSTS 1700.7, "Safety Policy and Requirements for Payloads Using the Space Transportation System."
- g. NSTS 13830, "Payload Safety Review and Data Submittal Requirements."



## **APPENDIX C**

### **PRODUCT ASSURANCE PLAN (PAP) OUTLINE**

- 1. INTRODUCTION**
  - 1.1 GENERAL
  - 1.2 MISSION SUCCESS CRITERIA
  - 1.3 IMPLEMENTATION
- 2. PRODUCT ASSURANCE PLAN**
  - 2.1 GENERAL
  - 2.2 CONTENT
    - 2.2.1 KEY CHARACTERISTICS
  - 2.3 APPROVAL
  - 2.4 CHANGES
  - 2.5 ASSESSMENT
  - 2.6 RESPONSIBILITIES
- 3. ACQUISITION QUALITY ASSURANCE**
  - 3.1 GENERAL
    - 3.1.1 Purchases of Hazardous Materials
    - 3.1.2 Quality System Requirements
  - 3.2 ACQUISITIONS
    - 3.2.1 Purchase Requests
    - 3.2.2 Contracts
    - 3.2.3 Responsibilities
  - 3.3 DELEGATION OF QUALITY FUNCTIONS
    - 3.3.1 Criteria
    - 3.3.2 Implementation
    - 3.3.3 Delegation to Other NASA Field Installations
    - 3.3.4 Responsibilities
  - 3.4 CONTRACT DEVIATIONS AND WAIVERS
    - 3.4.1 General
    - 3.4.2 Responsibilities
- 4. RISK MANAGEMENT**
  - 4.1 General
    - 4.1.1 Risk Management Overview
    - 4.1.2 Risk Management Concept
  - 4.1. Risk Management Requirements
    - 4.1.4 Risk Management Responsibilities
      - 4.1.4.1 Langley Project Managers Responsibilities...
      - 4.1.4.2 Langley Project Managers Responsibilities
      - 4.1.4.3 CMC Responsibilities
      - 4.1.4.4 Langley Mission Assurance Branch Responsibilities
  - 4.2 Overview of the Risk management Process at Langley
    - 4.2.1 Documenting and Communicating Risk

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- 4.2.2 Langley Program/Project Plan
- 4.2.3 Risk Management Plan
  - 4.2.3.1 Risk Management Plan Content
    - 4.2.3.2 Process Based Mission Assurance Knowledge System Website
    - 4.2.3.3 Statement of Risk
    - 4.2.3.4 Risk List
- 4.2.4 Risk Mitigation Plans
- 4.2.5 Risk Acceptance Records
- 4.2.6 Risk Trends
- 4.2.7 Risk Profile
- 4.2.8 Risk Communication

## **5. DESIGN ASSURANCE**

- 5.1 GENERAL
- 5.2 DESIGN REVIEWS
  - 5.2.1 General
  - 5.2.2 Responsibilities
- 5.3 DEVIATIONS AND WAIVERS
- 5.4 RELIABILITY
  - 5.4.1 Fault Tree Analysis
  - 5.4.2 Failure Modes and Effects Analysis
    - 5.3.2.1 Approach
    - 5.3.2.2 Criticality Category
    - 5.3.2.3 Disposition and Justification
    - 5.3.2.4 Critical Items List
    - 5.3.2.5 Responsibilities
  - 5.4.3 Reliability Prediction
  - 5.4.4 Derating Analysis
  - 5.4.5 Worst Case Analysis
- 5.5 MAINTAINABILITY AND AVAILABILITY
- 5.6 SUPPORTABILITY
- 5.7 PROBABLISTIC RISK ASSESSMENT
  - 5.6.1 PRA Process
- 5.8 PARTS AND MATERIAL ALERTS
  - 5.8.1 General
  - 5.8.2 Responsibilities
- 5.9 ORBITAL DEBRIS ANALYSIS

## **6. PARTS AND MATERIALS**

- 6.1 GENERAL
- 6.2 MECHANICAL PARTS
- 6.3 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL PARTS
  - 6.3.1 Implementation
  - 6.3.2 Standard Parts
  - 6.3.3 Nonstandard Parts
- 6.4 MATERIALS
  - 6.4.1 Selection

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- 6.4.2 Composites
- 6.4.3 Limited Life Items
- 6.4.4 Materials List
- 6.5 RESPONSIBILITIES

## **7. QUALITY ASSURANCE**

- 7.1 GENERAL
- 7.2 INSTITUTIONAL SAFETY INTERFACE
  - 7.2.1 General
  - 7.2.2 Responsibilities
- 7.3 SOFTWARE
- 7.4 METROLOGY
- 7.5 RECEIVING AND INSPECTION
  - 7.5.1 Certification
  - 7.5.2 Verification
  - 7.5.3 Rejection of Received Articles
  - 7.5.4 Responsibilities
- 7.6 FABRICATION PLANNING
  - 7.6.1 Fabrication Work Request
  - 7.6.2 Fabrication and Inspection Operations Sheet
  - 7.6.3 Fabrication Processes
  - 7.6.4 First Article Inspection
  - 7.6.5 Responsibilities
- 7.7 Workmanship Standards
  - 7.7.1 Worker Certification
- 7.8 HARDWARE IDENTIFICATION
  - 7.8.1 Identification Number
  - 7.8.2 Identification Number Location
  - 7.8.3 Identification Number Marking
  - 7.8.4 Identification Removal
  - 7.8.5 Responsibilities
- 7.9 NONCONFORMANCE AND FAILURE REPORTING
  - 7.9.1 Reporting
  - 7.9.2 Disposition
  - 7.9.3 Scrap
  - 7.9.4 Documentation
  - 7.9.5 Verification and Closeout
  - 7.9.6 Responsibilities
- 7.10 QUALITY STATUS STAMPS
  - 7.10.1 Quality Status
  - 7.10.2 Application
  - 7.10.3 Procedures
  - 7.10.4 Issuance and Control
  - 7.10.5 Responsibilities
- 7.11 BONDED STORES
- 7.12 LOGBOOKS
  - 7.12.1 Issue
  - 7.12.2 Component Logbook

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- 7.12.3 Subsystem Logbook
- 7.12.4 System Logbook
- 7.12.5 Ground Support Equipment (GSE) Logbook
- 7.12.6 Numbering System
- 7.12.7 Responsibilities
- 7.13 ASSEMBLY and INTEGRATION
  - 7.13.1 General
  - 7.13.2 Assembly Procedures
  - 7.13.3 Procedures
  - 7.13.4 Responsibilities
- 7.14 TESTING
  - 7.14.1 General
  - 7.14.2 Integrated Test Plans
  - 7.14.3 Procedures
  - 7.14.4 Reporting
  - 7.14.5 Responsibilities
- 7.15 ELECTROSTATIC DISCHARGE (ESD)
  - 7.15.1 Design
  - 7.15.2 Handling
  - 7.15.3 Work Stations
  - 7.15.4 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
  - 7.18.1 Handling
  - 7.18.2 Preservation
  - 7.18.3 Shipping
  - 7.18.4 Storage
  - 7.18.5 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

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- 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