Langley Research Center

LPR 7120.5

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Space Flight Project Practices Handbook

National Aeronautics and Space Administration

Office of Primary Responsibility: Exploration and Flight Projects Directorate

PREFACE

P.1 PURPOSE

a. To define the Center processes for planning and managing Langley space flight projects and to implement the provisions of the current version of NPR 7120.5, "NASA Space Flight Program and Project Management Requirements."

b. Provide documented practices that are continually improved through lessons learned, benchmarking, and other sources.

c. To provide a portal into the NASA and Langley repositories of documents and standards

P.2 APPLICABILITY

The Space Flight Project Practices Handbook (SFPPH) is applicable to all Langley Research Center (Langley) projects developing products (hardware systems and knowledge products) intended for use in space flight programs as defined in the current version NPR 7120.5, "NASA Space Flight Program and Project Management Requirements." The EFPPH is also applicable as directed by the Langley Center Management Council or by other organizations responsible for project execution.

P.3 AUTHORITY

a. NPD 7120.4, “Program/Project Management.”

P.4 APPLICABLE DOCUMENTS

(See Appendix F)

P.5 MEASUREMENT/VERIFICATION

Compliance with this LPR will be tracked by a project-maintained compliance matrix that is updated at the major project milestones (see Appendix B and Appendix D).

P.6 CANCELLATION

None

Original signed on file

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DISTRIBUTION:
Approved for public release via the Langley Management System; distribution is unlimited.

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1.0 Compliance Requirements

1.1 The Space Flight Project Practices Handbook (SFPPH) is applicable to all space flight projects at Langley Research Center (Langley). Space flight projects at Langley are:

a. Projects developing hardware or software systems for orbital, interplanetary or human space flight vehicles.

b. Sub-projects producing hardware, software or knowledge products (i.e.: engineering analyses) that are critical to the design, verification or operation of orbital, interplanetary or human space flight vehicles.

c. Projects where the customer expects Langley to meet the standards of NPR 7120.5 “NASA Space Flight Program and Project Requirements.”

d. Projects identified by the Center as Space Flight Projects.

1.2 The requirements statements in this document, contained in the "Practices" sections below, are mandatory for all space flight products and services produced under the direct control of Langley. Note the style convention explained in Section 2.5.1, which explains that the imperative "shall" is not used in the "Practices" sections. They are nonetheless mandatory.

1.3 The requirements in this document are not mandatory for space flight products and services supplied to Langley that are produced under the control of other NASA centers, other government agencies, or by other nations. However, if Langley has integration responsibilities for these Exploration products, appropriate equivalence must be shown. A Project’s Planning Approval Official, defined in Section 5.2.2.2, determines how that equivalence will be shown.

2.0 Introduction

2.1 Purpose

The purposes of this document are:

a. To define the Center processes for planning and managing Langley Exploration projects and to implement the provisions of the current version of NPR 7120.5, "NASA Space Flight Program and Project Management Requirements."

b. To provide documented practices that are continually improved through lessons learned, benchmarking, and other sources.
c. To provide a portal into the NASA and Langley repositories of documents and standards.

2.2 Criteria

The Practices herein have been selected on the basis of the following criteria:

a. They establish standards of consistency across all Langley space flight projects.
b. They incorporate methodologies that comply with NASA requirements.
c. They incorporate relevant best practices.
d. They incorporate lessons learned from previous Langley space projects.
e. They provide a basis for the deliberate tailoring of practices through the waiver process defined in Section 5.17 "Waivers."

2.3 Organization of the Practices

The Practices herein are organized into 3 main sections that are:

Section 5.0 - Management Practices
Section 6.0 - Engineering Practices
Section 7.0 - Safety and Mission Assurance Practices

Practices are collected along topical areas of project interest. Each topical area in Sections 5 -7 is comprised of a Preamble section (optional), a Practices section, and a Documents section.

2.4 Where to Find the Requirements

LMS - This document resides in the Langley Management System (LMS) and contains requirements that Exploration projects must meet or request waiver for.

2.4.1 Preamble Sections - Preamble sections are included to provide context for, or define the scope of, the topical area. Statements in the Preamble Sections are not requirements.

2.4.2 Practices Sections -- With the exception of "Notes" and "Examples," all statements in the Practices section of each topical area are institutional requirements, and compliance is mandatory unless appropriate waivers are approved and documented.

2.4.3 Documents Sections – Documents are divided into:

a. Requirements, which provide a reference to requirements that must be followed by each project unless documented by a waiver.

b. Guidance, which may be of assistance to the Project but which are not required.

2.5 Style and Format Conventions

2.5.1 In order to make the EFPPH more readable, the imperative "shall" is not used in the Practices sections. Nonetheless, the statements in the Practices sections represent requirements, and they shall be performed unless a waiver has been approved according to the procedure defined in Section 5.17 "Waivers."

2.5.2 Statements of the sort, "Project Managers..." refer specifically to activities that a project manager is directly accountable for, even if delegated to another individual.

2.5.3 Statements of the sort, "Projects do..." refer to activities that projects are responsible for, but which generally are the responsibility of persons other than the project manager. The Project Manager is nonetheless responsible and accountable for the fulfillment of the requirements.

2.5.4 Statements of the sort, "<Organization> chooses..." or "<Organization> ensures..." refer to activities that <Organization> is responsible for. The Director of the <Organization> is responsible and accountable for the fulfillment of the requirement. <Organization> may be the Center or a Directorate within the Center.

2.5.5 Special terms and acronyms are defined in Appendix A “Definitions and Acronyms.”

3.0 Implementation

3.1 Customer Requirements Flowdown

3.1.1 Langley’s space flight projects are either full projects within NASA space flight programs or sub-projects to space flight projects within NASA programs. In any case, the customers must comply with the current version of NPR 7120.5, “NASA Space Flight Program and

Project Management Requirements," and their requirements extend to Langley. In addition, the customers have other technical and programmatic requirements that extend to their Langley sup-projects and which are to be documented in a Project Plan or Project Management Plan as described in Section 5.2 "Planning."

3.1.2 In case of conflicting requirements

a. Customer requirements supersede Langley requirements if the customer requires more rigor.

b. If customer requires less rigor, then the Project may seek to reduce rigor by following the waiver process in Section 5.17.

c. NASA Procedural Requirements supersede customer requirements, although the waiver process in Section 5.17 may be followed to reduce the application of NASA requirements for a particular project.

3.2 Roles and Responsibilities

3.2.1 The Flight Projects Directorate (FPD) will:

a. Provide management oversight of projects, which includes ensuring proper compliance with Center and agency requirements.

b. Support Center and Product Unit management in representing Langley's Research Center, Langley's space flight projects, and Langley's supporting activities to our customers.

c. Provide project management support for schedules, configuration management, data management, resource management, and administrative tasks.

d. Review and approve Project Management Plans with each customer on behalf of Langley.

e. Review and approve Project Implementation Plans with the concurrence of the Langley Systems Management Office and other Center organizations.

f. Define the requirements and approve the Technical, Schedule, and Cost Control Plan identified in Appendix D.

g. Ensure that Langley's space flight projects meet customer requirements, comply with the requirements of this document, and comply with other NASA and Center requirements.

h. Ensure effective project management, resource management, data management, configuration management, and schedule management for each project.

i. Regularly review each project and report to the Center Management Council (CMC).

j. Continually improve the SFPPH by incorporating changes that enact lessons learned by Langley projects or that implement changes in NASA and Center policy.

3.2.2 The Project Manager is organizationally assigned to FPD and will:

a. Represent the Project to the customer and to Langley.

b. Lead the initiation of the Project, the staffing of the Project, and the definition, development, and approval of Project plans.

c. Lead the Project team in ensuring that the Project meets customer requirements for cost, schedule, and technical performance, that the Project meets the requirements of this document, and that the Project meets other NASA and Center requirements.

d. Report regularly to the customer, FPD, and the Center.

e. Be responsible for implementing Technical Authority as defined in the Langley Research Center Technical Authority Implementation Plan.

3.2.3 The Exploration and Space Operations Directorate will:

a. Represent the Langley Research Center, Langley's Exploration projects, and Langley's supporting activities to our customers in the Constellation Program and within the Constellation Projects.

3.2.4 The Science Directorate will:

a. Represent the Langley Research Center, Langley's science projects, and Langley's supporting activities to our customers in the NASA Science Mission Directorate and the funding Program Office.

3.2.5 The Systems Management Office (SMO) will:

a. Provide leadership, consultation services, technical and cost expertise.
b. Work with Project personnel to define the requirements and approve the Review Plan identified in Appendix D. The SMO has responsibility for oversight of Center project reviews and should be consulted for all Langley reviews.

c. Assure that the Project executes according to its Project Implementation Plan, the current version of NPR 7120.5, the requirements of this document, and other NASA and Center requirements.

d. Support dry runs and pre-reviews in advance of the Center Management Council (CMC) reviews and assist as requested in ensuring effective CMC reporting.

3.2.6 Core Resource Directorates (Systems Engineering Directorate, Research and Technology Directorate, Systems Analysis and Concepts Directorate, Center Operations Directorate, and Research Services Directorate) will:

a. Provide engineering leadership and staff for each project, including the Project Chief Engineer.

b. Ensure technical excellence in the engineering products and services developed by the projects.

c. Ensure the involvement of appropriate subject matter experts in the development and review of engineering products and services.

d. Define the requirements and approve technical control plans identified in Appendix D.

3.2.7 The Langley Chief Engineer will:

a. Lead the overall Technical Authority process as defined in the Langley Research Center Technical Authority Implementation Plan.

b. Verify compliance with the engineering provisions of this document and other NASA and Langley requirements documents.

c. Lead periodic reviews of the technical quality of work being performed on Exploration projects.

d. Guide the organization of major technical reviews for Exploration projects and approve each review's Terms of Reference.

3.2.8 The Safety and Mission Assurance Office (SMAO) will:

a. Provide the Project with risk management, safety, and mission assurance support as required.

b. Define the requirements and approve the Safety and Mission Assurance Plan and other control plans identified in Appendix D.

c. Ensure compliance with the safety and mission assurance provisions of this document and other NASA and Langley requirements documents.

d. Ensure involvement of appropriate subject matter experts in the development and review of safety and mission assurance products by the project.

e. Manage Langley’s contribution to the NASA Lessons Learned database.

3.2.9 The Office of the Chief Financial Officer (OCFO) will:

a. Provide valid cost-estimating tools.

b. Provide standard, Center-level cost rates.

c. Validate proposed budgets before they are submitted to funding sources.

3.2.10 The Office of Procurement (OP) will:

a. Approve the Acquisition Plan identified in Appendix D.

b. Provide Contracting Officer and other procurement support to the Project.

3.2.11 The Center Operations Directorate (COD) will:

a. Define requirements for environmental management, security, and export control plans defined in Appendix D.

b. Provide facilities support to the Project.

c. Provide security to the Project.

d. Provide subject matter experts in security, facilities, environmental protection, and International Traffic in Arms Regulations and other export control laws and regulations.

4.0 Changes and Waivers

Note: *For this section, "change" refers to revisions and updates to this document. "Waiver" refers to a modification of a requirement for a specific project.*

4.1 Change Authority

The Flight Projects Directorate shall chair the Change Control Board function for this document.

4.2 Waiver Authority

Authority to approve a waiver to the requirements herein and to those contained in other applicable requirement type documents is defined in Section 5.17 "Waivers."

4.3 Requesting Changes to This Document

Users of this document may submit requests for changes using the Langley Management System's Corrective, Preventive, and Improvement Action Tracking System (CAP Tracs).

4.4 Project Baseline

The Project Implementation Plan (PIP) documents the baseline developed during formulation, and includes the agreements and commitments among the project, program, customer, partners, and Langley management. The PIP baseline identifies the version of this document that is current at the time of PIP approval. Revisions of this document subsequent to PIP approval may represent new and changed requirements not accommodated within the baseline resources. The Project's Configuration Management plan defines how changes to this document will be incorporated into project planning documentation.

5.0 Management Practices

Management excellence for Exploration projects is about using NASA, contractor, and partner resources efficiently to deliver high quality products and services that meet our Exploration customers' needs on time and within budget. We use NASA standards for space flight project management for the same reason we use NASA standards for space flight engineering: They embody the best practices and lessons learned from many projects at many NASA Centers.

In addition, the Center has learned lessons from our own past projects and has assessed what is needed for carrying out human-rated space flight projects at Langley. These practices are required by the Center to make sure we bring to our Exploration projects the best practices that experience and necessity have shown us so far.

As a general reference for project management processes and some options on how to implement them, the Flight Projects Directorate has adopted the ANSI standard *A Guide to the Project Management Body of Knowledge* (PMBOK Guide), Third edition, published by the Project Management Institute.

5.1 Life Cycle

Preamble

Langley space flight projects follow a variety of life cycles – from a full space mission life cycle to specialized sub-project life cycles which that are contained within the overall life cycles of the supported projects. In this document, both full projects and sub-projects are called space flight projects or, simply, projects.

Examples of Langley space flight projects include:

- Climate Absolute Radiance and Refractory Observatory, a full mission project under study at Langley for the Earth Systematic Mission Program.
- Launch Abort System Project, a sub-project within the Orion Project of the Constellation Program.

Practices (Compliance is mandatory).

5.1.1 Within each project's life cycle, there are phases separated by decision gates. Projects plan the accomplishment of work based on the deliverable products the customers need and on the life cycle gate products required for the decision gates.

***Note**: Decision gates for sub-projects are often defined by the customers who thereby define some of the life cycle gate products.*

In addition, there are products required by Langley in order to obtain Center commitment to the plan for the next phase of the project.

5.1.2 The life cycle of full projects is defined through a series of Key Decision Points marking the transition from one phase of the life cycle to the next. These are defined in NPR 7120.5.
Because sub-projects at Langley have unique project life cycles, each Project--during the first 60 days of project initiation--defines the Project's life cycle, put in context of their customer's project. As part of this definition, the Project identifies Langley Project Maturity Milestones A, B, and C which determine the schedule for certain plans and other project management products given in Appendix D of this document. Nominally, Milestone A corresponds to Key Decision Point A at the end of the Concept Studies phase (Mission Concept Review), Milestone B corresponds to Key Decision Point B at the end of the Concept and Technology Development phase (System Definition Review), and Milestone C corresponds to Key Decision Point C at the end of Preliminary Design and Technology Completion phase (Preliminary Design Review).

Note: Langley projects are responsible for ensuring that our customers receive the full value of the products and services we deliver. Our project life cycles must include operations and logistics support if these are essential for delivering full value.

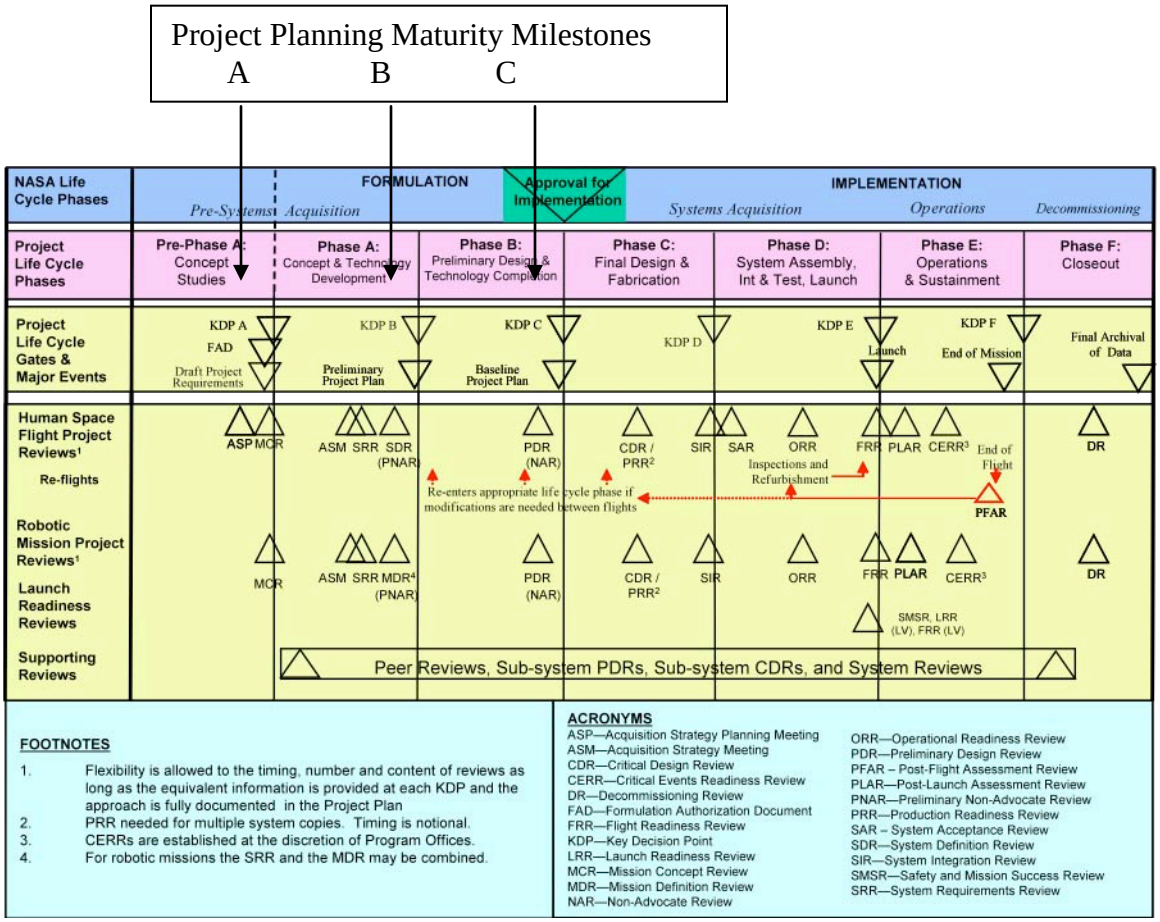

Figure 1. The life cycle of full projects is defined in NPR 7120.5. Many Langley sub-projects, however, follow a different life cycle, and the Project Planning Maturity Milestones must be defined according to the needs of the project.

Documents

Requirements

a. NPR 7120.5, "NASA Space Flight Program and Project Management Requirements"
b. Langley Management System (LMS) CP 5505, "Flight Project Critical Milestone Review (CMR) Planning and Implementation"

Guidance

a. Project Management Body Of Knowledge (PMBOK) Guide (Third edition), Chapter 2 "Project Life Cycle and Organization"

5.2 Planning

Preamble

This Planning Practice focuses on the planning required from initiation through Milestone C (PDR), at which point all the planning documents must be baselined. This corresponds to the Formulation Phase in NPR 7120.5 and is called the formulation phase in this document. Planning associated with annual budget activities or with changes in project scope are the subject of Section 5.15 "Updating Plans and Replanning" of this document.

Planning Documents--Full Projects
Full projects at Langley prepare a Project Plan as called for in NPR 7120.5. This document is signed by the Langley Center Director and the Associate Administrator for the sponsoring Mission Directorate at NASA Headquarters.

Planning Documents--Sub-Projects
Sub-projects at Langley prepare two plans during the formulation phase:

- The Project Management Plan (PMP) specifies the project requirements negotiated with and approved by the customer. This document is signed by the customer and the Center. It covers cost, schedule, reporting, and performance requirements as well as certain customer-defined aspects of the implementation approach, e.g., partners at other Centers and the system contractor. The primary customer of the Project Management Plan is the project of which the sub-project is a part.

- The Project Implementation Plan (PIP) is the Project Plan as called for in NPR 7120.5. It is a Langley document that specifies how the

Project intends to implement the activities required over the life cycle of the Project and is signed by the Center only. The heart of the PIP is made up of a series of control plans which may be part of the body of the PIP or may stand alone and be included in the PIP by reference. Also, plans may be combined, found to be "not applicable," or otherwise adapted so that they clearly define how the Project will be implemented. The primary customer of the Project Implementation Plan is the Langley Research Center and its component organizations who negotiate, review, and approve all or part of the PIP.

***Note*:** *The Project Management Plan will often contain PIP elements or summaries of PIP elements. For some projects, however, the customer may require control over particular Project Control Plans from the PIP and ask that they be included in the Project Management Plan. In that case, the customer will have approval authority in addition to the appropriate Langley authority.*

Baseline Plan

A Project's plan for a period of time has been "baselined" if the performing organizations commit to the constituent plans and to the Integrated Master Schedule, if the Center approves the budget, and if the Project has reviewed and established the Integrated Master Schedule as a baseline against which progress will be measured.

Practices (Compliance is mandatory)

5.2.1 In planning their implementation, space flight projects respond to NASA-wide requirements, customer requirements, and Langley institutional requirements. The planning establishes the project life cycle, deliverables, gate products, and the reviews for the Project.

5.2.2 When a customer expects that Langley will establish a space flight project, the Center begins a 60-day initiation activity with these key steps:

a. FPD assigns a Project Manager.

b. FPD identifies a Project's Planning Approval Official. The Planning Approval Official is the Director of FPD unless the role is delegated.

c. The organizations in the Center use their resources to accomplish the goals for Project staffing and collocation as defined in the Project Initiation Template given in Appendix C of this handbook or as modified with the approval of the Planning Approval Official.

***Note**: The state of understanding at the conclusion of Project Initiation is called "reference" understanding, as in "reference concept," "reference schedule," and "Reference Implementation Plan." See Appendix C "Project Initiation Template."*

5.2.3 By the end of the 60-day initiation activity,

a. Sub-projects will have negotiated a draft Project Management Plan with the customer.

b. Sub-projects will have documented a draft life cycle for the Project that is consistent with the draft Project Management Plan. The draft life cycle decision gates are identified along with the life cycle products needed to support the decisions. The draft life cycle will have been reviewed by the Systems Management Office and the Planning Approval Official.

c. The Project will have established the content of its Project Plan (full projects) or Project Implementation Plan (sub-projects). The contents include all elements listed in Appendix F "Project Plan Template" of NPR 7120.5, unless a revision has been negotiated with the owner of the plan's requirements, reviewed by the Systems Management Office, and approved by the Planning Approval Official. (Owners for each of the Project Plan content requirements are given in Appendix D of this document.) A plan for maturing the Project control plans, through the draft life cycle, will be complete.

d. The Project will have baselined a detailed plan for accomplishing the work that gets the Project through Milestone A (MCR).

e. The Project will have had a 60-Day Review as described in Section 5.14.1.1.

***Note:** If the Project is "small," the need for a 60-Day Review with the Center Management Council may be waived. In this case, the Planning Approval Official negotiates the waiver with the Systems Management Office, and the Center Director has the final decision.*

5.2.4 Each Project prepares preliminary and final Project Management Plans with content and format negotiated with the customer and according to a schedule negotiated with the customer.

***Note**: Project Management Plans represent a commitment by the Langley Research Center and must be reviewed and approved by an appropriate official. See Section 5.2.10.*

5.2.5 Revisions to the Project Management Plan require all the same approvals as the original release.

5.2.6 At Milestone A (MCR), the Project baselines a detailed plan for accomplishing the work through Milestone B (SDR). At Milestone B (SDR), the Project baselines a detailed plan for accomplishing the work through Milestone C (PDR). Also at Milestone B (SDR), the Project will have completed the preliminary version of the Project Plan or PIP. At Milestone C (PDR), the Project will have completed the final Project Plan or PIP and baselined the detailed plan for Project implementation.

5.2.7 Projects formulate implementation plans with consistent scope, schedule, and budget in accordance with the requirements contained in Section 5.6, "Scheduling, Cost Estimating, Performance Assessment and Control" and other sections of this document, specifically:

a. Project implementation planning is based on the NASA standard, product-oriented Work Breakdown Structure (WBS). Refer to Section 5.4, "Work Breakdown Structure."

b. Project implementation planning addresses major risks and potential mitigation actions. Refer to Section 5.16, "Risk Management."

c. Project implementation planning includes programmatic and technical margins. Refer to Section 5.6, "Scheduling, Cost Estimating, Performance Assessment and Control" for programmatic margins. Refer to Section 6.4.7 for technical margins.

d. Project implementation planning assumes a normal (40- hour) work week, with allowances made for training, holidays, and Langley averages for vacation and sick leave. Projects check with FPD to get the approved number of work hours in a work year to use for planning purposes.

5.2.8 Projects indicate planned compliance and non-compliance to the requirements of this document at the 60-Day review and at Milestones A, B, and C. See Appendix B and Appendix D.

5.2.9 Each Project submits its Project Plan (or its Project Management Plan or Project Implementation Plan) to the identified review

organizations for review and comment at least 30 calendar days in advance of the due dates.

5.2.10 For full projects, the Langley approval signature is the Center Director. For sub-projects, the Langley approval signature for both the Project Management Plan and the Project Implementation Plan is the Director of FPD, who will sign after concurrence of the review organizations has been obtained. The Director will not approve plans that fail to meet the requirements of Section 5.2.7.

Documents

Requirements

a. NPR 7120.5, "NASA Space Flight Program and Project Management Requirements"
b. LMS-CP-5526, "Product Requirements Development and Management Procedure"
c. LMS-CP-5505, "Flight Project Critical Milestone Review (CMR) Planning and Implementation"

Guidance

a. Space Flight Project Practices Handbook (SFPPH) Appendix C, "Project Initiation Template"
b. SFPPH Appendix D, "Elements of the Project Implementation Plan"
c. SFPPH Appendix B, "Compliance with the Requirements of the Langley Space Flight Project Practices Handbook"
d. PMBOK Guide, Section 3.2.2 "Planning Process Group" and the citations from there

5.3 Project Organization, Roles and Responsibilities, and Decision-Making

Preamble

The wide variety of space flight project types makes it impractical to establish a fixed organizational structure applicable to all space flight projects.

Practices (Compliance is mandatory)

5.3.1 Early in Formulation, each Project works with Center organizations, partners, and contractors to define the roles and responsibilities of key participants and the interrelationships among the key participants. The Project documents the results in PIP Section 1.4 "Project Authority, Governance Structure, Management Structure and Implementation Approach."

5.3.2 Langley Research Center senior management always has a stake in the performance of each Project and holds the Project Manager and supporting organizations accountable for good customer relations, effective planning, and successful execution.

5.3.3 For each Langley space flight project, there is a Product Unit responsible for Langley's overall relationship with the Project's customers. These Product Units (typically the Exploration and Space Operations Directorate or the Science Directorate) have key roles in project planning and implementation and in the Project's relationship with their customer. Each Project documents their working relationship with the appropriate Product Unit in the Project Plan or Project Implementation Plan. Of particular importance is the method for maintaining coordination in the relationships with the customer.

5.3.4 The Project Manager and other key managers are responsible for ensuring that the Project responds to the needs of the customer and other stakeholders. These needs are likely to change as programs become better defined. Projects must be prepared to respond to these changes. See Section 5.15 "Updating Plans and Replanning" of this document.

5.3.5 Organizational Breakdown Structure (OBS) and the WBS are defined and integrated to the Control Account level.

Documents

Requirements

a. NPR 7120.5, "NASA Space Flight Program and Project Management Requirements"
b. SFPPH Section 5.15, "Updating Plans and Replanning"

Guidance

a. PMBOK Guide, Chapter 2 "Project Life Cycle and Organization"

5.4 Work Breakdown Structure

Preamble

The NASA Space Flight Project WBS is a product oriented, hierarchical division of the work that the Project performs. It reflects the way in which project costs are planned, collected, and reported; but is not necessarily how the project is organized to accomplish the work.

It is Langley's policy to implement the standard WBS on all its projects unless there is a compelling reason to use a different WBS. WBS standardization

allows collection of cost data in a manner that facilitates cost comparisons among projects. WBS standardization also promotes completeness in cost estimating.

Practices (Compliance is mandatory)

5.4.1 Langley Exploration Projects use the NASA standard WBS given in Appendix G "Space Flight Project Work Breakdown Structure (WBS)" of NPR 7120.5, unless a waiver is granted by the Planning Approval Official.

5.4.2 The Project completes the WBS and WBS dictionary down to the Control Account level as part of getting ready for the 60-Day Review.

5.4.3 Projects extend the WBS and WBS dictionary to the level necessary to implement and verify the work. The Project WBS must be baselined by Milestone C (PDR), although breakdown to the work package level will continue as the Project advances into implementation.

Documents

Requirements

a. NPR 7120.5, "NASA Space Flight Program and Project Management Requirements"

Guidance

a. PMBOK Guide, Section 5.3 "Create WBS"
b. PMI Practice Standard for Work Breakdown Structures (second edition)

5.5 Testbeds, Models and Spares

Preamble

This practice requires projects to identify all the flight and development hardware models and simulations early in the Project and to describe the overall philosophy for the use of these models.

Practices (Compliance is mandatory)

5.5.1 The Project documents the quantities of hardware models, simulations, and testbeds, and describes the model philosophy in PIP Section 2.1 "Requirements Baseline."

5.5.2 The plan covers flight model hardware (including spares), development model hardware, testbeds, and simulations developed

to support system level verification and validation. The Project also defines its overall philosophy for the integrated use of these models for development, testing, and verification. If engineering and/or prototype models are intended to be possible flight spares, the plan for this use is included.

***Note**: Engineering and prototype models are typically made as identical as possible to the flight units in order to maximize their utility.*

5.5.3 In establishing these plans, the Project considers, as a minimum, the following factors: state of technology; inheritance and/or maturity of design; mission and system complexity; test support equipment; schedule; impact of failure, e.g. during Assembly, Integration, and Test; on the ability to meet commitments in the Project Management Plan; and on cost.

a. Projects develop engineering models for new and significantly modified designs for mission-critical hardware components.

5.5.4 For flight hardware products having active digital control:

a. Projects make available at least one dedicated hardware-in-the-loop testbed for software development and performance verification.

b. Projects provide simulations of hardware, and make these available for substitution in the testbed(s) when flight-like hardware (e.g. spare, engineering model, or breadboard) is not available.

c. Projects provide a simulation of the hardware and space environment with sufficient fidelity to support flight software development and testing, system validation, and post-launch operations.

d. Projects characterize testbeds against the flight article, and understand and document differences between testbeds and the flight articles in the Assembly, Integration, and Test environment, the launch environment, and the operational environment. Simulation models are validated by test to demonstrate the required fidelity for the intended uses.

e. Projects maintain testbed fidelity throughout the Project lifecycle consistent with its use(s), including after launch for sequence

validation, flight software maintenance, and anomaly investigation support.

5.5.5 Projects that produce reusable or maintainable flight or ground hardware follow the requirements of NPD 7500.1, "Program and Projects Logistics Policy" and develop and document an Integrated Logistic Support regimen which addresses at a minimum ground and flight systems hardware maintenance; supply support, including resupply and return; spares reprocurement; technical data and documentation; maintenance tools, test, and support equipment; material transportation and handling; maintenance training; and logistic support performance measurements for the life of the program or project. Resources applied to the logistics effort will be scaled to fit the scope and size of the individual program or project.

Documents

Requirements

a. NPD 7500.1, "Program and Projects Logistics Policy"

5.6 Scheduling, Cost Estimating, Performance Assessment and Control

Preamble

Langley's customers place high value on the control of cost, schedule, and technical performance, and in order to earn our customer's continued reliance on our capability, each Project must apply discipline in creating cost, schedule, and performance plans and in executing the Project according to the plans.

Projects control the work of implementation by anticipating and preventing problems and by getting deficiencies corrected before they impact cost, schedule, or the quality of the deliverables. Projects use objective measures of work performance and quality so that progress and quality are visible and can be controlled.

Langley's space flight projects will change as their customers' needs change, and annotated planning products developed during formulation can help make changes to the plan easy and reliable. In particular, Projects develop their cost estimate in a way that makes it easy to update at regular intervals, following the guidance of the NASA Cost Estimating Handbook that the cost estimating process is continuous and iterative over the life of the project.

Practices (Compliance is mandatory)

5.6.1 Scheduling

***Note**: Projects must be sure to allow enough time for:*

- *Preparing and establishing contracts.*
- *Funding to arrive at LaRC.*
- *Schedule reserve.*

a. Each Project produces a preliminary integrated schedule to below the subsystem or equivalent levels (i.e., WBS Level 3) in the first 60 days. The schedule reaches at least to each Control Account element.

b. Each Project baselines their resource-loaded, Integrated Master Schedule (IMS) for the implementation phase by the time of Milestone C (PDR).

c. Each Project considers the activities they may be required to do to support the customer's operational use of the Project's deliverables and includes these activities in the IMS.

d. Projects develop schedule margins based on assessed implementation risk, with no less than one month per year allocated along the critical path.

***Note**: High-risk items should be mitigated with additional margin and managed so that they stay off the critical path. Once they become part of the critical path, the time lost on high-risk items is generally not recoverable.*

e. The customer may want to hold the schedule reserves, and projects may be willing to accept a schedule challenge, but Langley will not commit to delivering products on a schedule that does not have adequate schedule reserves.

f. The Project will recommend control milestones within the schedule and a change process that will ensure that the Center is fully aware of upcoming changes, the reasons for the changes, and the impact of the changes. The Planning Approval Official will approve the control milestones and the controlling process, which may depend on the customer. The control milestones become part of the Project Implementation Plan.

g. The Project will recommend milestones to be tracked in a Milestone Trend Chart. The Planning Approval Official will approve the list of milestones and any revisions to the list.

5.6.2 Cost Estimating

Note: *Cost estimates transmitted to funding and other stakeholders outside of the Center represent a commitment by the Center even if explicitly labeled otherwise. For this reason, Projects must contact the Office of the Chief Financial Officer (OCFO) for guidance as soon as the requirement to transmit a cost estimate is known.*

a. Each Project develops cost estimates based on the defined scope of work, integrated schedules, and the planned implementation approach, documented in a Basis of Estimate. These estimates (also known as "grass roots" or "bottom-ups" estimates) are developed by the implementing organization at the lowest WBS level practicable and summed to a higher level to produce the Project Life Cycle Cost (LCC). The preliminary estimates (at the Control Account level or below) are completed prior to Milestone B (SDR). The baseline estimates (at the work package level) are completed prior to Milestone C (PDR).

b. The Project validates the "grass roots" cost estimate by some independent method, such as analogy with a past project or parametric cost modeling.

c. The Project includes reserves in the cost estimate based on assessed implementation risk. The standard level of reserves is 30% at the time of Milestone C (PDR), and a waiver is required for a smaller level of reserves in the cost estimate. The Center will not allow less than 15% reserves at the time of Milestone C (PDR). The customer may insist on holding the reserves, but each Project rigorously develops the reserve requirement and includes it in the cost estimate.

d. By Milestone B (SDR), each Category 1 and Category 2 (defined in NPR 7120.5) Project develops a Cost Analysis Data Requirement (CADRe) to support independent cost analysis by NASA. Additional CADRe's are required by Milestone C (PDR), System Integration Review (or its equivalent, prior to mission integration), Flight Readiness Review (or its equivalent), and the end of the mission (or its equivalent).

e. To support cost estimates made during the formulation phase, the Project identifies and maintains a list of programmatic and technical risks, including cost impact and probability of occurrence as the basis for cost-risk analysis.

f. The Project will update the cost estimate at each major review and as part of the annual budget cycle. A review of the cost

estimate will include a presentation that traces the current cost estimate back to the previous one.

5.6.3 Performance Assessment and Control

a. Each Project documents their plan to monitor and control the Project's requirements, technical performance, schedule and cost in PIP Section 3.1 "Technical, Schedule, and Cost Control Plan."

b. A Project will implement Earned Value Management in planning and controlling the work of the Project if:

(1) The value of the effort managed by the Project is greater than $20M over the life cycle,
(2) The Project's customer requires it, or
(3) The Center directs the Project to use Earned Value Management.

c. A Project implementing Earned Value Management will follow Langley's best practices or an equivalent system that the Project's customer may impose.

***Note**: Langley's best practices for Earned Value Management are maintained by the Systems Management Office.*

d. Projects impose earned value reporting on cost type contracts greater than $20M. Contractors provide earned value reports (in contractor format) on a regular basis.

e. During each phase, the Project objectively monitors the performance of the Project and reports at least monthly to FPD and other organizations at the Center. The Project highlights any developments that indicate a threat to Project success.

f. Projects report to, and resolve with, the customer any projected cost and schedule growth above the baselines defined in the approved Project Plan or PMP.

g. During implementation, each Project periodically (minimum yearly) generates an Estimate at Completion (EAC), analyzes variances, and takes corrective action as necessary.

h. During each phase, the Project maintains and reports monthly on a list of cost liens and accumulated encumbrances. A lien is a recognized potential threat to cost that may or may not come to

pass. When the threat becomes a certainty, the Project encumbers the expense (commits the funds as part of the plan).

i. Each Project reports monthly on the cumulative trend of encumbrance. Funds for the encumbrance may come from Project reserves or from savings elsewhere in the Project. When the cumulative trend of encumbrance or the Project Estimate at Completion indicate that the baselined estimate including reserves will not be sufficient for completing the Project, FPD will review the Project's plans and the causes of cost growth and will recommend corrective action to the Center.

j. At the end of each Project, Projects submit to the Langley OCFO records of resources expended and workforce used since Project inception.

Documents

Requirements

a. NPR 7120.5, "NASA Space Flight Program and Project Management Requirements"

Guidance

a. NASA Cost Estimating Handbook
http://www.nasa.gov/offices/pae/organization/cost_analysis_division.html
b. PMBOK Guide, Chapter 6 "Project Time Management"
c. PMBOK Guide, Chapter 7 "Project Cost Management"
d. PMBOK Guide, Section 3.2.4 "Monitoring and Controlling Process Group" and the citations listed in the section
e. PMI Practice Standard for Scheduling
f. PMI Practice Standard for Earned Value Management

5.7 Information Management and Information Technology

Preamble

This practice addresses the management and security of the Project's information technology (IT) environment and of its records, in particular of the data and information used for programmatic and technical purposes. The subject practices complement those in Section 5.8 "Configuration Management."

This practice does not apply to flight data management, which is addressed in Section 5.18 "Engineering Science Data Management," nor to software development, which is addressed in Section 6.10, "Software Development."

Projects create, acquire, and manage information and data of many types throughout the Project life cycle, including controlled documents, controlled records, and other recorded information in any format. All of these are known as "records," i.e. something that documents essential transactions, procedures, decisions, policies, and activities of the Project.

Projects also plan, set up, use, and appropriately decommission tools and services that constitute an effective IT environment--one that facilitates the Project's work and collaboration and that meets the Project's needs throughout the Project's life cycle.

Practices (Compliance is mandatory)

5.7.1 Projects are responsible for the protection, preservation, and distribution of project-generated information, for taking appropriate actions depending on its sensitivity (e.g., export-controlled, industry proprietary, competition sensitive, intellectual property, spacecraft commands), and for ensuring viability of the Project in the event of a disaster.

5.7.2 Each Project uses existing Langley and NASA IT infrastructure, (e.g., email systems, electronic libraries, network architecture, computer and network security, access control) to satisfy its on-Center needs and to provide the necessary interfaces with off-Center systems.

5.7.3 Within the first 60 days, each Project plans and begins implementing an IT environment and information management practices, e.g. to support collaboration with external partners and to meet customer requirements for information management.

5.7.4 Each Project documents its IT and information management requirements and approach in its Project Plan or PIP Section 3.13 "Information and Configuration Management Plan."

5.7.5 Each Project establishes and maintains a Project library (consisting of one or more repositories).

5.7.6 Projects generate records that document their actions and decisions.

5.7.7 Projects retain their records, whether created or acquired, and preserve those records throughout the Project life.

5.7.8 Projects manage their records in accordance with the requirements of Langley Records Management including transferring those records to inactive records storage no later than at the end of the Project.

Documents

Requirements

a. LPR 1440.7, "Langley Research Center (LaRC) Records Management Procedural Requirements"

5.8 Configuration Management

Preamble

Configuration management (CM) is the discipline that ensures rigorous control of project configuration items and their characteristics important for mission success. CM is applied to project documents, requirements, design and operations documentation, hardware and software products, testbeds, and other information (e.g. atmospheric and terrain models used in EDL analysis) as defined by the project.

Practices (Compliance is mandatory)

5.8.1 Planning

a. Each project documents its configuration management requirements and approach in the project Configuration Management (CM) Plan.

Note: *Projects may modify the Configuration Management Plan template that is available on the Flight Projects Directorate folder of the Langley NX site.*

b. Projects impose configuration management requirements on contractors and suppliers, and negotiate any waivers and/or exceptions prior to contract execution.

c. Projects require and approve contractor CM Plans for the contracted efforts.

d. Projects define the method(s) to be used to ensure reliable and timely communication and collaboration of changes across the project in the project CM plan.

e. Projects define the change control authority in the CM Plan. Projects that distribute the change control authority (e.g. among several Change Control Boards (CCBs)) define the limits on approval authority for each CCB level, and the methods to coordinate the actions of the different activities.

5.8.2 Implementation

a. Projects identify the items subject to configuration management, and ensure unique identification of these configuration items.

b. Projects commence change control as follows:

(1) Project documents are placed under change control not later than their initial official release.
(2) Requirements are placed under change control not later than Milestone C (PDR).
(3) Designs are placed under change control not later than 30 days after the corresponding CDR.

c. Projects manage the configuration records starting with release and ending with end of mission (EOM).

d. Early in formulation, projects plan for and initiate project CM processes to ensure coordinated control measures and understanding among all project participants for their use are timely. See Sections 5.7.3 and 5.7.4.

e. Projects use institutionally supported CM tools or customer provided tools for CM activity. If the Project uses a customer-provided tool for CM, the CM Plan identifies project products which will also be archived in Langley NX.

f. Projects use engineering change requests (ECRs) or equivalent to control change activity. Contractors use ECRs or equivalent systems.

g. Projects disposition change requests, via CCB after getting assessments of the impacts of the change from all areas affected by the change. Alternately, project CCBs direct the implementation of changes in the absence of impact assessments when it is apparent the additional insight would not change the decision.

h. Projects disposition and close all waivers and change requests prior to committing to mission operational use.

i. Projects incorporate all approved changes in hardware and software products, and associated documentation prior to committing to mission operational use.

5.8.3 Records and Reporting

a. Projects maintain records of the change activity, report its status periodically, and take action as appropriate to ensure timely close out of open items.

b. Projects maintain current the configuration records as changes are authorized ensuring the project “knows what it flies.”

c. Projects archive the final design and final product.

d. Projects archive photographic records from the closeout of flight and ground hardware as described in LPR 7600.1, "Closeout Photographs for Flight and Ground Hardware Procedural Requirements."

e. Projects will require that contractor controlled documents, drawings, and records are maintained and archived in the contractor CM system.

Documents

Requirements

a. NPR 7123.1, "NASA Systems Engineering Processes and Requirements"
b. LPR 7600.1, "Closeout Photographs for Flight and Ground Hardware Procedural Requirements"

Procedures

a. LMS-CP-5510, "Aerospace Systems Change Control within Systems Engineering"

Guidance

a. PMI, “Practice standard for Configuration Management”

5.9 Customer-Level Scope Margin

Preamble

Scope margin is one of the resources available to the Project for risk mitigation; i.e., the performance-risk trade space.

Customer-level scope margin, like other margins can be traded against risk, except that movement within this space requires customer approval.

Practices (Compliance is mandatory)

5.9.1 If it makes sense, a Project develops a "customer-level" descope plan, which is included in the Project Management Plan and reviewed at Milestones B and C.

5.9.2 Scope margin, in general, is part of the Project risk trade space, but customer-level descopes may not be used without prior customer approval.

5.9.3 Projects negotiate the customer-level requirements with the customer, and establish a baseline by Milestone B (SDR).

Documents

Requirements

a. LMS-CP-5526, "Product Requirements Development and Management Procedure"

Guidance

b. PMBOK Guide, Chapter 5 "Project Scope Management"

5.10 Project Staffing and De-staffing

Preamble

Project success depends primarily upon the excellence of the Project's personnel and their ability to work as a cohesive team. Slow staffing can lead to Project delays while slow destaffing can lead to cost overruns. Finally, removing staff from a project without the knowledge of the Project Manager and without a transition plan can lead to major disruptions in the execution of a project. Staffing and destaffing the Project is a collaborative effort between the Project and the participating organizations at the Center and the partners. Specific work can also be contracted. Projects should remember that contractor employees cannot be supervised or controlled by

government employees since this constitutes personal services and is a violation of Federal law and regulations.

Practices (Compliance is mandatory)

5.10.1 FPD chooses the Project Manager, with the concurrence of the Center Director.

5.10.2 The Project Manager develops staffing requirements consistent with needs over the life of the Project. The Project Manager works with designated points of contact within FPD, SED, RTD, SACD, and other organizations to identify people at the Center to staff the Project.

5.10.3 FPD ensures that each Project's top leadership--Project Manager, Deputy Project Managers (technical and resources), and Project Chief Engineer--has combined experience appropriate to cover the size and technical requirements of the Project. For large, human-rated space flight projects, the Project's top leadership must have experience in large space flight projects and in human-rated space flight projects.

5.10.4 Staffing the core team falls on the critical path for an space flight project and must be accomplished quickly. The Project Manager will supply an updated list of staffing needs weekly to Center leadership. Data on how the Center performs in staffing the Project are to be reported at the 60-Day Review.

***Note**: Langley sets a goal of 30 days for staffing the core team, in two waves. The goal for the first wave is to be complete by the end of week 2 from the time the customer expects Langley to establish the Project. The goal for the second wave is to be complete by the end of week 4.*

a. As applicable, the members of the first wave include:

(1) Project Manager
(2) Deputy Project Manager
(3) Deputy Project Manager for Resources/Program Analyst
(4) Project Chief Engineer
(5) Project Safety and Mission Assurance Manager
(6) Scheduler
(7) Configuration Manager
(8) Contracting Officer

b. As applicable, the members of the second wave include:

(1) Lead Subsystem Engineers
(2) Integration and Test Manager

5.10.5 Each Project allocates resources to provide technical oversight/ insight of system-contracted and subcontracted activities based on an assessment of project-unique risks. The level of support is initially determined during formulation, and subject to re-assessment throughout implementation.

5.10.6 Each Project allocates resources to provide technical oversight/ insight of activities at Langley and at partner organizations.

5.10.7 Each Project allocates resources to meet other project planning, control, and reporting requirements.

5.10.8 Projects and Center organizations concur on transition plans for key staff departing the Project before the planned date.

5.10.9 Projects and Center organizations collaborate in destaffing personnel whose support is no longer required by the Project.

5.10.10 Projects periodically assess the adequacy of Project staffing, and communicate to the Center organizations, partners, and contractors as early as possible any need to change the planned level of support.

5.10.11 Advance discussion with the customer is held before re-assignment of identified key personnel, to include:

a. Project Manager
b. Project Chief Engineer
c. Other personnel designated as 'key' in the Project Management Plan.

Documents

Requirements

a. LMS-CP-4523, "Contractor Performance Monitoring"
b. LMS-CP-4501, "Procurement Process Overview"

Guidance

a. PMBOK Guide, Chapter 9 "Project Human Resource Management"

5.11 Project Priorities/Competing Characteristics

Preamble

Safety of people (public, flight crew, and Project and support personnel) is the paramount requirement for all of NASA's missions. Hence, safety requirements and compliance thereto are not compromised in trade-offs against the other Project considerations. Personnel safety must not be compromised while achieving mission objectives.

The customer puts constraints on projects in terms of: scope, cost, performance, and schedule. The institution imposes requirements (Space Flight Project Practices Handbook, and other requirement-type documents) on projects to ensure prudent risk-taking.

Projects make decisions that impact in varying degrees the mission scope, performance, cost, schedule, and reliability. Early alignment and continual reinforcement (within the Project and among the Project, sponsor, and the institution) for the priority order among these competing factors are important for the Project to be successful.

Practices (Compliance is mandatory)

5.11.1 During formulation, each Project—in collaboration with the customer—decides the priority order among competing factors (reliability, schedule, cost, scope, and performance) that will guide its decision-making. The Project documents the approach in the Project Plan or in the Project Management Plan and Project Implementation Plan.

5.11.2 Prior to major milestones during implementation, each Project confirms with the customer the priority order among the competing factors used in decision-making.

5.11.3 When competing mission and system requirements exist, each Project also establishes a priority order among these competing requirements, in order to provide guidance to design and implementation trade-offs.

Documents

None

5.12 Acquisition and Surveillance

Preamble

For the purposes of this handbook, Project acquisitions include procurements, in-house development, and non-procurement acquisitions. Procurements consist of contracts, purchase orders, and contract task orders executed with industry, nonprofit organizations, and educational institutions. Non-procurement acquisitions are agreements placed with other organizations (e.g., other NASA Centers, federal agencies, state and local governments, and foreign governments and institutes).

Acquisition planning includes defining the acquisition strategy, including the utilization of the NASA Risk Based Acquisition Management process, and acquisition products, the identification of procurement, fabrication, and non-procurement actions, and other guidance for associated requirements packages.

Practices (Compliance is mandatory)

5.12.1 During the first 60 days, each Project develops a reference acquisition plan that includes all components of its deliverables. If there are going to be procurements, the Project includes a Contracting Officer as part of the first wave of the core team.

***Note**: The Project must not underestimate how much time and effort it will take to prepare for and execute procurements. Standard procurement lead times are shown in LMS-OP-4508, "Milestones and Leadtimes."*

5.12.2 Each Project that plans to have significant acquisition activities develops an acquisition and surveillance plan that is documented in the Project Plan or PIP Section 3.4 "Acquisition Plan."

5.12.3 Prior to engaging contractors in project work, the Project works with the Contacting Officer and legal counsel to identify and evaluate potential organizational conflicts of interest (OCI) and avoid, neutralize or mitigate potential OCI's before contract or task/delivery/purchase order award. OCI's can be categorized into three groups:

a. Biased ground rules, referring to situations where a company has an opportunity to skew a competition in its favor;
b. Unequal access to information, referring to situations where a company has access to nonpublic information that gives it an unfair advantage relative to a future competition; and

c. Impaired objectivity, referring to situations where a company is placed in a situation of evaluating itself or a related entity, which casts doubt on its ability to provide impartial advice.

Note: *It is a good practice to consider OCI implications for all organizations before they begin to participate in the project.*

5.12.4 The Project acquisition planning team obtains input from appropriate Langley organizations in areas of safety and mission assurance, health, environmental protection, information technology, export control, and security.

5.12.5 Projects prepare procurement requirements packages, including, as applicable, statement of work, delivery schedule or period of performance, specification(s), planned Langley oversight of the contractor and 2nd tier and lower-level subcontractors, contractor and subcontractor participation in Langley reviews, and contract Data Requirements List.

a. Projects flow relevant institutional requirements (including those in this document) to contractors through the contracting process, and negotiate known waivers or exceptions prior to contract execution. The Project comes to the Project Approval Official for waiver of requirements.

b. Project contracts include statements allowing on-site surveillance of contractor and all subcontractors at any level who are providing critical hardware, software, or services. Any exclusion must be approved by the Project's Planning Approval Official.

5.12.6 Each Project prepares for in-house development and non-procurement acquisitions in accordance with governing rules and consistent with process lead time. The Project exercises the same care in preparing for these acquisitions as they do for procurement acquisitions. The Project documents the plan for in-house development and non-procurement acquisitions in PIP Section 3.4 "Acquisition Plan."

a. Project agreements include on-site surveillance of in-house activities, partner activities, and related contractor and subcontractor activities at any level that are providing critical hardware, software, or services. Any exclusion must be approved by the Project's Planning Approval Official.

5.12.7 Following the 60-Day review and until contracts and other agreements are complete, the Project reports to FPD monthly on the

progress in developing the contracts and other agreements with its major suppliers.

Documents

Requirements

a. LMS-CP-4523, "Contractor Performance Monitoring"
b. LMS-CP-4501, "Procurement Process Overview"

Guidance

a. PMBOK Guide, Chapter 12 "Project Procurement Management"

5.13 Project and Institutional Reporting

Preamble

Center leadership can only serve the Center's projects well if they are informed about each Project's progress and problems.

Practices (Compliance is mandatory)

5.13.1 Each Project reports to its customer on a regular basis using a format and schedule negotiated with its customer.

5.13.2 Following the 60-Day Review, each Project reports monthly 1) on technical matters to the Engineering Project and Task Review conducted jointly by RTD, SACD, and SED, 2) on the project progress, problems, and plans to the Pre-CMC Review conducted by FPD, and 3) on project progress, problems, and plans to the Center Management Council.

5.13.3 If the Project is a key participant in launch activities, then beginning no later than 9 months prior to launch, the Project reports monthly to its Langley stakeholders on the status of the work that must be completed in order for NASA to be able to commit to launch. During the launch campaign, the Project provides daily reports to its Langley stakeholders.

Documents

Guidance

a. PMBOK Guide, Chapter 10 "Project Communications Management"

5.14 Reviews

Preamble

Reviews occur throughout the Project life cycle at important milestones to assess the quality of the requirements and design, uncover requirement and design deficiencies, identify risks to achieving performance on schedule and within budget, evaluate the status of and progress toward accomplishing the planned activities and to establish the activity's readiness for follow-on events.

The proper execution of the review process is a Project responsibility and regarded as an in-house activity, even if the reviews are conducted at another facility.

Practices (Compliance is mandatory)

5.14.1 Each Project develops a Project Review Plan in accordance with the requirements of LMS-CP-5505, "Flight Project Critical Milestone Review (CMR) Planning and Implementation." The Project Review Plan includes reviews required by the customer. At Milestone A (MCR), each Project submits a reference list of key deliverables and identifies which should be reviewed by the Center prior to release to the customer. Each Project also submits a reference list of key project milestones and identifies which milestone should be preceded by a Langley review. FPD works with the Center Chief Engineer and the SMO to complete a recommended review plan for the Center Management Council. The Project documents the approved review plan in the Project Plan or PIP Section 3.8 "Review Plan.

a. At the end of Project initiation, the Project Manager presents the 60-Day Review to the Langley Center Management Council. The objectives of the review are to find out how well the Center did in setting up the Project and to see that the Project has what it needs for the next phase of formulation.

***Note**: A presentation template for the 60-Day Review is available from FPD. The template includes notes on the required content.*

b. At Milestones A, B, and C, FPD leads a Center management review of the Project's plans. The format will be as a table-top review covering the contents of the Project Plan (or PMP and PIP), and current schedule, budget and workforce plans. The SMO, OCFO, RTD, SACD, SED, SMAO and other involved organizations participate in reviewing the plans and in arriving at a consensus recommendation on whether the Center should commit to the plan.

c. The Project Review Plan includes the planned support to reviews initiated external to the Project. Examples include:

(1) Independent assessment
(2) Institutional audit of compliance with Langley's applicable standards for flight projects
(3) Institutional assessment of progress in dispositioning risks in preparation for launch
(4) Institutional assessment of project-specific significant risk issues
(5) Institutional oversight at key milestones in the life cycle of project commitments to the sponsor

Note: *Reviews in support of customer processes are combined with Project planned reviews when the review objectives are sufficiently aligned.*

5.14.2 Although the list of deliverables and the review plan for the deliverables will be baselined at Milestone C, many new deliverables will be identified later in implementation. As requirements for deliverables change, Projects update their Review Plan and coordinate changes with FPD and other organizations involved in the reviews.

Documents
None

5.15 Updating Plans and Replanning

Preamble

This practice focuses on the planning associated with annual budget activities or with changes in project scope. These can happen at any time--from formulation through implementation.

A key principle of replanning is to keep control of the baseline plan. A series of small changes, each treated as an increment to the baseline, can mask a

significant change. Also, major changes may lead a Project to consider abandoning the baseline plan and creating an entirely new plan. Langley's policy is to control the baseline plan, and any new plan must be traced to the last baseline plan. The impact of changes on cost, risk, performance, and schedule must be made visible to all parties involved in the replanning effort.

Practices (Compliance is mandatory)

5.15.1 Budget cycle planning updates are required at least once per year and respond to the NASA budget process both through the customer and through the Center. At these times, the Project updates the Integrated Master Schedule and other planning tools to ensure that they are current and reconciled with workforce plans, procurement funding requirements, and indirect charges.

a. The Project will update the Project Plan or PIP at least once per year as part of the annual budget process. FPD will lead a Center management review of the updated PIP. The Project's Planning Approval Official approves the updated Project Plan or PIP.

5.15.2 The Project may receive a request to change the scope of the Project, either directly from the customer or through other channels. The Project promptly engages the appropriate Product Unit in evaluating the request and, if appropriate, developing plans to implement the change. For major changes, the Project promptly engages Center and partner leadership. The Project communicates any contract changes through the Contracting Officer.

***Note**: The customer may request that the Project do more work in order for the customer to be successful. There may be changes in the requirements for the deliverables, new deliverables may be added, and the life cycle may be extended.*

Or:

The customer may request that the Project do less work or even cease altogether.

a. In any case, the Project assesses the impact of the requested changes on the cost, risk, performance, and schedule of the Project and makes the impact visible to all the participants in the change process.

5.15.3 For small changes to the Project scope or schedule, a revision to the plans can be handled as in increment with respect to the baseline plan. The Project--with the concurrence of the appropriate FPD Exploration Project Office and the FPD Business Manager-- decides on the level of review required.

a. If a series of small changes have been requested since the plan was last baselined, the Project recommends to FPD leadership whether a rebaselining is required.

5.15.4 For major changes to the Project scope or schedule--or for an accumulation of small changes that result in a net major change--the Project replans the Project activities and baselines the new plan in a process of rebaselining that documents the connection between the old baseline plan and the new baseline plan.

a. Rebaselining follows the same process of review and commitment as baselining, defined in the preamble of Section 5.2 "Planning."

b. In addition, FPD leads a Rebaseline Review in which the documented connection between the old baseline plan and the new baseline is assessed and the process of rebaselining is evaluated. FPD develops and implements plans that respond to lessons learned from the changes to the plan and from the process of rebaselining.

5.15.5 For a change so large that it throws the Project into a different state, the Project will have to return to a formulation style of planning, with the planning activity itself having its own plan.

a. Even in the event of termination, the Project prepares a plan to develop the termination plan as the first phase of termination. The Project must not commit to completing a conceptual termination plan in less than 15 to 30 days, depending on the difficulty of preparing such a plan. The conceptual termination plan has approximate estimates for the cost of termination and gives a date when a detailed plan will be ready. Both the conceptual and the detailed termination plans include efforts to retain the value of work accomplished so far, at a level appropriate for the value of the work and for the likelihood that the Project may eventually be restarted. The termination plan includes termination liabilities for contracts, partners, and for Center workforce. The Project gets Center concurrence and customer approval for the termination plans.

Documents
None

5.16 Risk Management

Preamble

Risk management is conducted on all space flight projects throughout the Project life cycle. Risks are considered in Project schedule development and in Project cost estimating. Risk management includes consideration of risks related to cost, schedule, technical, scope, mission success, environmental, security, and safety factors during the implementation of the Project.

Risk management encompasses all elements of the Project. When partners and /or major contractors are involved, they are essential participants in the risk management activity.

Although Risk Management is addressed in this Section of the Handbook, the Office of Safety and Mission Assurance is responsible for the Risk Management processes used at the Center. The customer will often specify the Risk Management reporting and tracking tools that our project must use.

Practices (Compliance is mandatory)

5.16.1 Each Project documents the risk management objectives and approach over the Project life cycle in the Project Plan or PIP Section 3.3 "Risk Management Plan."

5.16.2 The Project Manager

a. Projects identify and assess potential risks using a standardized methodology, with pre-defined criteria for assessing likelihood and consequence of occurrence and approach to estimating total Project risk.

b. Projects assess risks to mission success (mission risk) and risks to implementation within program constraints (implementation risk) for each risk event identified.

c. The Project Manager takes appropriate actions based on the assessments to mitigate or retire risks. Alternatively, the Project manager may elect to take no action, accepting the risk without mitigation.

d. The Project Manager reports risks and risk status at each major review and at Langley and customer reviews.

e. Projects regularly review their Primary Risks (those risks having both high probability and high impact/severity) with Langley management and with customers.

f. Projects manage risk using either Langley-standard or customer-directed software tools consistent with NASA Continuous Risk Management methodology.

g. For missions involving launch, Projects review all risk dispositions (especially residual risk), after completion of the system level integration and test, with Langley and customer management in obtaining concurrence to launch.

Documents

Requirements

a. NPR 8000.4, "Risk Management Procedural Requirements"
b. LMS-CP-4753, “Project Risk Management Support”

Guidance

a. PMBOK Guide, Chapter 11 "Risk Management"

5.17 Waivers

Preamble

The scope of Section 5.17 applies to NASA requirements, institutional requirements including those of this handbook (the Space Flight Project Practices Handbook), and to Project generated requirements.

Practices (Compliance is mandatory)

5.17.1 For waivers to the requirements in this Space Flight Project Practices Handbook, a Project Manager will seek approval through the Project's Planning Approval Official, defined in Section 5.2.2.2.

a. The Planning Approval Official works with SMAO, the SMO, the Center Chief Engineer, and other identified authorities to process and document the disposition of waivers to the requirements of this document requested by the Project.

b. Each Project indicates planned compliance and non-compliance to the requirements of the Space Flight Project Practices Handbook through the use of the SFPPH Compliance Matrix. The final version is PIP Appendix B "EFPPH Compliance Matrix."

5.17.2 For waivers to other Center requirements documented in the Langley Management System, each Project will seek approval through processes defined in the particular Center Procedure, Policy Directive, or Procedural Requirement.

5.17.3 For waivers to NASA requirements, such as NPR 7120.5, each Project will seek approval through the SMO.

5.17.4 Each Project defines the process for granting waivers to Project Requirements in PIP 3.13 "Information and Configuration Management Plan."

5.17.5 Each Project defines the process for granting waivers to customer-imposed requirements in the PMP.

Documents

Guidance

a. EFPPH Appendix B, "Compliance with the Requirements of the Langley Space Flight Project Practices Handbook"

5.18 Engineering Science Data Management

Preamble

The knowledge gained from test data products, trade studies, system analysis, and other engineering analyses fulfills the purpose of many of the space flight projects undertaken by Langley Research Center. Generation, control, and release of useful data sets are the responsibility of our projects.

Practices (Compliance is mandatory)

5.18.1 Early in the Formulation, each Project defines which data products, analyses, and findings are to be made available for others to use. The plan for archiving and making these products available shall be documented in PIP Section 3.12 "Engineering Science Data Management Plan."

5.18.2 The Project restricts product access to organizations and individuals identified by our customer.

5.18.3 The Project includes the resources for executing the Engineering Science Data Management Plan as part of its life cycle budget.

Documents
None

5.19 External Communication

Preamble

For this practice, external communications refers to communications external to the project. The release of technical information is not within the scope of this practice.

Practices (Compliance is mandatory)

5.19.1 Each Project keeps Langley executive leadership, the appropriate FPD Project Office, and the Project's Flight customer informed of the latest status of the Project. Among the executive leadership are the Center Director, the Chief Financial Officer, and Directors of the engineering organizations, SMO, SMAO, and OP. Each Project also keeps key individuals in each of these organizations informed. Items requiring notification include, but are not limited to:

a. Major changes to the Project schedule
b. Requests for significant changes in scope
c. Significant changes to the Project fiscal commitments
d. Major changes in the status of facilities needed for the Project
e. Major anomalies during Project technical activities
f. Major findings

5.19.2 Projects maintain open and regular communications with key Branch Chiefs in the engineering organizations.

Documents

Guidance

a. PMBOK Guide, Chapter 10 "Project Communications Management"

5.20 Public Engagement

Practices (Compliance is mandatory)

5.20.1 Each Project plans for engaging the news media on newsworthy events that are Langley's responsibility.

a. Langley's News Media Office develops the Public Affairs Plan for each Project that needs one. The News Media Office ensures proper coordination with the Project's customer.

Documents

Guidance

a. PMBOK Guide, Chapter 10 "Project Communications Management"

5.21 Lessons Learned

Preamble

Our space flight projects are great learning opportunities, especially for learning about the effectiveness of new and old space flight project practices.

Practices (Compliance is mandatory)

5.21.1 Starting early and throughout the entire life cycle, each Project has their SMAO manager search the NASA Lessons Learned data base for relevant project-related lessons learned from previous projects.

Note: *When things don't go as expected, it is tempting to create a "lesson learned" along the lines of "be more conservative." These lessons are not particularly useful in the reality of NASA space flight with its tight budgets and tight schedules. Each Project makes the "lessons learned" practical to projects in similar situations.*

5.21.2 Each Project reviews their lessons learned at least annually and after every major review and reports them to FPD for action.

5.21.3 At the end of each Project, the Project conducts a final Lessons Learned Review led by the SMO. The Project publishes a final report on lessons learned.

5.21.4 Each Project will engage the Langley Lessons Learned Center Data Manager each time lessons learned are identified for entry into the NASA Lessons Learned Data Base.

Documents

Requirements

a. NPR 7120.6 “Lessons Learned”

Guidance

a. CALIPSO Lessons Learned

5.22 Margins and Margin Management

Preamble

Projects maintain programmatic and technical margins in order to provide resiliency in the planning, implementation and risk mitigation.

Practices (Compliance is mandatory)

5.22.1 Each Project defines, tracks, and actively manages margins throughout the life cycle of the Project.

a. Each Project describes the technical margins management approach in the Project's Systems Engineering Management Plan.

b. Each Project describes the programmatic margins management approach in PIP Section 3.1 "Technical, Schedule, and Cost Control Plan."

c. As a minimum, each Project develops margins for schedule, cost, mass, power, computer throughput, memory, mission scope, and any other parameter or resource that the Project assesses to be critical to mission success.

d. Each Project assesses and reports margins periodically and at major Project milestone reviews.

e. Each Project develops corrective action and mitigation plans whenever margins deviate significantly from plan.

Documents
None

5.23 Crisis Response

Preamble

This practice sets forth preparedness and response requirements to enable projects to take prompt and effective action should there be an occurrence during a project activity that results in:

- Loss of life or life-threatening personal injury.
- Damage to equipment or facilities that would likely jeopardize mission success or delay the ability of the project to meet its launch commitment.
- Significant public controversy resulting in opposition to the mission.
- Potential for significant NASA liability.

Practices (Compliance is mandatory)

5.23.1 Projects promptly report to Langley senior management any event, such as those described in the preamble that senior management should know about, without waiting for the usual reporting cycle. When in doubt, Projects notify the Director of FPD or the Director's representative to decide on the method and timing of the notification.

5.23.2 Each project prepares and maintains a Crisis Response Plan that:

a. Defines the range and scope of potential project crises.

b. Specifies response actions, timing of notifications and actions, and responsibilities of key individuals.

c. Contains an engineering support contact plan to aid in rapid anomaly resolution.

d. Is completed before Milestone C (PDR) and updated at key milestones to reflect changes in key personnel and responsibilities.

Note: *The Crisis Response Plan defines actions projects take, including the initiation of mishap reporting, when potential crises are encountered.*

5.23.3 Response actions are divided among key individuals to ensure their timely completion (i.e., the project manager cannot be responsible for all or most actions). Projects complete at least one tabletop exercise, prior to Milestone C (PDR), of the crisis response plan to verify interfaces and assess the adequacy of planned response actions.

5.23.4 Each project prepares a hierarchical notification tree, e.g.:

a. Project Manager
b. Deputy Project Manager
c. SMAO point of contact
d. Safety and Program Protection Branch in COD
e. Langley Center Director
g. Director of Flight Projects Directorate
h. Cognizant line management
i. Project Chief Engineer
j. Media Relations point of contact
k. Project Contracting Officer
l. Office of Chief Counsel

m. Customer representatives

The tree includes the names and phone numbers of individuals and is kept current over the project life cycle.

Documents

Requirements

a. LMS-CP-8621, "Reporting, Investigating, and Recordkeeping for Mishaps, Close Calls, and Previously Unidentified Serious Workplace Hazards"

6.0 Engineering Practices

6.1 Project Design

Preamble

Project design is driven by the objective of satisfying requirements. It is developed in close coordination and interaction with systems design. Project design also includes the design of fallback or contingency options that attempt to preserve project objectives by specifying how the project will adapt to failures or performance shortfalls in project-critical systems.

Practices (Compliance is mandatory)

6.1.1 Each project documents its design in the following documents which are all subject to peer review prior to launch in addition to project reviews:

a. A Project Implementation Plan, as described in Section 5.2.

b. A Systems Engineering Management Plan (SEMP), which provides the basis for implementing the technical effort and communicating what will be done, by whom, when, where, cost drivers, and why it is being done; the SEMP also identifies the roles and responsibility interfaces of the technical effort and how those interfaces will be managed.

c. An Operations Plan, which defines an operations strategy that satisfies project requirements and is achievable within and consistent with the Project Plan, the characteristics of the other project systems, and the overall mission operations strategies. The plan should address every segment of the mission and

describe how flight operations and science team members participate in the early development of the mission.

Documents

Requirements

a. NPR 7123.1, "NASA Systems Engineering Processes and Requirements"

6.2 Telecommunication Design

Preamble

Telecommunication links include all of the following types: earth-to/from-space, earth-to/from-entry/surface, space-to-space, space-to/from-entry/surface, surface-to-surface, and surface-to/from-entry.

Practices (Compliance is mandatory)

6.2.1 Projects are responsible for the design integrity of the telecommunication links or their interface to mission system telecommunication links.

6.2.2 Projects develop and maintain the project Telecommunication Design Control document defining the design of the project's telecom links and assumptions on communication system performance.

6.2.3 Projects determine predictions of telecommunications link performance via engineering analysis; using a statistical treatment and characterization of the link parameters.

6.2.4 Projects secure authorization for use of the telecommunications spectrum.

Documents

Requirements

a. NPR 7120.5, "NASA Program and Project Management Processes and Requirements"
b. NPR 7123.1, "NASA Systems Engineering Processes and Requirements"

6.3 Operations

Preamble

Projects are guided by the "Test as you fly; fly as you test" maxim in operation of the flight assets.

Projects conduct operations in a way that balances the need to achieve primary objectives with the desire to maintain system health and safety, and performance margins. This means staying focused on the primary objectives. This also means using the system as it was designed to meet the primary objectives, which implies that the system is designed and tested to meet the primary objectives so that there will be no design or test related impediment to using the system for these purposes.

Practices (Compliance is mandatory)

6.3.1 Controlling Documentation

a. Project operations teams operate systems according to the project-approved Operations Plan. During operations, the Project maintains and updates the Operations Plan to reflect changes in the environment and/or system performance.

b. Each project prepares a rules and constraints document, which includes the limitations within which the system and its instruments are operated.

c. Projects address operational mitigations (if any) in operations controlling documents for:

(1) Launch approval.
(2) Planetary protection.
(3) Orbital debris assessment.
(4) Waivers granted to institutional and project requirements.

6.3.2 Process and Procedure

a. After the appropriate reviews and concurrences, the Project Manager approves the following critical products:

(1) Project Implementation Plan
(2) Waivers to flight rules
(3) Sequences for critical events

b. After the appropriate reviews and concurrences, the Project Manager (or designee) approves the following:

(1) Sequence Activity Plan
(2) System anomaly recovery
(3) Restricted command usage
(4) Contingency plans
(5) Post-launch flight software modifications

c. Each project establishes, documents, and follows approved processes and procedures for conducting operations.

d. Each project independently checks each process involved in system control (e.g., command and sequence generation, navigation determination, and maneuver design).

***Note**: "Independent check" means that someone other than the originator or originating team (e.g., another person, a peer review, or software automation) checks the process.*

e. Each project maintains a capability (ground tools, personnel, and test facilities) to modify and test flight systems (hardware & software) throughout the operations phase.

f. Projects, as required, plan continuous coverage for tracking and data services; and plan appropriate staffing by operations personnel as follows:

(1) For at least the initial 7-day period of flight operations starting at launch.
(2) For at least the final 7-day period of flight operations leading up to and through mission critical events.

6.3.3 Flight Team

a. Each project defines and documents training and other criteria (e.g., demonstrated experience) for each flight team position. The required training and criteria are satisfied before the operations or functions are performed.

b. Each project identifies mission-critical functions within the flight team and trains at least one prime and one backup person for each of these.

***Note**: A person may be prime for one function and cross-trained as backup for another function.*

c. Each project develops and implements a plan to ensure continuity of system knowledge from the system integration and test phase into and throughout the operations phase. The project uses a combination of methods to achieve this continuity of system knowledge:

(1) Pre- launch development personnel continue into post-launch operations.
(2) Operations personnel participate in system integration and test.
(3) System developers generate description documents and other training material.

6.3.4 System Health and Safety, and Performance Analysis

a. Projects employ engineering measurement alarm limits to assure system health and safety.

b. Projects develop predictions for engineering measurements when warranted by consideration for preservation of system health and safety.

c. Projects use engineering data to analyze system health and safety, and to determine system performance. Trending is performed on selected system data for early identification of problems, and to allow mitigation actions to be taken.

6.3.5 Critical Events and First Time Events

a. Each project validates sequences for critical events prior to execution. Validation includes all of the following:

(1) Testing on a testbed (both nominal and off-nominal sequence execution).
(2) Project internal sequence review.
(3) Peer (project external) review (walkthrough) of the sequence and the testing performed on the testbed.

***Note**: Critical events are those that if not executed properly and in a timely manner could result in failure to achieve mission success.*

b. Prior to mission-critical events, each project demonstrates readiness of the operations team.

***Note**: The principal method of demonstrating readiness is by scheduling, performing, and documenting Operations Readiness Tests (ORTs). ORTs are often designed to demonstrate flight team readiness for both nominal and off-nominal conditions.*

c. Prior to critical events, each project identifies what could go wrong (e.g., by developing an event fault tree) and develops contingency plans consistent with the project risk posture to ensure each critical event occurs. When a time-critical response is required, contingency command files are generated and validated to the level needed to facilitate a rapid response.

d. Projects provide redundant ground equipment (e.g. emergency primary power) for mission-critical events.

e. Each project validates sequences for first-time events (e.g., first use of propulsion system in flight) prior to the event. This validation includes:

(1) Testing on a testbed (at least nominal sequence execution).
(2) Project internal sequence review.
(3) Identifying what could go wrong and developing contingencies if warranted. Planned contingency responses are also validated prior to their use.

f. Projects give special attention to the development of sequences for critical events and for first in-flight use of flight system functionality, especially for irreversible events.

g. Prior to critical events, projects conduct Critical Event Readiness Reviews sufficiently in advance of the critical event(s) to allow time for correction of deficiencies and to respond to critique received in the review process.

h. Prior to irreversible events, projects assure safe reliable operation in the design of sequences, e.g., by reviewing relevant development history including NFRs and analyses.

Documents
None

6.4 Systems Engineering

Preamble

Projects perform systems engineering across the project at each product level throughout all project phases to establish the architecture, requirements, design, interfaces, and verification criteria. This is done at the project, system, subsystem, and lower levels as required. See Section 5.1 for the life cycle gate products for proper phasing and maturity levels of these activities.

Governing principles for systems engineering are those found in NPR 7123.1, "NASA Systems Engineering Processes and Requirements."

Practices (Compliance is mandatory)

6.4.1 Projects develop architectures (e.g.: physical, behavioral, operational (control), functional, data) that are captured and maintained as part of the design baseline in functional block diagrams, state diagrams, flow diagrams, configuration drawings, etc.

6.4.2 Projects form and make use of systems engineering design teams with representatives from all affected areas. These design teams develop operations concepts and perform system analyses and trade studies to support architectural design and requirements definition. Trade-offs are performed as a means to achieve balance among cost, risk, and performance and consider, as applicable, safety, technology, security, environmental impact, acquisition strategies, operational needs, and infrastructure availability. Typical trade studies include:

a. Hardware/software trade-offs.
b. Alternative architectural options.
c. Requirements analysis to identify cost, risk, schedule, and performance drivers.
c. Flight system / ground system trade studies.
d. Operability / Maintainability.

6.4.3 Projects develop requirements through analysis, decomposition, and derivation. Projects allocate requirements from upper-level requirements through lower-level requirements to a level that can be implemented and verified.

6.4.4 Each project defines and documents requirements in compliance with LMS-CP-5526, “Product Requirements Development and

Management Procedure." The requirements are captured to allow project-wide accessibility and traceability.

6.4.5 Projects define interfaces between distinct elements of the system that are then documented, controlled and their implementation verified. Interface documentation includes electrical and mechanical interface control documents / drawings, software interface specifications, and operational interface agreements.

a. If project elements that are the subject of an interface agreement use different units of measure, the interface documentation includes the units native to each of the parties to the agreement.

6.4.6 Projects establish nomenclature and conventions in order to support development of project systems. Typically these include:

a. Element naming conventions.
b. Project phases.
c. Reference designators.
d. Coordinate systems.
e. Units of measure.
f. Definition of terms (e.g.: margin, reserve, contingency).

6.4.7 Projects establish margin strategies that are used to manage technical resources (e.g., mass, power, configuration, power switches, fusing, commanding, memory, link margins, processing time, Central Processing Unit (CPU) utilization, memory size, operations process time). Typical management techniques include allocation, analysis, tracking, and making recommendations.

6.4.8 Each project prepares a Systems Engineering Management Plan.

6.4.9 Consistent with the project priorities (see Section 5.11), projects make risk decisions with the support of systems engineering analysis and evaluations of:

a. Safety.
b. Mission success.
c. Technical capabilities and margins.
d. Available budgets.
d. Schedule reserves.

6.4.10 Projects predict performance using a combination of analysis, modeling, and empirical results. Uncertainties are dealt with by specifying nominal values and a range about the nominal that accounts for the worst (and best) case performance. Projects meet

requirements under worst-case “design to” conditions. Systems engineering procedures specify the approach used to address uncertainties in predicting performance and model validation. Predicted system performance and margin relative to specification are reported at the major reviews.

***Note**: The mission design should have the flexibility to take advantage of best-case performance.*

a. Projects identify and baseline (by Milestone C (PDR)) key metrics by which to characterize the system performance (e.g., lifetime, image quality, observing efficiency), and maintain and report trend data on these metrics throughout the development.

6.4.11 Projects develop for distinct mission phase activities (e.g.: launch, operations) scenarios that demonstrate requirements are satisfied while accommodating system-imposed constraints. Operating scenarios are developed at the system level accommodating subsystem/team-imposed constraints to validate system performance and capabilities used in the mission scenarios, and to establish a basis for development of detailed flight sequences.

6.4.12 Projects develop flight system and operations system designs concurrently to enable cost-effective trade-offs leading to efficient end-to-end operations. At the Milestone C (PDR), projects address the impacts associated with, and accommodation of, inherited/existing flight system elements on the operations system, and vice versa.

6.4.13 Projects identify the units of measure in all product documentation. Exceptions to use of SI units are documented in the Project Implementation Plan.

***Note**: Projects use the International System of Units (SI) unless such use is contrary to prevailing industry practice and/or increases the project cost unnecessarily.*

Documents

Requirements

a. LPR 8705.1, “Design, Verification/Validation and Operations Principles for Space Flight Systems”
b. LMS-CP-5526, “Product Requirements Development and Management Procedure”
c. NPR 7123.1, "NASA Systems Engineering Processes and Requirements"

Guidance

a. NPR 7123.1, "NASA Systems Engineering Processes and Requirements," Appendix D "Systems Engineering Management Plan"

6.5 Launch Services

Preamble

This practice applies to all flight projects for which Langley has project management responsibility. It also applies to Langley payloads flown on the Space Shuttle. It does not apply to Langley flight projects delivering instruments that are a part of the payload on missions managed by other Centers or organizations.

This practice sets forth the processes for:
- Acquiring expendable launch vehicles and the attendant launch services
- Using the Space Shuttle and attendant launch services
- Processing payloads at launch sites

Practices (Compliance is mandatory)

6.5.1 Projects use the NASA Launch Services (NLS) during the formulation phase to plan and initiate acquisition of launch services. As the project transitions to the implementation phase (or at an earlier time agreed to between the NLS and project), the NLS hands the launch service acquisition activities over to the project's launch vehicle integration engineer.

6.5.2 Projects planning to launch from the U.S. use either an expendable launch vehicle procured through the NASA Launch Services acquisition process, or the NASA Space Transportation System (Space Shuttle).

6.5.3 Each project planning to use the NASA Space Transportation System (Space Shuttle) requests approval of such use from NASA Headquarters and satisfies the NASA shuttle use policy.

6.5.4 In support of launch service costing-estimates, projects identify requirements on the launch system including the need, if any, for non-standard launch services and mission-unique launch vehicle modifications and services. Projects secure cost estimates from KSC (for launches using expendable launch vehicles) and from Johnson Space Center (JSC) (for launches using the Space Shuttle) during the formulation phase.

6.5.5 The Project will designate a launch vehicle integration engineer as the single point of contact for coordinating launch vehicle integration activities among the project, the spacecraft system contractor, the launch facility, the range, and the launch services provider.

a. Launch vehicle payload processing through the Eastern Test Range (ETR) is coordinated by the launch vehicle integration engineer with the NASA Launch Site Support Manager (LSSM). Projects coordinate with LSSM for training, facility access, and personnel certifications required for operations at ETR.

b. Launch vehicle payload processing at the Western Test Range (WTR) is coordinated with the NASA Launch Site Support Manager (LSSM) located at the NASA Resident Office at Vandenberg Air Force Base (VAFB). Projects coordinate with the NASA/VAFB Resident Office for any training, facility access, support and personnel certifications required for operations at WTR.

Documents

Guidance

a. NPD 8610.12F, “Office of Space Operations (OSO) Space Transportation Services for NASA and NASA-Sponsored Payloads”
b. NSTS 07700, Program Definitions and Requirements, Volume XIV Shuttle Payload Accommodations

6.6 Inheritance

Preamble

Using designs, hardware, or software inherited from other programs has often led to major problems for space flight projects. Inherited items that at first appear to offer savings or reduced risk can easily turn out to be more expensive and dangerous than new items specifically designed to meet system requirements.

Practices (Compliance is mandatory)

6.6.1 Prior to using inherited designs, hardware, software, and ground support equipment, the project evaluates the benefits in comparison with the associated risks and life cycle costs.

6.6.2 Prior to using inherited items, each project has cognizant engineers and mission assurance personnel review the complete pedigree of

the inherited item. The project reviews and justifies any differences in the qualification environments from the inheritance to the intended application.

6.6.3 Projects conduct inheritance reviews for inherited designs, hardware, software, and ground support equipment as early as practical in the formulation phase.

6.6.4 Projects apply the same rigor in certification of inherited items and/or designs as required for new designs.

Documents

Requirement

a. LPR 8705.1, “Design, Verification/Validation and Operations Principles for Space Flight Systems”

6.7 Planetary Protection

Preamble

Planetary protection includes:

- Controls on organic and biological contamination from Earth organisms, which may be carried to planets or other solar system bodies.
- Protection of Earth from the potential hazards of extraterrestrial matter carried by a spacecraft returning from another planet or other extraterrestrial sources.

Projects exempt from planetary protection requirements include:

- Earth-orbiting missions
- Missions that neither target nor encounter any solar system body (other than the Earth).

Note*: NASA has established various categories of planetary protection. Once established for the project, the category determines the scope of the project’s planetary protection program and its path through the planetary protection process.*

Practices (Compliance is mandatory)

6.7.1 Projects provide for planetary protection.

Note*: "Planetary" missions include those to and from the Earth's moon.*

6.7.2 Prior to Milestone C (PDR), projects propose a planetary protection category for approval by the NASA Planetary Protection Officer.

6.7.3 Prior to Milestone C (PDR), projects (except Planetary Protection [PP] Category I and those which are exempt) develop a Planetary Protection Plan as defined in NPR 8020.12C that defines the project plan for meeting planetary protection (PP) requirements. The plan sets forth the policy, procedures, and approach that the particular project will implement to comply with PP requirements.

6.7.4 During the implementation phase, projects report on their planetary protection activity at major reviews. Also, projects provide planetary protection reports to the NASA Planetary Protection Officer at key pre-launch, post-launch, and end of mission milestones.

6.7.5 Projects obtain approval from the NASA Planetary Protection Officer that the requirements of the Planetary Protection Plan have been met. This approval is a condition for launch.

6.7.6 Projects, whose flight operations will extend beyond the nominal end of mission, provide a planetary protection extended mission report to NASA. The extended mission represents a deviation from the Planetary Protection Plan and must be approved by the NASA Planetary Protection Officer as a prerequisite for the start of the extended mission.

6.7.7 Sample return projects that are categorized for restricted Earth return must obtain approvals of the NASA Planetary Protection Officer at several key milestones. These approvals are prerequisite for "launch" back to Earth and for Earth atmospheric entry, descent and landing.

Documents

Requirements

a. NPD 8020.7, "Biological Contamination Control for Outbound and Inbound Planetary Spacecraft"
b. NPR 8020.12C, "Planetary Protection Provisions for Robotic Extra-terrestrial Missions

6.8 Flight System Fault Tolerance/Redundancy

Preamble

Flight system redundancy may be used to provide flight system fault tolerance, and thus protect against random failures that may occur in flight. However, redundancy is not intended as protection against the adverse consequences of the natural or induced environments to which the flight system will be exposed.

In rare instances, multiple units are provided to address wear-out, but this is not considered redundancy per se. In such cases, the need for additional units for redundancy must still be addressed.

Practices (Compliance is mandatory)

6.8.1 Each project defines the required level of flight system fault tolerance and the use of redundancy and cross strapping prior to Milestone C (PDR), in order to properly scope and cost the project.

a. Each project develops an approach to ensure the consistent application of redundancy and cross strapping.

b. The project reports the use of and rationale for flight system redundancy and cross strapping, or lack thereof, at major reviews.

c. Each project having a single fault tolerant requirement develops a list of exempted potential single point failures prior to Milestone C (PDR).

***Note**: Single point failure policy exemptions represent advanced approval of waivers, and are typically justified by adequate design margins.*

d. During development, projects with a single fault tolerant policy identify and assess the likelihood of potential single point failures, explore mitigation options for those deemed credible, and perform trade-offs to disposition the risk. Potential single point failures accepted by the project, together with the rationale for the decision, are reported at major reviews. The list of accepted, potential single point failures is communicated to the flight operations team by the integration and Test Readiness Review, and updated, if necessary, prior to the Pre-Ship Review.

***Note**: Single point failure policy exceptions represent approved waivers, evident as part of the design process, and are typically*

justified by technical assessment that concludes acceptable minimal risk associated with the proposed alternate to the established policy.

Documents

Requirements

a. LPR 8705.1, “Design, Verification/Validation and Operations Principles for Space Flight Systems”
b. NPR 7123.1, "NASA Systems Engineering Processes and Requirements"

6.9 Materials, Processes, and Contamination Control

Practices (Compliance is mandatory)

6.9.1 Projects select, apply, and use materials and processes that meet project requirements for both flight and ground support equipment.

6.9.2 Each project maintains and reviews materials identification and usage listings to document proper selection during design and to provide control during procurement and fabrication.

6.9.3 Projects use approved processes for developing, evaluating, and qualifying materials and processes to include in-situ resource utilization (e.g. processing of lunar materials), as well as for accepting and using nonstandard materials.

6.9.4 All flight contractors, subcontractors, and suppliers select, apply, and use materials consistent with Langley practices. Waivers to the Langley practices are negotiated prior to contract execution.

6.9.5 Each project conducts an evaluation of the proposed flight system in Phase A to identify components that have a potential for degradation due to particulate and molecular contamination. When contamination is determined to be a potential risk to meeting requirements, the project develops and implements a contamination control program that includes a detailed susceptibility analysis and a Contamination Control Plan.

6.9.6 Each project develops a Materials and Processes Plan and addresses items such as outgassing of materials in the crew compartments; radiation shielding of materials for crew and electronics; and radiation degradation of material thermal and mechanical properties.

Documents
None

6.10 Software Development

Practices (Compliance is mandatory)

6.10.1 Each project has an individual (or individuals) who is (are) responsible for identification and classification of all project software, approval of all project software management plans, coordination of Independent Validation &Verification (IV&V) (if applicable) and software quality assurance activities, and reporting software status at project periodic status reviews.

6.10.2 Projects will classify and baseline by Milestone B (SDR) all software to be developed, acquired, or incorporated into Langley-accountable products as one of the following:

a. Class A: Human-Rated
b. Class B: Non-Human Space Rated
c. Class C: Mission Support
d. Class D: Development Support and Technology

6.10.3 Development, Maintenance and Acquisition Practices

a. Projects develop and maintain, or acquire, software according to a process that contains the activities identified in the Software Planning, Development, Acquisition, Maintenance, and Operations (LMS-CP-5528) procedure, and is consistent with the software classification as stated above.

b. Projects establish and maintain a Software Management Plan, which is the basis for managing the software development or acquisition.

c. Flight projects provide software related documentation at key milestones.

Documents

Requirements

a. LPR 8705.1, “Design, Verification/Validation and Operations Principles for Space Flight Systems”
b. LMS-CP-5526, “Product Requirements Development and Management Procedure”

c. LMS-CP-5528, “Software Planning, Development, Acquisition, Maintenance, and Operations”
d. NPR 7120.5D, “NASA Space Flight Program and Project Management Requirements”
e. NPR 7123.1, "NASA Systems Engineering Processes and Requirements"
f. NPR 7150.2, “NASA Software Engineering Requirements”

6.11 Protection and Security of Flight Hardware

Practices (Compliance is mandatory)

6.11.1 Each project designates a specific individual to be responsible for each item of flight hardware that is to be delivered to system integration. This individual is typically the Cognizant Engineer or equivalent, and is responsible for all aspects of processing and testing the item through delivery for flight.

6.11.2 Projects will maintain control of all hardware. Projects will house hardware not under the Cognizant Engineer’s immediate control in a stores area certified by the responsible quality assurance (QA) organization, or in a controlled access facility such as for system assembly or launch processing.

6.11.3 All facilities intended for processing, operations, or testing flight hardware undergo a combined audit by the responsible QA, Safety, and technical organizations to ensure their suitability for the intended efforts. The project safety manager ensures that potential hazards to hardware or personnel safety are corrected prior to the start of the effort.

6.11.4 Projects will review and approve all plans for the moving of critical hardware within a given facility prior to the start of the transportation. QA and Systems Safety personnel are required participants in the review.

6.11.5 The Cognizant Engineer:

a. Initiates QA, Systems Safety, and other transportation surveys to ensure the safe movement of all flight hardware.

b. Approves plans and procedures for the environmental testing of the item and any changes to initially approved plans and procedures involving the unit.

c. Conducts a review prior to initiation of any environmental test or other potentially hazardous activity of an item of flight hardware. The review:

(1) Verifies the flight configuration of the test article, and that the test article matches the released flight hardware drawings.
(2) Confirms the adequacy of the procedures, that the test parameters and alarm limits are understood.
(3) Confirms that there is suitable environmental test facility, safety provisions, test personnel, and QA coverage.

d. Protects all hardware containing electronic circuitry from electrostatic discharge (ESD) damage.

e. Treats qualification hardware and all hardware planned for upgrade to flight status as items of flight hardware according to the configuration, test conditions, test provisions, and required handling precautions.

f. Explicitly declares on the submittal for environmental testing the intended purpose of each item of hardware, to ensure that flight units will not be tested under improper conditions or without the necessary test coverage, review, or approval.

g. Corrects any liens against the test prior to test initiation, including findings that represent potential safety hazards to either hardware or personnel, or lack of suitable emergency provisions in the event of test malfunction.

6.11.6 QA oversees and monitors all environmental testing of flight hardware as a unit, or as an element of a larger assembly, according to written, approved procedures, and identifies and measures protection related to the safety of the unit and personnel.

6.11.7 The environmental test organization provides for adequate protection and surveillance to preclude to the maximum practicable extent applying unplanned or excessive stimuli to flight hardware under test.

6.11.8 Prior to embarking on hazardous integration and test activities, projects (in addition to getting approval from system safety for the activity) take special measures to ensure safety of personnel and flight assets, and to ensure a successful outcome.

Note: Examples of such special measures are:

- *Annotating test procedures, or specific steps in test procedures, as 'hazardous' when threats exist to personnel, flight hardware, and/or mission critical equipment,*
- *Thinking about what could go wrong, and developing a plan for contingency actions,*
- *Verifying operation of back-up systems that would be called upon in an emergency,*
- *Ensuring the participation of the knowledgeable persons in the planning and conduct of the hazardous operation(s),*
- *Performing a walk-through with the test team of the relevant procedure(s),*
- *Performing peer review of the operation(s) to be attempted,*
- *Path finding the operation(s) using non-flight hardware model(s).*

6.11.9 Unattended Operation of Flight Hardware

a. Prior to the delivery of flight-configured items to system integration, Projects will require written approval of the project manager for unattended operation. The approval will be granted only after a documented risk assessment.

b. After the delivery of flight-configured items to system integration, Projects will require written approval of the Director of FPD for unattended operation. The approval will be granted only after a documented risk assessment and a review.

Documents
None

6.12 Design and Verification for Environmental Compatibility

Practices (Compliance is mandatory)

6.12.1 Projects design and verify all flight hardware to be fully compatible with all anticipated environments. Specifically, each project:
a. Defines the relevant mission environments.

Note: *Relevant mission environments include launch, space, and mission environments as well as ground operations including test and launch vehicle integration, shipping and handling, transportation, storage, and other incidental environments.*

b. Specifies the environmental design and verification requirements including appropriate margins to the anticipated environments.

***Note**: Environmental verification requirements are developed for hardware at both the system and unit level (subsystem or assembly). Included is a minimum acceptable probability of survival for exposure to each environment that is statistical in nature, e.g. solid particles and solar flares.*

c. Defines and documents its environmental verification plan.

***Note**: The appropriate configuration level for hardware verification (whether by testing and/or analysis) is determined for each application. Testing is used, in lieu of analysis, unless testing is impossible or unless analysis provides better insight and understanding of the performance.*

d. Implements an environmental verification program consistent with the plan.

e. Identifies, tracks, and manages risks inherent in the accomplishment of the environmental verification program.

***Note**: Waivers from the planned environmental verification program are documented and include assessment of the risks associated with the waiver(s).*

f. Prepares and maintains documentation to track progress and be able to report status of the environmental verification activity, and serve to certify proper implementation and completion of the environmental verification program.

***Note**: "System level" refers to the configuration of the test article in which the article experiences the environment. For example, a surface rover experiences the launch vibration environment only when it is in the lander on the cruise stage. Hence this would be the system level for the launch vibration environment. Similarly, the system level for the Mars surface thermal environment would be at the Rover-level only.*

***Note**: At the system level, the baseline environmental test program includes modal, static, vibration, acoustic, pyro shock, thermal, and EMI/EMC. Analysis for structural design integrity, and (when appropriate) meteoroids and magnetic cleanliness is (are) included.*

***Note**: At the assembly/subsystem level, the baseline environmental verification program includes random vibration, acoustic, pyro shock, thermal, electromagnetic compatibility*

(EMC), and mission-specific tests (e.g. target body atmospheric tests). Analyses for launch pressure profile and radiation, and (when appropriate) meteoroids are included.

***Note**: Under certain conditions, the requirements for pyro shock and acoustic testing may be eliminated. A risk assessment and approval are required for these exceptions.*

6.12.2 Test Authorization

The Project will not authorize environmental testing that is 1) not consistent with the requirements of the project's environmental verification program and 2) not documented in a project-approved environmental test authorization form.

6.12.3 Test Execution

a. Projects will conduct all tests according to previously prepared, approved, and controlled test procedures covering test methods, test environments, test configuration, functional testing, pass/fail criteria, and all other relevant aspects of the test.

6.12.4 Test Configuration

a. Projects determine the appropriate test configuration for each hardware item, and document and maintain this information so as to record the planned environmental test program.

b. Use of system-level testing for subsystem- or assembly-level qualification or acceptance testing requires project manager approval.

c. All system-level environmental testing includes the full complement of flight hardware. Use of any non-flight model hardware in system-level environmental testing requires project manager approval.

6.12.5 Post-Test Documentation

a. The Cognizant Engineer documents the test results, including any departures from prescribed test conditions or expected functional performance, or loss of calibration.

6.12.6 Test Results

a. Following each environmental test, the cognizant engineer and the environmental requirements engineer review the test results. They evaluate any departures from prescribed test conditions or expected functional performance, or any loss of calibration to determine if the test objectives and requirements have been satisfied.

6.12.7 Environmental Qualification and Flight Acceptance Testing

a. Qualification and flight acceptance testing is performed at the subsystem, instrument, or assembly level as follows:

(1) Projects classified as Category I perform qualification testing of one flight-like unit followed by flight acceptance testing of all other flight units.
(2) For all other projects, such testing is accomplished either by protoflight testing all flight articles, or by qualification testing one flight-like unit followed by flight acceptance testing of all other flight units.

b. A unit used for qualification testing may not be used for flight without review and risk identification.

6.12.8 Reporting

Projects report at key milestones and major reviews the status of the environmental verification program, and any waivers from the planned environmental verification program.

Documents
None

6.13 Project and System Level Functional Verification and Validation

Preamble

The scope of this practice includes flight system verification and validation, ground system verification and validation including operations testing and team training, mission system verification and validation, and system level verification and validation in the system testbed(s).

Projects are guided by the “Test as you fly; fly as you test” maxim in the development of their verification and validation test programs. Verification shows that the system (hardware and software) satisfies the design

requirements; validation demonstrates that the system actually performs as intended.

Testing is the preferred method of verification. When testing is either not possible (e.g., due to damage to equipment, or limitations of the 1-g environment) or not appropriate, other methods (such as analysis, simulation, inspection, and demonstration) may be used. When analyses and/or simulations are used, the analysis and simulation results are independently reviewed. When inspections are used, they are performed on the final, as-built configuration.

Practices (Compliance is mandatory)

6.13.1 Planning

a. Projects plan system verification as a combination of test, analysis, demonstration, simulation, inspection and other methods, and is documented in a verification matrix that shows traceability from the project's requirements.

b. Each project develops and documents verification and validation (V&V) requirements and plans.

***Note**: Examples include Flight System Integration and Test Plan, System Testbed Integration and Test Plan, Mission Operations System (MOS)/Ground Data System (GDS) V&V Plan, and Project Verification and Validation Plan.*

***Note**: Projects perform end-to-end verification and validation of the integrated project to demonstrate full functionality.*

c. In these plans, Projects specify the scope of the activity, roles and responsibilities, methods to be used, facilities and venues, models, support equipment, and schedule. In the plans, Projects also define the level of retest required, if any, in response to design changes, new software deliveries, and anomalies found in test.

d. Each project develops an Incompressible Test List that defines the minimum set of tests that must be completed prior to launch in order to validate compatibility with the mission environments, and to demonstrate functional capability to execute the mission.

e. Prior to launch, each project develops for each post-launch critical event an Incompressible Test List that defines the minimum set of

tests that must be completed prior to the critical event in order to validate readiness to perform the mission critical event.

6.13.2 Verification and Validation

a. The project design is validated by exercising the project systems through design verification tests that simulate the mission enabling sequences (e.g., operations, trajectory correction maneuver, safing, and launch).

b. Projects will repeat baseline tests throughout the test program as a means to discover changes in performance that may signal latent problems. Such baseline testing is done specifically before and after environmental testing.

c. Projects verify flight sequences and system performance under nominal conditions, and off-nominal conditions in which simulated faults are introduced e.g. in verifying the integrity of flight system autonomous fault protection, and operations system team training and contingency planning.

d. Projects perform stress testing to demonstrate performance margins and evaluate capability boundaries. Stress testing may be conducted at all levels, and is defined in the Project Verification and Validation Plan.

e. Project capabilities developed for flight operations (e.g., flight sequences, command/telemetry data bases, workstations, software tools) are employed in system testing of the flight system. The specific uses are defined in the Project Verification and Validation Plan.

f. Projects validate contingency plans (including the associated command files) developed for launch using the launch version of flight software, either on the flight vehicle or a high fidelity testbed.

g. Projects complete the Incompressible Test List complement of tests before transition to mission operational use.

6.13.3 Re-verification

a. Projects correct design deficiencies, resolve unexpected behavior during test, and perform re-verification of the changed design prior to committing to operational use.

6.13.4 Data Analysis

a. Projects perform real-time and non-real-time data analysis to thoroughly evaluate the results of testing, including performance of science instruments.

6.13.5 Documentation

a. Projects maintain records of the verification and validation activity to be able to demonstrate compliance with V&V plans and requirements. These records are maintained for the life of the project.

b. Projects document design idiosyncrasies found during test, and provide this information to those who will perform the flight operations.

c. Projects document exceptions to the Test-As-You-Fly principle, and provide an assessment of the resulting risk.

d. Projects document waiver(s), if any, from the approved Incompressible Test List; provide an assessment of the resulting risk, and get the appropriate programmatic and institutional approvals for the waiver(s).

6.13.6 Reporting

a. The project reports on V&V planning, progress, and status at major technical reviews and key project milestones.

b. Projects report at key milestones and major reviews leading to launch, waivers to the baseline verification program presented at the CDR.

c. Projects report Test-As-You-Fly exceptions at major reviews with adequate lead-time; in case of lack of endorsement for the assumed acceptable level of risk taking.

d. Projects report the status of the testing defined in the Incompressible Test List against the plan for its completion periodically during and at major milestone reviews.

6.13.7 Certification

a. Certification of Flight Readiness

Each project prepares the Certificate of Flight Readiness (CoFR) in attesting to the integrity and completeness of the pre-launch development, and gets institutional approvals that all required pre-launch actions have been satisfactorily completed as a condition for the transition to mission operational use.

b. Certification of Critical Event Readiness

c. Each project prepares the Certificate of Critical Event Readiness (CoCER) in attesting to the integrity and completeness of the preparation for the post-launch critical event(s), and gets institutional approvals that all required actions have been satisfactorily completed as a condition for performing the critical event.

6.13.8 Transition to Launch Operations

a. Each project develops launch-hold criteria that define the launch day decision-making authority and the mandatory conditions required to exist on launch day in order to give the "go" for launch.

Documents

Requirements

a. LPR 8705.1, “Design, Verification/Validation and Operations Principles for Space Flight Systems”
b. NPR 7120.5, “NASA Program and Project Management Processes and Requirements”
c. NPR 7123.1, "NASA Systems Engineering Processes and Requirements"

6.14 Orbital Debris

Preamble

Orbital debris refers to the residue left in Earth orbit during and upon completion of Earth operations, including that which strikes the Earth's surface following atmospheric reentry.

Projects are assisted in their understanding and fulfillment of the sponsor's requirements on orbital debris using compliance assessment methods that are in accordance with the NASA guidelines.

Practices (Compliance is mandatory)

6.14.1 Projects comply with NASA policy for limiting generation or proliferation of earth orbiting debris by analyzing the degree to which flight systems (instruments/payload, spacecraft, and launch vehicles) comply with orbit debris mitigation guidelines, and by employing debris-limiting options for hardware designs, if required.

6.14.2 Projects support compliance assessment efforts by doing the following:

a. Supplying information relating to the project and the flight system design, and
b. Validating (prior to their submission) the results of, including the assumptions used in, the orbital debris limiting assessments.

6.14.3 Projects with mission management responsibility prepare and provide to NASA the following documents:

a. An orbital debris preliminary compliance assessment prior to Milestone C (PDR),
b. An orbital debris final compliance assessment not later than 45 days prior to the corresponding CDR, and
c. A decommissioning plan for earth orbiting hardware not later than 9 months prior to end of mission.

6.14.4 Projects with mission management responsibility alert NASA with as much advance notice as possible of any expectation that reentering flight hardware will strike the earth's surface.

6.14.5 Projects with mission management responsibility report on orbital-debris-limiting activities at major reviews as follows:

a. Identification of orbital debris sources and potential hazards, and an initial assessment are presented prior to phase B,
b. A preliminary functional design implementation is presented at Milestone C (PDR), and
c. A final functional design implementation is presented at the corresponding CDR.

6.14.6 Instrument/payload projects support orbital debris compliance assessment performed by the project(s) having mission management responsibility on which they are manifested.

Documents

Requirement

a. LPR 8705.1, “Design, Verification/Validation and Operations Principles for Space Flight Systems”
b. NPR 7120.5, “NASA Program and Project Management Processes and Requirements”
c. NPR 8715.6, “NASA Procedural Requirements for Limiting Orbital Debris”

Guidance

a. NASA-STD-8719.14, “Process For Limiting Orbital Debris”

6.15 Hardware Development

Preamble

The scope of this section includes the subsystem and assembly level hardware development (fabrication, assembly, integration, calibration, verification, and validation) before delivery to system integration and test, except those practices relating to design and verification for environmental compatibility that are contained in Section 6.12, "Design and Verification for Environmental Compatibility." See Section 6.13, "Project and System Level Functional Verification and Validation," for project and system level functional verification and validation subsequent to hardware delivery.

The Test-As-You-Fly principle applies to all levels of hardware assembly in an integrated test program, and is especially important prior to hardware delivery to system integration and test when it will be the last opportunity to ensure the product will perform its intended purpose in the mission environment. Coordination of the testing to be performed at the various levels in the project hierarchy is assumed to occur early in the project life cycle, and is subject to review at the major milestones.

Practices (Compliance is mandatory)

6.15.1 Projects define resource allocations, the scope of the hardware development tasks, and any waivers from institutional requirements and procedures, and invoked standards.

6.15.2 Projects submit hardware designs to independent technical review.

6.15.3 Projects specify requirements for reporting on hardware development activities (progress, issues, and resource margins) to the implementing organizations.

6.15.4 Projects specify required drawing classes in the CM Plan, subject to the following constraints:

a. Flight hardware drawings are not less than Class B.

b. Drawings for support equipment that interfaces with flight hardware are not less than Class C.

***Note**: The drawing classes for various applications are defined in the Engineering Drawing Practices standard.*

6.15.5 Projects deliver as-built documentation of hardware upon delivery of an assembly to the next level of integration.

***Note**: Projects release as-built documentation to support inspection of hardware prior to integration that would preclude access to the hardware features to be inspected.*

6.15.6 Projects do integration and verification of hardware products in a hierarchical manner. Lower-tier verification occurs before integration into the next higher level of assembly. Correct operation of the lower-tier element is demonstrated after integration into the next higher level of assembly. This sequence continues until the project systems are integrated, after which the end-to-end mission system performance is verified.

6.15.7 Projects define requirements and develop a plan for instrument and payload calibration as part of the pre-launch development. The results of these calibrations are documented, and provided to the flight operations team prior to the Operations Readiness Review (ORR).

6.15.8 Projects perform life testing to demonstrate margin against the planned use for hardware items susceptible to wear-out.

Documents

Requirements

a. LPR 8705.1, “Design, Verification/Validation and Operations Principles for Space Flight Systems”

b. NPR 7123.1, "NASA Systems Engineering Processes and Requirements"

6.16 Operations System Development

Preamble

Operations system (OS) development includes development of the Ground Data System (GDS).

Practices (Compliance is mandatory)

6.16.1 Each project develops a preliminary Operations Concept prior to the start of phase B. The Operations Concept is approved prior to Milestone C (PDR).

6.16.2 Projects develop system requirements on the OS and GDS that are documented and approved prior to Milestone C (PDR).

6.16.3 Projects develop OS (including GDS) design specifications (including interface specifications) that are documented and approved prior to CDR.

6.16.4 Each project produces a GDS Software Management Plan either incorporated in the project level plan, or as a stand-alone plan. All GDS software (including institutionally and externally supplied components) is evaluated for mission criticality and categorized accordingly.

6.16.5 Pre-launch, projects develop the flight sequences for launch and early flight operations, and develop a baseline version of critical and enabling sequences.

6.16.6 Projects develop operations process scenarios for each mission phase and validate them prior to the OS/GDS CDR.

6.16.7 Projects develop rules (or guidelines and constraints) for conduct of mission operations, which are documented, and approved prior to launch.

6.16.8 Projects identify reusable sequence pieces (or “blocks”) for repetitive flight system activities. The blocks are documented, built, and tested on the system and/or testbed.

6.16.9 Projects negotiate commitments for institutionally supplied services that will be needed during operations.

Documents

None

7.0 Safety and Mission Assurance Practices

Safety and Mission Assurance practices apply for all Exploration projects and a wide range of other projects. Traditional space flight projects that require S&MA support include atmospheric science instruments and missions, Shuttle and International Space Station payloads and experiments, and planetary science payloads and missions. Safety and Mission Assurance requirements must be met on human space flight projects and also on risk reduction flights, flight experiments, flights of opportunity that are sub-orbital, involve sounding rockets, un-crewed aerospace vehicles, drop models and major UAV operations.

7.1 Mission Assurance Management

Practices (Compliance is mandatory)

7.1.1 Projects engage the Safety and Mission Assurance Office (SMAO) Mission Assurance Branch in all phases of a flight project.

7.1.2 Projects route Statements of Work and technical modifications to existing contracts, and other technical documents related to a procurement action through the Mission Assurance Branch prior to sending them to the Contracting Officer. Projects and Contract Specialists coordinate all procurements with SMAO to ensure all appropriate quality assurance requirement are identified and incorporated in the Procurement Strategy Meeting presentation documents, other memoranda, and in the solicitation and contract.

***Note**: Cost modifications and other modifications with no technical, safety, or mission assurance impacts do not have to be routed through the Mission Assurance Branch.*

7.1.3 SMAO assigns Mission Assurance Managers for each project and keeps the positions filled throughout the life cycle.

7.1.4 Projects establish Mission Success Criteria. The Criteria document mission science requirements, required data products, and a numerical reliability goal for a specified mission duration, which if satisfied, will deem the mission to be successful.

7.1.5 SMAO prepares a Product Assurance Plan (PAP) for each project. The PAP documents the project's mission assurance requirements and is tailored to the flight project's characteristics.

***Note**: The PAP may carry a different title based on the rules/requirements/conventions of the Project customer or sponsor.*

The PAP may be titled a Mission Assurance Plan, Safety and Mission Assurance Plan, or Safety, Reliability and Quality Plan.

a. The Product Assurance Plan will specify mission-assurance related requirements for the following, e.g.:

(1) System Safety
(2) Reliability and Maintainability
(3) Quality Assurance
(4) Software Assurance
(5) Electronic Parts
(6) Problem Reporting
(7) Risk Management

Note: *Some Project requirements and/or complexity may drive the need for a separate plan for one or more of the above topics.*

7.1.6 Projects will conduct design and certification reviews, as a condition for delivery to and use in system level integration and test, for:

a. Flight hardware,
b. All hardware that interfaces directly with flight hardware,
c. Flight and mission critical ground software, and
d. Mission critical support hardware.

Documents

Procedures

a. LMS-CP-4750, “Develop Product Assurance Plans”

Requirements

a. LPR 5300.1, “Product Assurance Plan” – Chapters 1, 2 & 3

Guidance

a. CxP 70055, "CxP Safety, Reliability and Quality Assurance Plan"
b. CxP 70059, "CxP Integrated Safety, Reliability & Quality Assurance Requirements"

7.2 Reliability Engineering

Practices (Compliance is mandatory)

7.2.1 Each Project supports the development of a Mission/Product Assurance Plan in accordance with LPR 5300.1, “Product Assurance Plan,” which includes a section defining reliability requirements.

7.2.2 Projects, in support of flight equipment development, acceptance and design verification, perform design analyses on all flight hardware, including:

a. Fault Tree Analysis of systems/subsystems
b. Failure Modes and Effects Analyses and development of a Critical Items List

7.2.3 Projects start analyses during Formulation, update them throughout Implementation, and present them at major system-level reviews.

7.2.4 Projects perform analyses to demonstrate that failures in non-flight equipment (e.g., support equipment, test equipment, and breadboard and engineering model hardware) cannot propagate to the flight equipment, or adversely affect the mission.

7.2.5 Projects maintain design analyses to reflect the hardware configuration as the flight design evolves throughout the life cycle.

7.2.6 Probabilistic Risk Assessment (PRA)

a. Category I programs and projects with NASA risk classification “A” perform limited scope probabilistic risk assessment.

b. Projects other than Category I or NASA risk classification “A” assess applicability of the PRA technique to their mission during Formulation.

c. Each project using PRA:

(1) Develops a PRA Implementation Plan that defines the plan to use, including objectives and scope, and
(2) Updates the PRA throughout the implementation phase as is appropriate to its use.

Documents

Requirements

a. LPR 5300.1, “Product Assurance Plan” – Chapter 5

Guidance

a. CxP 70043, "Hardware Failure Modes and Effects Analysis and Critical Items List (FMEA/CIL) Methodology"
b. CxP 70017, "Constellation Probabilistic Risk Assessment Methodology"

7.3 Electric, Electronic and Electromechanical (EEE) Parts Reliability & Application

Practices (Compliance is mandatory)

7.3.1 Each Project initiates EEE involvement using LMS-CP-5502, "Systems Engineering Requirements Definition & Implementation Planning for Research Project/Experiments."

7.3.2 Projects generate an EEE Parts Program compliant with LMS-OP-5515, "Electric, Electronic, and Electromechanical (EEE) Parts Assurance."

a. Part Grade is based on application, use, and mission in accordance with LPR 5300.1, Product Assurance Plan. This includes consideration of factors such as environment, duty cycle, and de-rating. It is based on mission classification (e.g., per NPR 8705.4, Risk Classification for NASA Payloads, a class "A" payload requires Grade 1 parts).

7.3.3 Special Reviews Are Held for All Custom Hybrids, Multi-Chip Modules (MCMs), Application-Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), and complex Radio Frequency (RF) parts. Projects define such special reviews in the projects EEE Parts Plan.

7.3.4 Prior to initiating parts procurement, each project reviews their parts lists against Government Industry Data Exchange Program (GIDEP) Alerts and NASA Advisories. Projects continue to review their parts lists against GIDEP Alerts and NASA Advisories issued through launch plus 30 days.

7.3.5 Projects generate a project parts list for tracking potential parts application issues and stress. The project keeps the parts lists current and assesses for risk prior to build and periodically throughout the development process.

7.3.6 Projects evaluate all flight parts for application, reliability, and susceptibility to radiation effects.

7.3.7 Projects analyze designs to ensure that the Total Ionizing Dose (TID) radiation design factor is met.

7.3.8 Projects analyze designs to ensure that radiation induced Single Event Effect (SEE) rates meet project requirements.

7.3.9 Projects perform application analyses to verify that parts meet the required de-rating.

7.3.10 Projects perform failure analyses on all parts that fail during a life test, or subsequent to first application of power after part installation, to the point that lot dependency of the failure mode can be determined.

Documents

Procedures

a. LMS-CP-5502, "Systems Engineering Requirements Definition & Implementation Planning for Research Project/Experiments
b. LMS-OP-5515, "Electric, Electronic, and Electromechanical (EEE) Parts Assurance"

Requirements

a. LPR 5300.1, "Product Assurance Plan" – Chapter 6

7.4 Selection of Materials

Practices (Compliance is mandatory)

7.4.1 In selecting materials, including mechanical parts and components, Projects address flammability, stress-corrosion, out-gassing, and off-gassing requirements based upon payload cleanliness goals and spacecraft vehicle requirements.

***Note**: In the absence of requirements from the spacecraft/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 usage.*

7.4.2 Projects document materials not meeting flammability, stress corrosion, out-gassing, and off-gassing requirements in a Material Usage Agreement (MUA), which is submitted to the Mission Assurance Branch for approval.

7.4.3 If composite materials are selected for use in structural applications, Projects submit a Composite Material Qualification Plan to the Mission Assurance Branch for approval.

7.4.4 Projects identify limited-shelf-life materials and observe their expiration dates. Use of materials with expired date codes requires 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 Mission Assurance Branch for approval.

7.4.5 Projects develop and maintain a list of selected materials. The Materials List contains a reference to the document from which acceptability was ascertained.

Documents

Requirements

a. LPR 5300.1, "Product Assurance Plan" – Chapter 6

Guidance

a. Johnson Space Center (JSC) 09604/Marshall Space Flight Center (MSFC) HDBK-527, "Materials Selection List for Space Handbook Systems"

7.5 Quality Assurance

Practices (Compliance is mandatory)

7.5.1 Hardware providers implement a quality system consistent with the requirements below:

a. Work that is both critical and complex is performed in accordance with the quality system requirements of AS9100.

(1) 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 significant mission resources (e.g., government test or launch facility).
(2) Complex work involves either: a) the design, manufacture, fabrication, assembly, testing, integration, maintenance, or repair of machinery, equipment, subsystems, systems, or platforms, or b) the manufacture/fabrication of parts or assemblies which have quality characteristics not wholly visible in the end item and for which conformance can only be established progressively through precise measurements, tests and controls applied.

b. Critical, but not complex work is performed in accordance with the quality system requirements of AS9100 or ISO 9001, or the inspection and test quality system requirements of AS9003.

c. Complex, but not critical work is performed in accordance with the quality system requirements of AS9100 or ISO 9001.

d. 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 are supported by records evidencing their performance and outcome.

7.5.2 Project solicitations, contracts, and work tasking documents invoke/specify the above quality system requirements.

7.5.3 Quality Assurance (QA) personnel perform receiving and shipping inspections on flight hardware whenever the hardware enters or leaves any facility (e.g. LaRC, another NASA Center, or Contractor facility).

7.5.4 Quality Assurance personnel, along with the Project, define mandatory inspections for critical hardware (e.g., in-process and final) at LaRC, contractors, sub-contractors and suppliers.

7.5.5 Quality Assurance personnel support integration and test activities and participate in contamination control in clean rooms.

7.5.6 All personnel involved in the fabrication, assembly, handling or testing of flight hardware are certified to standards approved by the responsible QA organization.

7.5.7 Inspection of flight hardware is performed to formally released documents and or drawings.

7.5.8 Projects maintain records of the flight system configuration during assembly, test and launch operations to demonstrate the “as-tested” and “as-flown” configurations.

7.5.9 In support of fabrication, assembly, inspection, and test activities Projects only use measurement instruments and test equipment that have current calibration. Procedures for the calibration and control of such equipment are a part of the supplier’s quality system.

7.5.10 Projects fabricate all flight products and associated GSE at LaRC facilities in accordance with LMS-CP-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 LMS-CP-5640.

a. A completed NASA LaRC Form 133, “Fabrication Work Request” (FWR) is required to initiate fabrication activities. All space flight FWRs are to be marked as “Formal” and signed by the requestor or project representative and approved by the Fabrication Representative.

b. A NASA LaRC Form 136, “Fabrication and Inspection Operations Sheet (FIOS) is to be prepared for each serialized part, group of parts or subassembly as per LMS-CP-5640, “Requesting, Performing, and Closing Fabrication Services Requests.” All FIOSs require approval by the Quality Assurance Branch, the Fabrication Representative and the requestor or the project representative.

7.5.11 Projects require fabrication process specifications for certain fabrication and assembly operations when any of the following conditions exist:

a. The final result or completion operation cannot be inspected or tested.

b. The operation is sufficiently complex such that an experienced operator cannot successfully perform the operation with repeatable results.

c. The operation is potentially destructive to the hardware or personnel.

d. The operation can generate destructive by-products, such as contamination, not apparent to the operator.

7.5.12 On qualification and flight hardware, Projects use existing proven processes (e.g.: soldering, welding, heat treatment, coatings) performed by qualified personnel.

7.5.13 The Quality Assurance Branch submits process specifications to the Project 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.

7.5.14 Projects fabricate hardware to the following NASA Workmanship Standards as applicable:

a. NASA-STD-8739.1, “Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies”

b. NASA-STD-8739.2, “Surface Mount Technology”

c. NASA-STD-8739.3, “Soldered Electrical Connections”

d. NASA-STD-8739.4, “Crimping, Interconnecting Cables, Harnesses, and Wiring”

e. NASA-STD-8739.5, “Fiber Optic Terminations, Cable Assemblies, and Installation”

Worker and Inspector training and certification are required for each of the above standards. Alternate workmanship standards may be used when approved by the Mission Assurance Branch and the Project. The developer will submit, for review and acceptance, the alternate standard and the differences between the alternate standard and the required standard prior to the above approvals.

7.5.15 Projects identify parts and assemblies with an Identification (ID) number consisting of a Part number (PN) and a Serial number (SN) per the requirements of Chapter 7.7 of LPR 5300.1, “Product Assurance Plan.” Exceptions to the hardware identification requirements are also specified in chapter 7.7.

7.5.16 Projects use Quality Status Stamps (QSS) on flight hardware documentation. 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 the specific criteria, application, procedures, issuance and control detailed in Chapter 7.9 of LPR 5300.1, “Product Assurance Plan.”

7.5.17 Projects establish bonded stores per LMS-CP-4892, “Bonded Storage,” when assembling flight hardware to closely controlled safety and product quality.

7.5.18 Project personnel are required to obtain and maintain appropriate logbooks from the Mission Assurance Branch Quality Assurance Specialists when two or more parts are to be assembled after release from the Fabrication process. Logbooks are used for components, sub-systems, systems and GSE.

7.5.19 Projects use logbooks 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 performed, inspections and Non-compliance Failure Reports. The Mission Assurance Branch Quality Assurance Specialist issues and maintains accountability of all logbooks and assures logbooks are maintained current by the Project.

7.5.20 Projects assemble and disassemble all space hardware and associated ground support equipment using approved drawings and/or procedures. All assembly or disassembly is to be verified by Mission Assurance Branch personnel. Mission Assurance personnel are to be present during all critical inspection activities identified in the assembly procedure. Items required to be identified in assembly procedures are detailed in Chapter 7.12.3 of LPR 5300.1, “Product Assurance Plan.”

7.5.21 Projects generate an Integrated Test Plan (ITP). The ITP shall outline the scope, technical intent, and success criteria. The ITP is to be submitted to Mission Assurance Branch personnel 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.

7.5.22 For purposes of flight acceptance, Projects conduct functional and environmental testing of flight hardware and associated GSE according to written and approved plans and procedures. All testing activities are to be verified by Mission Assurance Branch personnel. Mission Assurance personnel are to be present during all critical inspection activities identified in the ITP. Items required to be identified in the test procedures are detailed in Chapter 7.13.3 of LPR 5300.1, “Product Assurance Plan.”

7.5.23 Certain electrical and electronic parts (e.g.: microelectronic and semiconductor devices, thick and thin film resistors, chips and hybrid devices, piezoelectric crystals) are sensitive to the damaging effects of Electrostatic Discharge (ESD). Assemblies and equipment containing these parts are also susceptible to damage when an ESD occurs at the terminals or when exposed to electrostatic fields. Projects implement ESD controls in accordance with NASA-STD-8739.7, “Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices).”

7.5.24 Projects develop a Contamination Control Plan (CCP) and submit it to the Mission Assurance Branch for approval. The plan will specify the cleanliness and environmental conditions required during

assembly, test, transport and operation of space products to maintain the desired level of cleanliness. In addition, all space products flown on the Shuttle or the International Space Station are to comply with those respective cleanliness levels.

7.5.25 Organizations responsible for the operation of clean rooms/work stations shall conduct appropriate training for all personnel using their facilities. Certification of completed training shall also be provided. Clean rooms, work stations and worker certifications are subject to review by Mission Assurance personnel.

7.5.26 When lifting flight hardware, Projects comply with LPR 1740.2, "Facility Safety Requirements." Specific requirements for lifting devices used in critical lifts apply. A critical lift is defined as a lift where failure/loss of control could result in loss of life, loss or damage to flight hardware, or lift involving special high dollar items, such as spacecraft, one-of-a-kind articles or major facility components whose loss would have serious programmatic or institutional impact. Specific written procedures shall be prepared and followed for all critical lifts and pre-lift reviews shall be conducted.

7.5.27 Projects prepare an Integrated Data Package (IDP), provided at the point of delivery to an integrated test facility or launch site and which documents the configuration, functional characteristics, and flight worthiness of all deliverable space products, GSE and associated spares. The IDP will comply with all specific integrated test facility or launch site requirements. 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. As a minimum, the following are to be included in the IDP:

a. Index of included items

b. Notes/Documents (customer's option)

c. All exceptions and waivers (both open and closed)

d. List of shortages

e. Closed NFRs affecting LaRC

f. Open NFRs affecting integration activities

g. Listing of unplanned/deferred work

h. Identification (as-built configuration/drawings)

i. Limited operating life/age sensitive items

j. Pyrotechnic data

k. All installed non-flight items identified

l. Current certification of proof-loaded and calibration of delivered GSE

m. Operating test procedures

n. List of open items from Phase III Ground Safety Review

7.5.28 Projects follow LMS-CP-4756, "Handling, Preservation, Storage and Shipping of Space Flight Hardware" in the handling, preservation and shipping of space flight hardware. Projects also follow applicable requirements of LMS-CP-4759, "Acquisition of Hazardous Materials" in the handling preservation, and shipping of hazardous materials.

Documents

Procedures

a. LMS-CP-5640, "Requesting, Performing, and Closing Fabrication Services Requests"
b. LMS-CP-4756, "Handling, Preservation, Storage and Shipping of Space Flight Hardware"
c. LMS-CP-4892, "Bonded Storage"
d. LMS-CP-4759, "Acquisition of Hazardous Materials"

Requirements

a. LPR 5300.1, "Product Assurance Plan" – Chapter 7
b. NASA-STD-8739.1, "Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies"
c. NASA-STD-8739.2, "Surface Mount Technology"
d. NASA-STD-8739.3, "Soldered Electrical Connections"
e. NASA-STD-8739.4, "Crimping, Interconnecting Cables, Harnesses, and Wiring"
f. NASA-STD-8739.5, "Fiber Optic Terminations, Cable Assemblies, and Installation"
g. LPR 1740.2, "Facility Safety Requirements"
h. NASA-STD-8739.7, "Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)"

Guidance

a. CxP 70055, "CxP Safety, Reliability and Quality Assurance Plan"
b. CxP 70059, "CxP Integrated Safety, Reliability & Quality Assurance Requirements"

7.6 Problem Reporting

Preamble

For non-conformances and failures, Projects are required to meet reporting, disposition, documentation, verification and close out requirements. Specific requirements are in Chapter 7.8 of LPR 5300.1, “Product Assurance Plan.”

- Non-conformance – A condition or characteristic of any hardware or software item which does not conform to a drawing or other specification

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

Practices (Compliance is mandatory)

7.6.1 Projects document all LaRC Non-conformance and failures associated with space products in the LaRC Non-conformance/Failure Reporting (NFR) Web-based system. Contractors responsible for delivering flight hardware shall utilize a functionally similar system based on company procedures and report according to contract requirements. The help section of the web-based system will give instructions for the use of the system. The URL for the system is http://nfr-anomaly.larc.nasa.gov.

7.6.2 Projects disposition discrepant items at a Project Material Review Board (MRB), unless the discrepant item is returned for completion of work, returned to the supplier, or scrapped.

a. Minimally, the MRB consists of a Designated Project Engineer, a Quality Assurance Representative and the Project Manager or Project Management designee. The Quality Assurance representative will be from either the Quality Assurance Branch or Mission Assurance Branch depending on where the work was when the non-conformance or failure occurred.

b. Unanimous agreement by the MRB is required for the preferred disposition. If unanimous agreement cannot be reached, the Project Manager is authorized to make an appropriate disposition. The designated quality assurance representative has the authority

to defer any disposition to the Mission Assurance Branch Head if unable to concur with the disposition.

7.6.3 To close a NFR, Projects complete all quality actions and dispositions and obtain verification by the designated quality assurance representative.

7.6.4 Projects log and maintain all NFRs generated during the fabrication process on the appropriate FIOS. A paper copy of all NFRs generated will be included in the Work Order Package.

7.6.5 Projects include hard copies of all NFRs generated outside of fabrication in the appropriate logbook. Open NFRs are to be included in the Integrated Data Package.

7.6.6 Projects report on the status of Open NFRs at every major Project Review.

Documents

Procedures

a. LMS-CP-5507, “Reporting and Disposition of Nonconforming Aerospace Hardware Items and Products”

Requirements

a. LPR 5300.1, “Product Assurance Plan” – Chapter 7.8

Guidance

a. CxP 70068, "CxP Problem Reporting, Analysis and Corrective Action Methodology"

7.7 System Safety

Preamble

Integrating organizations, launch sites and/or Programs/Projects can differ with respect to safety requirements, forms, processes and Reviews. These specific safety requirements need to be determined early in the Project formulation. The following are examples of projects that will have multiple and/or differing requirements.

- ELV payloads
- Shuttle payloads
- Space Station experiments
- Constellation Program

Names given below for the following plans and analyses (i.e., System Safety Plan, Flight Safety Analysis) are generic in nature and are meant to convey

the content. Different integration organizations and Ranges use different terminology.

Practices (Compliance is mandatory)

7.7.1 Projects apply system safety requirements to all operations throughout the project life cycle.

7.7.2 Projects submit System Safety Plans (SSP's) to the Mission Assurance Branch approval.

***Note**: Separate SSP's may be required for each flight project by the integrating organization as opposed to being included in the Product Assurance Plan.*

7.7.3 Projects address the following items in the SSP for the appropriate launch system and site:

a. Organizational responsibilities, authority and interrelationships as related to system safety
b. Orbital debris assessment
c. Required system safety analyses
d. Internal and external safety review processes
e. Hazardous operation surveillance
f. Accident investigation and reporting
g. Operator training and certification
h. Required Safety Compliance Data package documentation

7.7.4 For hardware and software flight project products, Projects prepare and update Flight Safety Analyses (FSA) as the project progresses through design, fabrication, test, integration and launch. FSA's include the following:

a. Identification of the Hazard
b. Description of the undesired event or triggering event (hazard title)
c. Identification of the causes
d. The control or technical explanation demonstrating the potential hazard does not pose an unacceptable risk
e. Method of verification of the control(s)
f. Current status of the hazard control and verification

***Note**: Fault Tree Analysis (FTA) and results from Failure Modes and Effects Analysis (FMEA) are often used to generate the hazard sheets or supplement the hazard development process.*

7.7.5 Projects design fault tolerance requirements into systems as applicable. Fault tolerance requirements are specified in multiple

Agency documents and also Range Safety documents. Agency requirements may differ from Range Safety requirements and both need to be addressed appropriately.

7.7.6 Projects prepare a Ground Safety Analysis (GSA) for each payload and associated GSE when the use of a facility or the performance of an activity could result in subjecting personnel and/or facilities to hazards. Ground Safety Reviews are required by integrating and Range organizations. GSA includes the same hazard information as the FSA, but the emphasis is on hazards to ground processing personnel and facilities and must include GSE and any hazards posed by GSE and/or testing performed during integration up to launch.

7.7.7 Projects submit a Safety Compliance Data Package (SCDP) to the applicable Safety Review Panel. The SCDP is to include the following for the appropriate launch system and site:

a. Mission overview
b. List of applicable documents
c. Payload description
d. Safety overview
e. Flight Safety Analysis
f. Ground Safety Analysis
g. Supplemental Analyses
h. Approved exceptions and waivers
i. Payload safety non-compliance reports

7.7.8 Customer safety boards conduct specific Safety Reviews outside Project reviews, depending on the requirements. Review dates for Shuttle payloads generally coincide with Project Reviews and use a Phase 0/I/II/III terminology. ELV payloads generally require deliverable of a Safety Data package at several pre-determined times based on when the payload is scheduled to arrive and/or the launch is scheduled.

Documents

Requirements

a. LPR 5300.1, “Product Assurance Plan” – Chapter 8

Guidance

a. CxP 70038, "Hazard Analysis Methodology"
b. NASA-STD-8719.13B, "Software Safety Standard"

7.8 Software Assurance & Software IV&V

Preamble

NASA has determined independent verification and validation (IV&V) of software, when required, will be managed and carried out by the NASA IV&V Facility. The NASA IV&V Facility provides an independent set of services to identify software risks and recommended mitigations.

NASA applies IV&V according to a priority ranking done across the Agency, and funds the work performed by the IV&V Facility. LaRC Projects receive assistance on the NASA IV&V process by the LaRC IV&V Liaison in the Mission Assurance Branch.

Software IV&V is an independent activity and is not used in place of, or as a substitute for, project software V&V or software assurance.

Practices (Compliance is mandatory)

7.8.1 In its software, Projects comply with LMS-CP-5528, "Software Planning, Development, Acquisition, Maintenance, and Operation." This includes software developed by contractors.

7.8.2 The Mission Assurance Branch will conduct software assurance activities for the Project, including 1) ensuring that software is correctly classified prior to commencing development, 2) reviewing software development plans, products and related processes, 3) ensuring software meets pre-defined set of guidelines and standards, and 4) assuring all software meets stated requirements.

***Note**: A separate Software Assurance Plan (SAP) may be developed depending on program requirements, development complexity, and software classification.*

7.8.3 Each Project arranges for software assurance verification of the software traceability matrix to ensure that requirements are correctly applied and that critical mission/payload software has been appropriately tested.

7.8.4 Projects perform software process and product evaluations. These evaluations are performed against institutional and project requirements and standards and the resulting findings are tracked to closure. The evaluations are performed throughout the project life cycle and include:

a. Assessment of the preliminary planned software development process and associated work products prior to the SRR.

b. Assessment of the baselined software development process and associated work products prior to Milestone C (PDR).

c. Assessment of the baselined software development processes and associated work products prior to CDR or its equivalent, prior to completion of the software development, and during integration.

d. Assessment of all software processes, work products, closure of all actions, and non-conformances prior to acceptance testing.

7.8.5 Projects, working with the LaRC IV&V Liaison, complete a self-assessment of software functional complexity using NASA defined criteria by filling out the Software Inventory Scoring Template used to determine the project's priority ranking which is subject to review by the Agency.

7.8.6 Projects selected for IV&V:

a. Support the IV&V Facility in performing and, when appropriate, updating the IV&V Plan.

b. Report IV&V work status at management (e.g., IV&V Quarterly) reviews.

Documents

Procedures

a. LMS-CP-5528, "Software Planning, Development, Acquisition, Maintenance, and Operation"

b. LMS-CP-4754, "Software Assurance (SA) for Development and Acquisition"

Requirements

a. LPR 5300.1, "Product Assurance Plan" – Chapter 7.3

Appendix A: Definitions and Acronyms

	Item	Definition
A.1	ASIC	Application-Specific Integrated Circuit
A.2	Basis of Estimate	The cost Basis of Estimate provides a record of the procedures, ground rules and assumptions, data, environment, and events that underlie a cost estimate's development or update.
A.3	Baseline a plan	1) Obtain the commitment of the performing organizations to constituent plans and to the Integrated Master Schedule, 2) obtain the Center's approval of the budget, and 3) establish an independently reviewed, Integrated Master Schedule as a baseline against which progress will be measured.
A.4	Benchmarking	Continual improvement activity of evaluating processes in relation to best practices.
A.5	BOE	Basis of Estimate.
A.6	CADRe	Cost Analysis Data Requirements. Used to report information about the full cost of the project.
A.7	CAM	Control Account Manager--see definition of Control Account
A.8	Category 1, Category 2 projects	Generally having a life cycle cost greater than $250M, although priority can raise lower-cost projects up to one of the higher categories. Defined in NPR 7120.5D
A.9	CDR	Critical Design Review
A.10	CM	Configuration Management
A.11	CMC	Center Management Council--a monthly review of project progress, problems, and plans
A.12	COD	Center Operations Directorate
A.13	Control Account	A management control point in the WBS where scope, budget, actual cost, and schedule are integrated and effective management can be exerted. Each control account is associated with a specific single organizational component in the Organizational Breakdown Structure. See the definition in PMBOK.
A.14	Critical events	In mission operations, critical events are those that if not executed properly and in a timely manner could result in failure to achieve mission success
A.15	Customer	In general, anyone or any organization who will use the project's products. In this Handbook, references to "the customer" generally mean the Constellation program or project element that has asked Langley to produce project products.

	Item	Definition
A.16	Customer-level requirements	The equivalent of "Level 1" requirements. Cannot be changed without the approval of the customer.
A.17	EDL	Entry, Descent, and Landing
A.18	EEE parts	Electrical, Electronic, and Electromechanical parts
A.19	EMI/EMC	Electro-magnetic Interference, Electro-Magnetic Compatibility
A.20	Encumbrance	An expense not originally accounted for which must certainly be paid.
A.21	Engineering organizations	Systems Engineering Directorate (SED), Research and Technology Directorate (RTD), Systems Analysis and Concepts Directorate (SACD), Center Operations Directorate (COD), and Flight Research Systems Directorate (FRSD)
A.22	ESOD	Exploration and Space Operations Directorate
A.23	Estimate at Completion	An EVM estimate of the total cost of the project when it is completed. See definition and discussion in PMBOK.
A.24	EVM	Earned Value Management
A.25	Exploration Project	Langley-specific term for sub-projects of the NASA Constellation Program that are conducted at Langley
A.26	FIOS	Fabrication and Inspection Operations Sheet
A.27	FMEA	Failure Modes and Effects Analysis
A.28	FPD	Flight Projects Directorate
A.29	FPGA	Field Programmable Gate Array
A.30	FTA	Fault Tree Analysis
A.31	GDS	Ground Data System
A.32	GIDEP	Government Industry Data Exchange Program, a source for alerts about bad or questionable electronics parts
A.33	GSA	Ground Safety Analysis
A.34	GSE	Ground Support Equipment
A.35	IDP	Integrated Data Package
A.36	IMS	Integrated Master Schedule--see definition

	Item	Definition
A.37	Independent check	Someone or some team other than the originator or originating team (e.g., another person, a peer review, or software automation) checks the process.
A.38	Integrated Master Schedule	A networked schedule with predecessors and successors identified and logically tied. The IMS details the work required during the entire period of performance of the project. Near-term tasks may be more detailed than far-term.
A.39	ITAR	International Traffic in Arms Regulations
A.40	ITP	Integrated Test Plan
A.41	IV&V	Independent Verification and Validation
A.42	Lien	An expense not originally accounted for and which is not certain but which has at least a 10% chance that it will have to be paid.
A.43	MCR	Mission Concept Review. Normally at the end of Concept Studies phase.
A.44	Milestone A	Project Maturity Milestone A, corresponds to Key Decision Point A, nominally at the end of the Concept Studies phase (Mission Concept Review)
A.45	Milestone B	Project Maturity Milestone B, corresponds to Key Decision Point B a the end of the Concept and Technology Development phase (System Definition Review)
A.46	Milestone C	Project Maturity Milestone C, corresponds Key Decision Point C at the end of the Preliminary Design and Technology Completion phase (Preliminary Design Review)
A.47	MCM	Multi-Chip Module
A.48	MRB	Project Material Review Board
A.49	NFR	Nonconformance/Failure Report
A.50	OBS	Organizational Breakdown Structure--see definition.
A.51	OCFO	Office of Chief Financial Officer
A.52	OP	Office of Procurement

	Item	Definition
A.53	Organizational Breakdown Structure	A hierarchically organized depiction of the project organization arranged so as to relate the work packages to the performing organizational units. See the definition in PMBOK
A.54	OS	Operations system
A.55	PDR	Preliminary Design Review
A.56	PIP	Project Implementation Plan
A.57	Planning Approval Official	The Director of FPD, unless it is delegated
A.58	PMBOK	Project Management Body of Knowledge, Project Management Institute, an ANSI standard (*ANSI/PMI 99-001-2004)* for Project Management
A.59	Pre-CMC	Monthly review of project progress, problems, and plans by FPD, generally the week before projects present to the CMC
A.60	PRA	Probabilistic risk assessment
A.61	Project	An effort of sufficient complexity, value, or criticality that its success depends on having organized project management, including a Project Manager, a Chief Engineer, and a Project Implementation Plan. "Complexity" is meant to include factors that require control of cost, schedule, configuration, and risk.
A.62	Project Maturity Milestone A	Corresponds to Mission Concept Review
A.63	Project Maturity Milestone B	Corresponds to System Definition Review
A.64	Project Maturity Milestone C	Corresponds to Preliminary Design Review
A.65	QA	Quality Assurance
A.66	Reference (adj)	The state of understanding, e.g.: at the conclusion of Project Initiation the state is called a "reference" understanding, as in "reference concept," "reference schedule," and "Reference Implementation Plan."
A.67	RF	Radio Frequency
A.68	RFP	Request for Proposal
A.69	RTD	Research Technology Directorate

	Item	Definition
A.70	SACD	System Analysis and Concepts Directorate
A.71	SAP	Software Assurance Plan
A.72	SAR	System Acceptance Review
A.73	SCDP	Safety Compliance Data Package
A.74	SDR	System Definition Review. Normally at the end of Concept Definition phase.
A.75	SED	Systems Engineering Directorate
A.76	SFPPH	Space Flight Project Practices Handbook
A.77	SMAO	Safety and Mission Assurance Office
A.78	SMO	Systems Management Office
A.79	Software Class	Classification of software by complexity; Defined in NPR 7130.2, Appendix B
A.80	SOW	A contract or RFP Statement of Work
A.81	SRR	System Requirements Review
A.82	WBS	Work Breakdown Structure--see definition. (Also used by the NASA financial management system to designate program account numbers. In this Handbook, however, WBS refers exclusively to the standard tool of project management.)
A.83	Work Breakdown Structure	A deliverable-oriented, hierarchical decomposition of the work to be performed by the Project to accomplish the project objectives. See the definition of "Work Breakdown Structure" in PMBOK.
A.84	Work Package	The work-package level is the lowest level in the WBS and is the point at which the cost and schedule can be reliably estimated. See the definition of Work Package in PMBOK.

Appendix B: Compliance with the Requirements of the Langley Space Flight Project Practices Handbook

Use this outline as a template for reporting on your planned compliance with the requirements of this Handbook.

5 Management Practices

5.1 Life Cycle
5.2 Planning
5.3 Project Organization, Roles and Responsibilities, and Decision-Making
5.4 Work Breakdown Structure
5.5 Spares, Testbeds, and Models
5.6 Scheduling, Cost Estimating, Performance Assessment and Control
5.7 Information Management and Information Technology
5.8 Configuration Management
5.9 Customer-Level Scope Margin
5.10 Project Staffing and Destaffing
5.11 Project Priorities/Competing Characteristics
5.12 Acquisition and Surveillance
5.13 Project and Institutional Reporting
5.14 Reviews
5.15 Updating Plans and Replanning
5.16 Risk Management
5.17 Waivers
5.18 Engineering Science Data Management
5.19 External Communication
5.20 Public Engagement
5.21 Lessons Learned
5.22 Margins and Margin Management
5.23 Crisis Response

6 Engineering Practices

6.1 Project Design
6.2 Telecommunication Design
6.3 Operations
6.4 System Engineering
6.5 Launch Services
6.6 Inheritance
6.7 Planetary Protection
6.8 Flight System Fault Tolerance/Redundancy
6.9 Materials, Processes, and Contamination Control
6.10 Software Development
6.11 Protection and Security of Flight Hardware
6.12 Design and Verification for Environmental Compatibility

Appendix C: Exploration Project Initiation Template

C.1 Project Initiation

C.1.1 Project initiation is on the critical path for many space flight projects, and this template is intended to set a standard for the Center's activities in initiating a space flight project quickly. For projects not having an urgent need to start, a revised schedule must be proposed to the Director of Flight Projects within a week after the Project Manager is identified.

C.1.2 The state of understanding at the conclusion of Project Initiation is called "reference" understanding, as in "reference concept," "reference schedule," and "Reference Implementation Plan."

C.1.3 Project Initiation starts when an outside customer commits to funding the Project and expects Langley to start the Project. It lasts until the 60-Day review is successfully completed.

C.1.4 Key milestones:

a. Project called into existence (t = 0)
b. First wave staffing complete (t = 2 weeks)
c. Second wave staffing complete (t = 4 weeks)
d. Reference Implementation Plan complete (t = 6 weeks)
   (The Project Reference Implementation Plan is defined below.)
e. 60-day review (t = 8 weeks, 4 days)

C.1.5 A template for the 60-Day Review is available from the Exploration and Flight Projects Directorate. The template includes notes on the required content.

C.2 Project Initiation Team

C.2.1 First wave -- to be complete by the end of week 2.

a. Project Manager
b. Deputy Project Manager
c. Deputy Project Manager for Resources/Program Analyst
d. Project Chief Engineer
e. Project Safety and Mission Assurance Manager
f. Scheduler
g. Configuration Manager
h. Contracting Officer

C.2.2 Second wave -- to be complete by the end of week 4.
a. Lead Subsystems Engineers
b. Integration and Test Manager

C.2.3 Team meetings
a. Project initiation is a period of rapid change. In order to keep the Team informed, the Initiation Team should expect to meet daily for the duration of project initiation. Invite everyone on the initiation team to every meeting, even if it appears that they might not need to attend, including the Contracting Officer, Scheduler, and Configuration Manager.

C.3 Planning requirements

C.3.1 Project Reference Implementation Plan
a. Introduction.
b. Reference project organization chart.
c. Reference list of important deliverables, including both final and intermediate products and services. Include a brief description and a reference schedule.
d. Reference list of important receivables, including possible procurements and their reference schedule. If a make/buy decision must be made, indicate when it must be made.
e. Reference list of important plans. Include a reference schedule for the development and review of plans. Include expected budget cycle activities.
f. Reference list of important reviews, including the lower-level reviews that run up to major reviews. Include a reference schedule.
g. Reference list of top-level project requirements, including a brief description.
h. Reference Work Breakdown Structure (WBS, no more than Level 3 needed).
i. Reference Integrated Master Plan (IMP).
j. Reference Integrated Master Schedule (IMS).
k. Reference Organizational Breakdown Structure (OBS).
l. Reference map of OBS to WBS, identifying Control Account Manager points (names not needed).
m. Reference cost estimate, including Basis of Estimate.
n. Reference funding profile.
o. Reference internal project communications plan.

C.3.2 How to tell that the plan is a good one
a. Deliverables have been negotiated with the customer, and there is a plan to check back with the customer on a regular basis.

b. Receivables have been identified and there is a reference plan for their acquisition.
c. WBS follows NASA standard.
d. A staffing plan has been developed and reviewed with FPD and other, appropriate Center organizations.
e. Cost estimate includes all appropriate FPD and other Center organization charges and has been reviewed by FPD and OCFO authorities.
f. Cost estimate has reserves budgeted at a level appropriate for the maturity of the cost estimate.
g. Cash flow plan includes carryover for at least 6 weeks into each new fiscal year.

C.3.3 Set up Earned Value Management system
The Systems Management Office will help.

C.4 Reporting during initiation

C.4.1 Reporting frequency and method
a. Report to the customer as required, at least weekly.
b. Report to the Director of FPD at a frequency established with the Director during the first week of the project.
c. Reports should include:
(1) Status of establishing the Project
(2) Financial status
(3) Workforce status
(4) Status of acquisition
(5) Baseline for what will be acquired
(6) Acquisition schedule
(7) Progress along acquisition schedule
(8) Status of the Project Reference Planning Document
b. Send a weekly e-mail to the Center Director and other Center leaders, if appropriate

C.5 Timeline

C.5.1 Get first wave team in place (by end of week two)
Define deliverables (by end of week four)
C.5.2 Set up WBS (by end of week four)
C.5.3 Set up financial system (by end of week four)
C.5.4 Plan top-level task network (by end of week four)
C.5.5 Develop schedule (by end of week four)
C.5.6 Bring second wave of team on (by end of week four)
C.5.7 Review draft Project Reference Planning Documents with customers and stakeholders (by end of week six)
C.5.8 Conduct the 60-Day Review (by the end of week 9)

C.6 How management can tell that project initiation is going well

C.6.1 Staffing requirements met.
C.6.2 Must-have team members are on duty within two weeks of the start of project initiation.
C.6.3 Planning requirements are met.
C.6.4 Preparation for the 60-Day Review has been included in the plans.and that scheduled preparation activities are carried out on time.
C.6.5. Funding has arrived.
C.6.6 No major activities have been dropped or missed.
C.6.7 Team dynamics are effective and free of problems.
C.6.8 Office space has been established.
C.6.9 Lessons are being recorded that will improve Langley's system for initiating projects.

Appendix D: Elements of the Project Implementation Plan

D.1 The Project Implementation Plan is the Langley Project's plan for carrying out the project. For space flight projects, the maturity of the Project Implementation Plan is developed according to Project Maturity Milestones A, B, and C defined during Project Initiation.

D.1.1 The outline presented here is based on Appendix F "Project Plan Template" of NPR 7120.5. Compliance is required unless a revision is negotiated with the owner of the plan's requirements, reviewed by the Systems Management Office, and approved by the Planning Approval Official. The Project's Planning Approval Official will direct the Project to the owner of a plan's requirements if a waiver makes sense. Owners are identified below. "Engineering organization" refers to SED, RTD, SACD, or other organization having the greatest ownership for a given document on a particular project.

D.1.2 Projects indicate planned compliance and non-compliance to the requirements of this document at the 60-Day review and at Milestones A, B, and C. Appendix B provides an outline for reporting compliance.

D.2 Outline of the Project Implementation Plan

[PROJECT NAME] PROJECT IMPLEMENTATION PLAN

1.0 PROJECT OVERVIEW--*FPD*
- 1.1 INTRODUCTION
- 1.2 OBJECTIVES
- 1.3 MISSION DESCRIPTION AND TECHNICAL APPROACH
- 1.4 PROJECT AUTHORITY, GOVERNANCE STRUCTURE, MANAGEMENT STRUCTURE AND IMPLEMENTATION APPROACH
- 1.5 STAKEHOLDER DEFINITION

2.0 PROJECT BASELINE--*FPD*
- 2.1 REQUIREMENTS BASELINE
- 2.2 WBS BASELINE
- 2.3 SCHEDULE BASELINE
- 2.4 RESOURCE BASELINE

3.0 PROJECT CONTROL PLANS *(With owning organization)*
- 3.1 TECHNICAL, SCHEDULE, AND COST CONTROL PLAN--*FPD*
- 3.2 SAFETY AND MISSION ASSURANCE PLAN--*SMAO*
- 3.3 RISK MANAGEMENT PLAN--*SMAO*
- 3.4 ACQUISITION PLAN--*OP*

Appendix E: The Seven Principles of Earned Value Management

E.1 Plan all work scope for the project to completion.

E.2 Break down the project work scope into finite pieces that can be assigned to a responsible person or organization for control of technical, schedule and cost objectives.

E.3 Integrate project work scope, schedule and cost objectives into performance measurement baseline plan against which accomplishments may be measured. Control changes to the baseline.

E.4 Use actual costs incurred and recorded in accomplishing the work performed.

E.5 Objectively assess accomplishments at the work-performed level.

E.6 Analyze significant variances from the plan, forecast impacts, and prepare an estimate at completion based on performance to date and work to be performed.

E.7 Use earned value information in the Project's decision-making and review processes.

Appendix F: List of Referenced Requirements, Standards, and Guidance

F.1 Requirements

F.1.1 NPR 7120.5, "NASA Space Flight Program and Project Management Requirements"

F.1.2 NPR 7123.1, "NASA Systems Engineering Processes and Requirements"

F.1.3 NPR 7150.2, "NASA Software Engineering Requirements"

F.1.4 NPD 7500.1, "Program and Projects Logistics Policy"

F.1.5 NPR 8000.4, "Risk Management Procedural Requirements"

F.1.6 NPR 8020.12, "Planetary Protection Provisions for Robotic Extra-terrestrial Missions"

F.1.7 LPR 1740.2, “Facility Safety Requirements”

F.1.8 LPR 1440.7, " Langley Research Center (LaRC) Records Management Procedural Requirements"

F.1.9 LMS-CP 4501, "Procurement Process Overview"

F.1.10 LMS-CP 4523, "Contractor Performance Monitoring"

F.1.11 LMS-CP-4750, “Develop Product Assurance Plans”

F.1.12 LMS-CP-4753, “Project Risk Management Support”

F.1.13 LMS-CP-4754, “Quality Assurance (QA) for Software Development and Acquisition”

F.1.14 LMS-CP-4756, “Handling, Preservation, Storage and Shipping of Space Flight Hardware”

F.1.15 LMS-CP-4759, “Acquisition of Hazardous Materials”

F.1.16 LMS-CP-4892, “Bonded Storage”

F.1.17 LPR 5300.1, “Product Assurance Plan”

F.1.18 LMS-CP-5502, “Systems Engineering Requirements Definition & Implementation Planning for Research Project/Experiments

F.1.19 LMS-CP-5505, "Flight Project Critical Milestone Review (CMR) Planning and Implementation"

F.1.20 LMS-CP-5507, “Reporting and Disposition of Nonconforming Aerospace Hardware Items and Products”

F.1.21 LMS-CP-5510, "Aerospace Systems Change Control within Systems Engineering"

F.1.22 LMS-OP-5515, “Electric, Electronic, and Electromechanical (EEE) Parts Assurance”

F.1.23 LMS-CP-5526, "Product Requirements Development and Management Procedure"

F.1.24 LMS-CP-5528, "Software Planning, Development, Acquisition, Maintenance, and Operations"

F.1.25 LMS-CP-5640, “Requesting, Performing, and Closing Fabrication Services Requests”

F.1.26 LPR 7600.1, "Closeout Photographs for Flight and Ground Hardware Procedural Requirements."

F.1.27 LMS-CP-8621, "Reporting, Investigating, and Recordkeeping for Mishaps, Close Calls, and Previously Unidentified Serious Workplace Hazards"

F.1.28 LPR 8705.1, "Design, Verification/Validation and Operations Principles for Space Flight Systems"

F.2 Standards

F.2.1 NASA-STD-8719.13B, "Software Safety Standard"

F.2.2 NASA-STD-8739.1, “Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies”

F.2.3 NASA-STD-8739.2, “Surface Mount Technology”

F.2.4 NASA-STD-8739.3, “Soldered Electrical Connections”

F.2.5 NASA-STD-8739.4, “Crimping, Interconnecting Cables, Harnesses, and Wiring”

F.2.6 NASA-STD-8739.5, “Fiber Optic Terminations, Cable Assemblies, and Installation”

F.2.7 NASA-STD-8739.7, “Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)”

F.3 Guidance

F.3.1 *ANSI/PMI 99-001-2004, A Guide to the Project Management Body of Knowledge*, 3rd Edition, (PMBOK Guide), 2004. Project Management Institute, Inc, Newtown Square, PA.

F.3.2 PMI, “Practice Standard for Project Configuration Management”, Project Management Institute, Inc, Newtown Square, PA

F.3.3 PMI, “Practice Standard for Earned Value Management”, Project Management Institute, Inc, Newtown Square, PA

F.3.4 PMI, “Practice Standard for Scheduling”, Project Management Institute, Inc, Newtown Square, PA

F.3.5 PMI, “Practice Standard for Work Breakdown Structures”, Project Management Institute, Inc, Newtown Square, PA

F.3.6 NASA Cost Estimating Handbook http://www.nasa.gov/offices/pae/organization/cost_analysis_division.html

F.3.7 CALIPSO Lessons Learned

F.3.8 NSTS 07700, "Program Definitions and Requirements, Volume XIV Shuttle Payload Accommodations"

F.3.9 NPD 8610.12, "Office of Space Operations (OSO) Space Transportation Services for NASA and NASA-Sponsored Payloads"

F.3.10 NPD 8020.7, "Biological Contamination Control for Outbound and Inbound Planetary Spacecraft

F.3.11 CxP 70017, "Constellation Probabilistic Risk Assessment Methodology"

F.3.12 CxP 70038, "Hazard Analysis Methodology"

F.3.13 CxP 70043, "Hardware Failure Modes and Effects Analysis and Critical Items List (FMEA/CIL) Methodology"

F.3.15 CxP 70055, "CxP Safety, Reliability and Quality Assurance Plan"

F.3.16 CxP 70059, "CxP Integrated Safety, Reliability & Quality Assurance Requirements"

F.3.17 CxP 70068, "CxP Problem Reporting, Analysis and Corrective Action Methodology"

F.3.18 Johnson Space Center (JSC) 09604/Marshall Space Flight Center (MSFC) HDBK-527, “Materials Selection List for Space Handbook Systems”