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Langley Research Center

Space Flight Project Practices Handbook

National Aeronautics and Space Administration

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Office of Primary Responsibility: 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 of NPR 7120.5, NASA Space Flight Program and Project Management Requirements. The SFPPH is also applicable as directed by the Langley Center Management Council (CMC) or by other organizations responsible for project execution.

P.3 AUTHORITY

a. NPD 7120.4, Program/Project Management.

P.4 APPLICABLE DOCUMENTS AND FORM

(See Appendix F)

P.5 MEASUREMENT/VERIFICATION

The project will track compliance with this LPR through a compliance matrix that is updated at the major project milestones (see Appendix B and Appendix D).

P.6 CANCELLATION

LPR 7120.5, dated January 9, 2009

Original signed on file
Virginia C. Wycoff
Acting Associate Director

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Table of Contents

1.0 Compliance Requirements 5

2.0 Introduction 6
2.1 Purpose 6
2.2 Criteria 6
2.3 Organization of the Practices 6
2.4 Where to Find the Requirements 7
2.5 Style and Format Conventions 7

3.0 Implementation 8
3.1 Customer Requirements Flowdown 8
3.2 Roles and Responsibilities 8

4.0 Changes and Waivers 12
4.1 Change Authority 12
4.2 Waiver Authority 12
4.3 Requesting Changes to This Document 12
4.4 Project Baseline 12

5.0 Management Practices 13
5.1 Life Cycle 13
5.2 Planning 15
5.3 Project Organization, Roles and Responsibilities, and Decision-Making 19
5.4 Work Breakdown Structure (WBS) 20
5.5 Testbeds, Models and Spares 21
5.6 Scheduling, Cost Estimating, Performance Assessment, and Control 23
5.7 Information Management (IM), Records Management (RM) & Configuration and Data Management (CDM) 27
5.8 Customer-Level Scope (Performance) Margin 28
5.9 Project Staffing and De-staffing 29
5.10 Project Priorities/Competing Characteristics 31
5.11 Acquisition and Surveillance 32
5.12 Project and Institutional Reporting 34
5.13 Reviews 35
5.14 Updating Plans and Replanning 37
5.15 Risk Management 39
5.16 Waivers 40
5.17 Engineering Science Data Management 41
5.18 External Communication 42
5.19 Public Engagement 43
5.20 Lessons Learned 43
5.21 Margins and Margin Management 44
5.22 Crisis Response 45

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

6.0 Engineering Practices 47
6.1 Telecommunication Design 47
6.2 Operations 47
6.3 Systems Engineering 51
6.4 Launch Services 54
6.5 Inheritance 55
6.6 Flight System Fault Tolerance/Redundancy 56
6.7 Materials, Processes, and Contamination Control 57
6.8 Software Development 58
6.9 Protection and Security of Flight Hardware 59
6.10 Design and Verification for Environmental Compatibility 61
6.11 Project and System Level Functional Verification and Validation 64
6.12 Orbital Debris 68
6.13 Hardware Development 69
6.14 Operations System (OS) Development 71

7.0 Safety and Mission Assurance Practices 72
7.1 Mission Assurance Management 72
7.2 Reliability Engineering 73
7.3 Electric, Electronic and Electromechanical (EEE) Parts Reliability & Application .. 75
7.4 Selection of Materials 76
7.5 Quality Assurance (QA) 77
7.6 Problem Reporting 84
7.7 System Safety 85
7.8 Software Assurance & Software IV&V 88

Appendix A: Definitions and Acronyms 90

Appendix B: Compliance with the Requirements of the Langley Space Flight Project Practices Handbook 96

Appendix C: Project Initiation Template 97

Appendix D: The Seven Principles of Earned Value Management 101

Appendix E: Elements of the Earned Value Management (EVM) Implementation Procedures 102

Appendix F: List of Referenced Requirements, Standards, and Guidance 105

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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 sections below, are for all space flight projects

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 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.

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2.0 Introduction

2.1 Purpose

The purposes of this document are:

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. 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.

d. To provide project managers with a clear and concise roadmap for project execution.

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:

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

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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 space flight projects must meet or request waivers 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 – Practices sections contain “Notes,” “Examples,” “Practices,” and “Requirements.”

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 is not required.

2.5 Style and Format Conventions

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

2.5.2 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.

2.5.3 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.

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

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3.0 Implementation

3.1 Customer Requirements Flowdown

All NASA space flight projects shall comply with NPR 7120.5, tailored as permissible per the LaRC 7120.5 tailoring tool, and each Center participating in a multi-Center Project follows its own Center procedures. Inter-Center agreements on applicable procedures are documented in an MOU. The word “customer” means either NASA Headquarters on an LaRC-led project; the lead Center on a multi-Center project led by another NASA Center; or reimbursable customer.

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 all elements of Project Planning and Control (PP&C)

d. Review and concur Project Plans with the concurrence of the Langley Office of the Chief Engineer (OCE) and other Center organizations.

e. Define the requirements and approve the Technical, Schedule, and Cost Control Plan.

f. Ensure that Langley’s space flight projects meet NASA requirements and comply with the requirements of this document.

g. Ensure effective project management, Project Planning, and Control (PP&C) for each project.

h. Regularly review each project and report to the CMC.

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

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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 Space Technology and Exploration Directorate (STED) will:

a. Represent Langley Research Center, Langley's Exploration projects, and Langley's supporting activities to our customers in the programs and projects of the Human Exploration and Operations Mission Directorate and Space Technology Mission Directorate.

b. Represent Langley Research Center, Langley's Space Technology projects, and Langley's supporting activities to our customers in the NASA Space Technology Program.

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 Core Resource Directorates (Engineering Directorate (ED), Research Directorate, Systems Analysis and Concepts Directorate, Center Operations Directorate (COD), 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.

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d. Define the requirements and approve technical control plans identified in the Project Plan.

3.2.7 The Langley Chief Engineer will:

a. Lead the overall Technical Authority process as defined in LPR 7120.4, “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 space flight projects.

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

e. Work with Project personnel to define the requirements and approve the Review Plan identified in the Project Plan.

f. Support dry runs and pre-reviews in advance of the CMC reviews and assist as requested in ensuring effective CMC reporting.

g. Manage the monthly Engineering Project and Task Reviews (EPTR).

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

a. Provide the Technical Authority (TA) to establish and oversee the SMA design processes, specifications, rules, best practices, etc., necessary to fulfill mission performance requirements.

b. Provide the Project with, safety and mission assurance support as required.

c. Define the requirements and approve the Safety and Mission Assurance Plan and other control plans identified in the Project Plan.

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

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

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

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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 the Project Plan.

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 the Project Plan.

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 (ITAR) and other export control laws and regulations.

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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 FPD shall chair the Change Control Board (CCB) 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 LMS Corrective, Preventive, and Improvement Action Tracking System (CAPTracs).

4.4 Project Baseline

The Project Plan documents the management baseline developed during formulation, to include the integrated set of requirements, cost, schedule, technical content, and the associated Joint Confidence Level (JCL). The Project Plan includes agreements and commitments among the project, program, customer, partners, and Langley management. The Project Plan baseline identifies the version of this document that is current at the time of approval.

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5.0 Management Practices

Management excellence for space flight projects is about using NASA, contractor, and partner resources efficiently to deliver high quality products and services that meet our 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 regularly used by the Center to make sure we bring to our space flight projects the best practices that experience and necessity have shown us so far.

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 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.

Projects may be competed or directed. Competed projects respond to a NASA solicitation. The proposal and selection process for competed projects replaces MCR and KDP-A.

Examples of Langley space flight projects include:

- TEMPO, a full, mission project under formulation at Langley for the Earth System Science Pathfinder Program Office.
- Launch Abort System Project, a sub-project within the Multi-Purpose Crew Vehicle Project of the Human Exploration and Operations Mission Directorate.

Practices

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.

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

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<u>Note:</u> *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.*

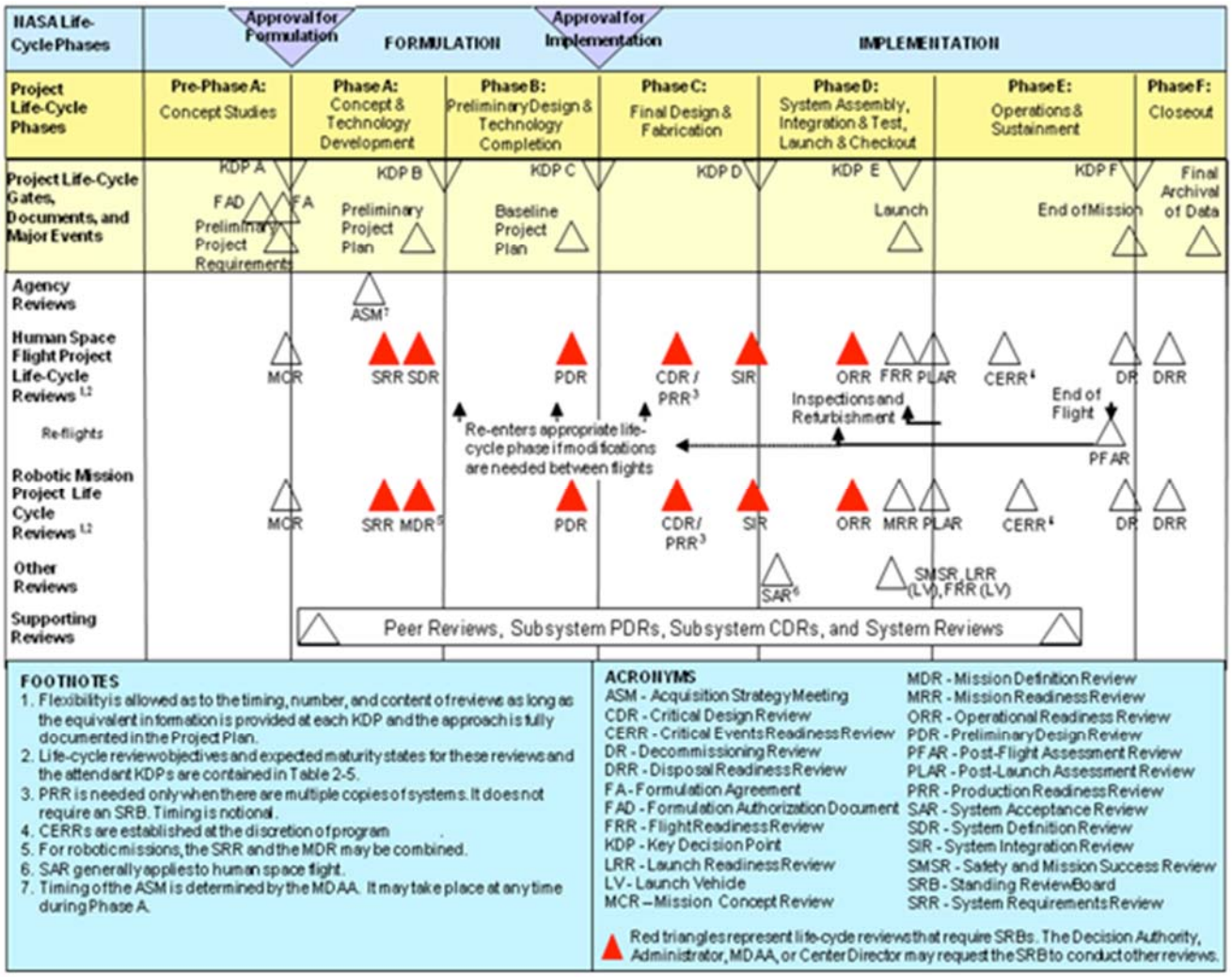

Figure 1. The life cycle of full projects is defined in NPR 7120.5

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Documents

Requirements

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

b. LPR 7510.1, Project Initiation and Proposal Procedural Requirements

5.2 Planning

Preamble

This Planning Practice focuses on the planning required from initiation through 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.

The Project Formulation Authorization Document (FAD) authorizes the project to initiate the planning of a new project. The Formulation Agreement is prepared by the project in response to the FAD to establish the technical and acquisition work that needs to be conducted during Formulation and defines the schedule and funding requirements during Phase A and Phase B for that work.

Project Proposal/Initiation Reviews

During the project proposal/initiation phase, four reviews are required of all projects: the Kick-off Meeting, the Bid/No Bid Gate, the Red Team Review, and the Center Commitment Review (CCR). The content, format, attendance, outcomes, and Decision Authority requirements for these reviews depends upon the Project's size, complexity, and value and is defined in LPR 7510.1.

Planning Documents

All projects at Langley prepare a Formulation Agreement at the start of Phase A as called for in NPR 7120.5, following the template in NPR 7120.5 Appendix F. This document is signed by the Langley Center Director and the Associate Administrator (AA) for the sponsoring Mission Directorate at NASA Headquarters

Projects also prepare a Project Plan during Phase A as called for in NPR 7120.5. The project plan content is tailored as permissible by NPR 7120.5 using the LaRC 7120.5 tailoring tool. This document is signed by the Langley Center Director and the Associate Administrator (AA) for the sponsoring Mission

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Directorate at NASA Headquarters for those Projects with LaRC as the lead NASA Center. For those projects where LaRC is a partner on a project with another lead NASA Center, the document is signed by Center management at LaRC and appropriate personnel at the lead NASA Center.

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 (IMS), if the Center approves the budget, and if the Project has reviewed and established the IMS as a baseline against which progress will be measured.

Practices

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

5.2.2 The Project shall complete the Project Initiation Reviews outlined in LPR 7510.1 and will have received approval from the Decision Authority to submit the Project for Project initiation.

After the mission selection announcement for competed missions, a formal Authorization to proceed for a directed project, or a LaRC agreement with another NASA Center to provide an element of their mission, 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,

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a. Projects will have negotiated a draft Formulation Agreement with the customer. At this stage, the Project Plan includes: the cost, schedule (including decision gates), reporting, and project deliverables (including performance requirements)

b. Projects will have documented a draft life cycle for the Project that is consistent with the draft Project 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 Planning Approval Official.

c. The Project will have established the content of its Project Plan. The contents will include all elements listed in Appendix G, Project Plan Template, of NPR 7120.5 unless tailoring has been negotiated with the owner of the plan's requirements, reviewed by the OCE, and approved by the Planning Approval Official. Any such tailoring is identified in the compliance matrix of the draft Formulation Agreement (see prior section). The compliance matrix will note required sections that are omitted for stated rationale as well as those that are judged inapplicable. A plan for maturing the Project control plans, through the draft life cycle, will be complete. Approved waived sections are to be included in the Project Plan's Part 4, Waivers or Deviations Log.

d. The Project will have baselined a detailed plan for accomplishing the work that gets the Project through the next Key Decision Point (or equivalent).

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

Note: *If the Project is small, there is no need for a 60-Day Review with the CMC may. In this case, the Planning Approval Official negotiates the waiver with the OCE, and the Center Director has the final decision.*

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

5.2.5 During Formulation, the Formulation Agreement includes plans for work through the next Key Decision Point. An updated Formulation Agreement including work through the next Phase is approved at each Key Decision Point. The Project will have completed the preliminary version of the Project Plan at MDR or SRR. At PDR, the Project will have completed the final Project Plan and baselined the detailed plan for Project implementation.

5.2.6 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:

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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.

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. (See Systems Engineering Best Practices Appendix to LPR 7123.1)

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.

5.2.7 Projects indicate planned compliance and non-compliance to the requirements of this document at the 60-Day review and at MCR, MDR or SDR, and PDR (see Appendix B).

5.2.8 Each Project submits its Project Plan to the identified review organizations for review and comment at least 30 calendar days in advance of the due dates.

5.2.9 Project Plans represent a commitment by the Langley Research Center and shall be reviewed and approved by an appropriate official For LaRC-led projects, the Langley approval signature is the Center Director. For other NASA Center led-projects, the Langley approval signature for the Project 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. (Requirement)

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

Requirements

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

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

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c. LPR 7120.7, Space Flight Independent Life Cycle Review Procedural Requirements

Guidance

a. Space Flight Project Practices Handbook (SFPPH) Appendix C, Project Initiation Template

b. SFPPH Appendix B, Compliance with the Requirements of the Langley Space Flight Project Practices Handbook

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

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 first the Formulation agreement (Phase A/B) and then Project Plan (Phase B onwards), 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 Space Technology and Exploration (STED) or the Science Directorate) have key roles in project planning and implementation and in the Project's relationship with their customer. Each Project documents its working relationship with the appropriate Product Unit in the Project 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 during formulation. Projects must be prepared

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to respond to these changes. See Section 5.15 of this document, Updating Plans and Replanning.

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 5.14, Updating Plans and Replanning

Guidance

5.4 Work Breakdown Structure (WBS)

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

5.4.1 Langley space flight 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 preparing 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 PDR, although breakdown to the work package level will continue as the Project advances into implementation.

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Documents

Requirements

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

Guidance

5.5 Testbeds, Models and Spares

Preamble

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

Practices

5.5.1 The Project documents the quantities of hardware models, simulations, and testbeds, and describes the model philosophy in Project Plan 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 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; ability to meet commitments in the Project 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.

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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 life cycle 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 Project Life-Cycle Logistics Support Policy, and develop and document an Integrated Logistic Support regimen that addresses, at a minimum, ground and flight systems hardware maintenance; supply support, including resupply and return; spares re-procurement; 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

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

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 to earn our customers' 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 affect cost, schedule, or quality of deliverables. Projects use objective measures of work performance and quality so progress and quality are visible and can be controlled.

Langley's space flight projects will change as customers' needs change, and annotated planning products developed during formulation can help make changes to the plan easy and reliable. In particular, Projects shall develop cost estimates in a way that makes them 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

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.*

Projects develop a detailed schedule package called the Integrated Master Schedule (IMS). The IMS contains task content, timelines, logic network, durations, work units and resource units. It is initially developed as part of the proposal for a project during project initiation and continues to be validated and managed throughout the Project's life cycle. LMS-CP-7154, LaRC Project Integrated Schedule Development, provides the LaRC processes that include paneled IMS Internal Schedule Reviews and Integrated Budget and Schedule Reviews.

a. Each Project produces a preliminary integrated schedule at the subsystem or equivalent levels (i.e., WBS Level 3) by SDR/MDR. The schedule is cost-and risk-informed.

b. Each Project baselines its cost-loaded IMS at PDR.

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c. Each Project includes in the IMS the required activities, including contractors' and supporting organizations' activities, to complete the project's objectives and meet customer commitments.

d. Projects shall include funded schedule margin along the critical path of the IMS. Guidance for funded schedule reserve margin that should be validated by assessment of implementation risk is:

- Formulation through subsystem development = 1 month margin per year
- System I&T through delivery to launch site (or storage) = 2 months margin per year
- Launch processing through mission completion = 1 month margin per year

Note: *High-risk items should be mitigated with additional margin and managed so that they stay off the critical path.*

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 reports schedule progress monthly to Langley management. Reporting format is provided in Pre-CMC and CMC guidance.

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 the Center represent a commitment by the Center even if explicitly labeled otherwise. For this reason, Projects must contact the OCFO for guidance as soon as the requirement to transmit a cost estimate is known.*
The FPDO shall review and approve and the OCFO review and concur with all cost estimates before transmitting them to the customer.

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 (BOE). These estimates (also known as "grass roots" or "bottom-up" 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 fidelity of the estimate increases at each Life Cycle Review. An initial estimate is

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developed for MCR for directed projects and for the original proposal for competed projects. The preliminary estimates (at the Control Account level or below) are completed prior to MDR or SDR. The baseline estimates (at the work package level) are completed prior to 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. The Project should include a subject matter expert review of the BOE for each CAM.

c. The Project shall include reserves in the cost estimate based on assessed implementation risk. The standard level of reserves is 30 percent at the time of (PDR), and a waiver is required for a smaller level of reserves in the cost estimate. The Center will not allow less than 15 percent reserves at the time of 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 MDR or SDR, each Category 1 and Category 2 (defined in NPR 7120.5) Project develops Cost Analysis Data Requirements (CADRes) to support independent cost analysis by NASA. Additional CADRes are required by 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. Each Category 1 and Category 2 (defined in NPR 7120.5) Project develops a Joint Confidence Level (JCL) estimate as specified in NPR 7120.5 at SDR or MDR and at PDR.

f. 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.

g. 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 its plan to monitor and control the Project’s requirements, technical performance, schedule and cost in Project Plan Section 3.1, Technical, Schedule, and Cost Control Plan, as designated by applicable policy, requirements, and authorizing documents.

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

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(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. See appendix F for LaRC best practices.

Note: *Langley's best practices for Earned Value Management are maintained by the FPD and supporting documents are maintained on the NASA Earned Value Management website http://evm.nasa.gov.*

d. Projects impose earned value reporting on cost-type contracts greater than $20M and conduct an Integrated Baseline Review (IBR) after contract award. Contractors provide earned value reports (in contractor format) on a regular basis. The contractor is required to have an EVMS that has been formally validated by the Government.

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.

g. A project implementing Earned Value Management generates an Estimate at Completion (EAC), analyzes variances monthly, 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 EAC 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.

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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. Integrated Baseline Review (IBR) Handbook, December 2009 (http://evm.nasa.gov/handbooks.html)

c. NASA Schedule Management Handbook, March, 2011 (http://evm.nasa.gov/handbooks)

d. NASA Work Breakdown Structure (WBS) Handbook, January 2010 (http://evm.nasa.gov/handbooks.html)

e. NASA EVM Implementation Handbook, NASA/SP-2012-599 (http:evm.nasa.gov/handbooks.html)

5.7 Information Management (IM), Records Management (RM) & Configuration and Data Management (CDM)

Preamble

Information management (**IM**) is the collection and management of information from one or more sources and the distribution of that information to one or more audiences. Projects create, acquire, and manage information of many types throughout the Project life cycle, including controlled documents, controlled records, and other recorded information in any format via the implementation of configuration and data management.

Configuration and Data Management (CDM) is the management discipline which, applied over a project's life-cycle, provides visibility into and ensures rigorous control of project configuration items and their characteristics identified for mission success. CDM is applied to project artifacts and products, whether those be documents, requirements, design and operations documentation, hardware and software. Project artifacts and products are the recorded information providing the evidence of the performance and fulfillment of NASA's mission and belong to the government, not to individuals.

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Records Management (RM) is the planning, controlling, directing, organizing, training, promoting, and other managerial activities related to creating, maintaining, using, and disposing of records to achieve adequate and proper documentation of Federal policies and transactions and effective and economical management of Agency operations. (Also called records administration)

Practices

5.7.1 Each project is responsible for imposing the requirements and the management practices for information management, records management and configuration and data management in accordance with requirement, procedural, and guidance documents identified below on the project team, contractors and suppliers to support collaboration and meet customer requirements.

5.7.2 Each project is 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.

Documents

Requirements

a. NPR 2190.1, NASA Export Control Program

b. NPR 7123.1, NASA Systems Engineering Processes and Requirements

c. LAPD 1440.7, Langley Research Center (LaRC) Records Management

d. LPR 7600.1, Closeout Photographs for Flight and Ground Hardware Procedural Requirements

e. LPR 7150.2, LaRC Software Engineering Requirements

Procedures

a. LMS-CP-8041, Flight Projects Directorate Master Configuration and Data Management Plan

Guidance

a. NASA-STD-005, NASA Configuration Management (CM) Standard

5.8 Customer-Level Scope (Performance) Margin

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Preamble

Project Level 1 Requirements (Program Level Requirements Agreement (PLRA)) define Baseline and Threshold performance requirements. The difference between the Baseline and Threshold performance levels can be called scope margin. 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

5.8.1 Each Project develops a descope plan, which is included in the Formulation Agreement and later in the Project Plan and reviewed at MDR/SDR and later at PDR.

5.8.2 Scope margin, in general, is part of the Project risk trade space, but customer-level descopes require customer approval.

5.8.3 Projects negotiate the customer-level requirements with the customer as part of the PLRA, and establish a baseline by MDR/SDR.

Documents

Requirements

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

Guidance

5.9 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, the participating organizations at the Center, and the partners. Specific work can also be contracted. Projects should remember that contractor employees cannot

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be supervised or controlled by government employees since this constitutes personal services and is a violation of Federal law and regulations.

Practices

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

5.9.2 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, Engineering Directorate (ED), Research Directorate (RD), System Analysis and Concepts Directorate (SACD), and other organizations to identify people at the Center to staff the Project.

5.9.3 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.

5.9.4 Staffing the core team falls on the critical path for a 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
(9) Risk Manager
(10) Office of Chief Council attorney

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

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

5.9.5 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.

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

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

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

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

5.9.10 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.

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

a. Project Manager
b. Project Chief Engineer

Documents

Requirements

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

Guidance

5.10 Project Priorities/Competing Characteristics

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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 (SFPPH and other requirement-type documents) on projects to ensure prudent risk-taking.

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

Practices

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

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

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

Documents

None

5.11 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

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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. Sample procurement packages are available from the Office of Procurement and in the FPD NX collection.

Practices

5.11.1 During the first 60 days, each Project develops a reference acquisition plan that includes all components of its deliverables. If procurements are anticipated, 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 are needed to prepare for and execute procurements. Standard procurement lead times are shown in LMS-OP-4508, Milestones and Leadtimes.*

5.11.2 Each Project that plans to have significant acquisition activities develops an acquisition and surveillance plan that is documented in the Project Plan Section 3.4, Acquisition Plan.

5.11.3 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 OCIs before contract or task/delivery/purchase order award. OCIs 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.

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 essential to consider OCI implications for all organizations before they begin to participate in the project.*

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

5.11.5 Projects prepare procurement requirements packages, including, as applicable, statement of work (SOW), delivery schedule or period of performance, specification(s), planned Langley oversight of the contractor and second 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.

5.11.6 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 for procurement acquisitions. The Project documents the plan for in-house development and non-procurement acquisitions in Project Plan 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.

5.11.7 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

5.12 Project and Institutional Reporting

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Preamble

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

Practices

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

5.12.2 Following the 60-Day Review, each Project reports: 1) on technical matters to the Engineering Project and Task Review, 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 CMC.

5.12.3 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 for NASA to be able to commit to launch. During the launch campaign, the Project provides daily reports to its Langley stakeholders.

Documents

Requirements

a. LPR 7130, Project and Task Review Procedural Requirements

5.13 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 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.

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Practices

5.13.1 Each Project develops a Project Review Plan in accordance with the requirements of NPR 7120.5 and LPR 7130. The Project Review Plan includes reviews required by the customer. At MCR for directed missions, or after proposal selection for competed missions, each Project submits to FPD and then Langley OCE a reference list of key deliverables and identifies that 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 what type of review (e.g., agency Standing Review Board, Langley independent review board, engineering review) should precede the milestones. FPD works with the Center Chief Engineer to complete a recommended review plan for the CMC. The Project documents the approved review plan in the Formulation Agreement and then the Project Plan Section 3.8, Review Plan.

a. At the end of Project initiation, the Project Manager presents the 60-Day Review to the Langley CMC. 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 MCR, MDR/SDR, and PDR, 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 Formulation Agreement or the Project Plan (as appropriate), and current schedule, budget and workforce plans. The OCE, OCFO, RD, SACD, ED, 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.

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5.13.2 Although the list of deliverables and the review plan for the deliverables will be baselined at PDR, 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

Guidance:

a. NPR 7120.5, NASA Space Flight Program and Project Management Requirements
b. NPR 7123.1, NASA Systems Engineering Processes and Requirements
c. LPR 7130, Project and Task Review Procedural Requirements
d. LPR 7120.7, Space Flight Independent Life Cycle Review Procedural Requirements

5.14 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. Formal rebaselines after KDP-C require customer approval and a rebaseline review. 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

5.14.1 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 IMS 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 Formulation Agreement or Project Plan (as appropriate) at least once per year as part of the annual budget process.

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FPD will lead a Center management review of the updated plan. The Project's Planning Approval Official approves the updated Project Plan.

5.14.2 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 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 participants in the change process.

5.14.3 For small changes to the Project scope or schedule, a revision to the plans can be handled as an increment with respect to the baseline plan. The Project, with the concurrence of the appropriate FPD Project Office and the FPD Deputy Director for Project Planning and Control, 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 rebaselining is required.

5.14.4 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.

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5.14.5 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 obtains Center concurrence and customer approval for the termination plans.

Documents

None

5.15 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.

Practices

5.15.1 Each Project documents the risk management objectives and approach over the Project life cycle in the Formulation Agreement or Project Plan (as appropriate) Section 3.3, Risk Management Plan.

5.15.2 Each Project tracks risks, including mitigation activities and status, in the project risk register. Tools are determined by the Project, unless directed by the customer.

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

5.15.3 Each Project reports status of top project risks monthly to Center management at Pre-CMC and CMC. Reporting format may be directed by customer.

5.15.4 Each Project follows the principles of Continuous Risk Management (CRM), as prescribed in NPR 8000.4.

5.15.5 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, Agency Risk Management Procedural Requirements

Guidance

a. NASA Risk Management Handbook, NASA/SP-2011-3422

5.16 Waivers

Preamble

The scope of Section 5.16 applies to NASA requirements, institutional requirements including those of this handbook (the SFPPH) and to Project generated requirements.

Practices

5.16.1 For waivers to the requirements in this SFPPH, 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 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 SFPPH through the use of the SFPPH Compliance Matrix.

5.16.2 For waivers to other Center requirements documented in the LMS, each Project will seek approval through processes defined in LMS-CP-7151

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

5.16.3 For waivers to NASA requirements, such as NPR 7120.5, each Project will submit change requests through the OCE.

a. Change requests will be submitted for disposition to the office responsible for the document and shall be copied to the SMA TA for risk review.

b. Approval authorities for Project waiver requests will consist of the Program Manager, the Center Director, the Mission Directorate Associate Administrator (MDAA), and the Chief Engineer.

c. Waivers due to non-applicable requirements can be approved by the project level TA.

d. Waivers to NPR 7120.5 requirements are to be documented in the Project Plan's Part 4, "Waivers or Deviations Log."

e. The Project will maintain retrievable Project documentation of waivers to other prescribed requirements.

Documents

Requirements

a. LMS-CP-7151, Obtaining Waivers for Langley Management System (LMS) Requirements

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

Guidance

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

5.17 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.

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Practices

5.17.1 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 Project Plan Section 3.12, Engineering Science Data Management Plan.

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

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

Documents

None

5.18 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

5.18.1 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, the Center Chief Engineer, 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 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

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

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

Documents

None

5.19 Public Engagement

Practices

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

a. Langley's Office of Communications develops the Communication Plan for each Project that needs one. The Office of Communications ensures proper coordination with the Project's customer.

Documents

Guidance

None

5.20 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

5.20.1 Starting early and throughout the entire life cycle, each Project has its SMAO manager search the NASA Lessons Learned Information System 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.*

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

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5.20.3 At the end of each Project, the Project conducts a final Lessons Learned Review activity. The Project publishes a final report on lessons learned.

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

Documents

Requirements

a. LPR 7120.6, Lessons Learned Process for Sustained Process Improvements

Guidance

a. CALIPSO Lessons Learned
b. ARES 1X Lessons Learned

5.21 Margins and Margin Management

Preamble

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

Practices

5.21.1 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 (SEMP).

b. Each Project describes the programmatic margins management approach in the Formulation Agreement or Project Plan 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 the Project assesses to be critical to mission success.

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

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

Documents

None

5.22 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:

a. Loss of life or life-threatening personal injury.

b. Damage to equipment or facilities that would likely jeopardize mission success or delay the ability of the project to meet its launch commitment.

c. Significant public controversy resulting in opposition to the mission.

d. Potential for significant NASA liability.

Practices

5.22.1 Projects shall 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.

5.22.2 Each project shall prepare and maintain 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.

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

5.22.3 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.

5.22.4 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

f. Director FPD

g. Cognizant line management

h. Project Chief Engineer

i. Media Relations point of contact

j. Project Contracting Officer

k. Office of Chief Counsel

l. 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

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

6.0 Engineering Practices

6.1 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

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

6.1.2 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.

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

6.1.4 Projects secure authorization for use of the telecommunications spectrum.

Documents

Requirements

a. LPR 2570.5, Radio Frequency Spectrum Management

Guidance/Additional Information

a. LPR 7123.1, LaRC Systems Engineering Processes and Requirements, Appendix G, Engineering Best Practices

6.2 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

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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

6.2.1 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 identifies and documents flight rules and constraints, which include 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.

6.2.2 Process and Procedure

a. 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.*

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

c. 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.

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

6.2.3 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.

6.2.4 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.

6.2.5 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.

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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 Non-conformance/Failure Reports (NFRs) and analyses.

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Documents

Guidance/Additional Information

a. LPR 7123.1, LaRC Systems Engineering Processes and Requirements, Appendix G, Engineering Best Practices

6.3 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.

Practices

6.3.1 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.

6.3.2 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.

d. Flight system / ground system trade studies.

e. Operability / Maintainability.

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6.3.3 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.

6.3.4 The requirements are captured to allow project-wide accessibility and traceability.

6.3.5 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.

6.3.6 Projects establish nomenclature and conventions 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).

6.3.7 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.

6.3.8 Each project prepares an SEMP.

6.3.9 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.

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c. Technical capabilities and margins.

d. Available budgets.

e. Schedule reserves.

6.3.10 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.

6.3.11 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.

6.3.12 Projects develop flight system and operations system (OS) 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 OS, and vice versa.

6.3.13 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. NPR 7123.1, NASA Systems Engineering Processes and Requirements

b. LPR 7123.1, LaRC Systems Engineering Processes and Requirements

Guidance

a. NPR 7123.1, Appendix D, Systems Engineering Management Plan

6.4 Launch Services

Preamble

This practice applies to all flight projects for which Langley has project management responsibility. 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:

a. Acquiring expendable launch vehicles (ELV) and the attendant launch services.

b. Processing payloads at launch sites.

Practices (Compliance is mandatory)

6.4.1 Projects use the NASA Launch Services Program (LSP) 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 LSP and project), the LSP hands the launch service acquisition activities over to the project's launch vehicle integration engineer.

6.4.2 Projects planning to launch from the U.S. use either an ELV procured through the LSP acquisition process, or an ISS resupply launch.

6.4.3 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 Kennedy Space Center (KSC) (for launches using ELVs) and from Johnson Space Center (JSC) (for launches to the ISS) during the formulation phase.

6.4.4 The Project will designate a launch vehicle integration engineer as the single point of contact for coordinating launch vehicle integration activities among the

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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 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 8610.12G, "Human Exploration and Operation Mission Directorate (HEOMD) Space Transportation Services for NASA and NASA-Sponsored Payloads"

6.5 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)

6.5.1 Prior to using inherited designs, hardware, software, and ground support equipment (GSE), the project evaluates the benefits in comparison with the associated risks and LCCs.

6.5.2 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.

6.5.3 Projects conduct inheritance reviews for inherited designs, hardware, software, and GSE as early as practical in the formulation phase.

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

Documents

None

6.6 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)

6.6.1 Each project defines the required level of flight system fault tolerance and the use of redundancy and cross strapping prior to PDR, 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 (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.

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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. NPR 7123.1, NASA Systems Engineering Processes and Requirements

6.7 Materials, Processes, and Contamination Control

Practices

6.7.1 Projects select, apply, and use materials and processes that meet project requirements for both flight equipment and GSE.

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

6.7.3 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.

6.7.4 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.

6.7.5 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 (CCP).

6.7.6 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.

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

Documents

Requirements

a. LPR 1710.12, Potentially Hazardous Materials – Hazard Communication Standard

Guidance/Additional Information

a. LPR 7123.1, LaRC Systems Engineering Processes and Requirements, Appendix G, Engineering Best Practices

6.8 Software Development

Practices (Compliance is mandatory)

6.8.1 Each project has an individual (or individuals) 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 (QA) activities, and reporting software status at project periodic status reviews.

6.8.2 Projects will classify and baseline by Milestone B (SDR) all software to be developed, acquired, or incorporated into Langley-accountable products per LPR 7150.2.

6.8.3 Development, Maintenance and Acquisition Practices

a. Projects develop and maintain, or acquire, software consistent with the determined software classification per LPR 7150.2.

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. NPR 7150.2, NASA Software Engineering Requirements

b. LPR 7150.2, LaRC Software Engineering Requirements

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

6.9 Protection and Security of Flight Hardware

Practices

6.9.1 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.

6.9.2 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 QA organization, or in a controlled access facility such as for system assembly or launch processing.

6.9.3 All facilities intended for processing, operationing, 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.

6.9.4 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.

6.9.5 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 and that the test parameters and alarm limits are understood.
(3) Confirms that there are suitable environmental test facility, safety provisions, test personnel, and QA coverage.

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

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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.

6.9.6 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.

6.9.7 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.

6.9.8 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.*
- *Pathfinding the operation(s) using non-flight hardware model(s).*

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

6.9.9 Unattended Operation of Flight Hardware

a. Prior to the delivery of flight-configured items to system integration, the project manager shall approve any unattended operational procedures and related risk assessments.

b. After the delivery of flight-configured items to system integration, the project manager shall submit any unattended operational procedures and related risk assessments to the Director of FPD for approval.

Documents

Guidance/Additional Information:

a. LMS-CP-4756, Handling, Preservation, Storage, and Shipping of Space Flight Hardware and Ground Support Equipment

b. LMS-CP-4759, Acquisition of Hazardous Materials

c. NASA-STD-8739.21, Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)

6.10 Design and Verification for Environmental Compatibility

Practices

6.10.1 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.

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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 electromagnetic interference/compatibility (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, 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.*

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6.10.2 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.

6.10.3 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.

6.10.4 Post-Test Documentation

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

6.10.5 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, expected functional performance, or any loss of calibration to determine if the test objectives and requirements have been satisfied.

6.10.6 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.

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

6.10.7 Reporting

a. 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

Guidance/Additional Information

a. LPR 7123.1, LaRC Systems Engineering Processes and Requirements, Appendix G, Engineering Best Practices

6.11 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.

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Practices

6.11.1 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 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 V&V 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 testing.

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.

6.11.2 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

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introduced, e.g., in verifying the integrity of flight system autonomous fault protection, and OS 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 V&V 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 V&V 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.

6.11.3 Re-verification

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

6.11.4 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.

6.11.5 Documentation

a. Projects maintain records of the verification and validation activity to demonstrate compliance with V&V plans and requirements per LAPD 1440.7.

b. Projects document design idiosyncrasies found during testing, 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).

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6.11.6 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.

6.11.7 Certification

a. Certification of Flight Readiness. Each project prepares the Certificate of Flight Readiness (CoFR), attesting to the integrity and completeness of 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. Each project prepares the Certificate of Critical Event Readiness (CoCER), attesting to the integrity and completeness of 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.

6.11.8 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. NPR 7120.5, NASA Program and Project Management Processes and Requirements

b. NPR 7123.1, NASA Systems Engineering Processes and Requirements

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Guidance/Additional Information

a. LPR 7123.1, LaRC Systems Engineering Processes and Requirements, Appendix G, Engineering Best Practices

6.12 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 in accordance with NASA guidelines.

Practices (Compliance is mandatory)

6.12.1 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.

6.12.2 Projects support compliance assessment efforts by doing the following:

a. Supplying information relating to the project and the flight system design.

b. Validating (prior to their submission) the results of, including the assumptions used in, the orbital debris limiting assessments.

6.12.3 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.

c. A decommissioning plan for earth orbiting hardware not later than 9 months prior to EOM.

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6.12.4 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.

6.12.5 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).

c. A final functional design implementation is presented at the corresponding CDR.

6.12.6 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. NPR 7120.5, NASA Program and Project Management Requirements

b. NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris

Guidance

a. NASA-STD-8719.14, Process for Limiting Orbital Debris

6.13 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

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system integration and testing 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

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

6.13.2 Projects submit hardware designs to independent technical review.

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

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

6.13.4 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.*

6.13.5 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.

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

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

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Documents

Requirements

a. NPR 7123.1, NASA Systems Engineering Processes and Requirements

b. LPR 7320.1, Engineering Drawing System

6.14 Operations System (OS) Development

Preamble

OS development includes development of the GDS.

Practices

6.14.1 Each project develops a preliminary Operations Concept prior to the start of phase B. The Operations Concept is approved prior to PDR.

6.14.2 Projects develop system requirements on the OS and GDS that are documented and approved prior to PDR.

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

6.14.4 Each project produces a GDS Software Management Plan, either incorporated into the project level plan or left as a standalone plan. All GDS software (including institutionally and externally supplied components) is evaluated for mission criticality and categorized accordingly.

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

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

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

6.14.8 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.

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

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Documents

None

7.0 Safety and Mission Assurance Practices

Safety and Mission Assurance practices apply for all space flight projects and a wide range of other projects. Traditional space flight projects that require S&MA support include atmospheric science instruments and missions, 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 unmanned aerial vehicular (UAV) operations.

7.1 Mission Assurance Management

Practices (Compliance is mandatory)

7.1.1 Projects engage the 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 QA requirements are identified and incorporated in the Procurement Strategy Meeting presentation documents, other memoranda, and 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.

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.

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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 (QA)
(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 testing, for:

a. Flight hardware.

b. All hardware that interfaces directly with flight hardware.

c. Flight and mission critical ground software.

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

7.2 Reliability Engineering

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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 (FTA) 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 as defined in NPR 7120.5, “NASA Program and Project Management Processes and Requirements,” (i.e., LCC>$1B or significant radioactive material or human space flight).

b. NASA payloads with risk classification “A.”

c. Any other program or project determined by the program manager to meet the criteria of Priority Ranking I programs/projects as defined in NPR 8715.3, “NASA General Safety Program Requirements.”

d. Each project using PRA.

(1) follows NPR 8705.5, Technical Probabilistic Risk Assessment (PRA) Procedures for Safety and Mission Success for NASA Programs and Projects.

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Documents

Requirements

a. LPR 5300.1, Product Assurance Plan, Chapter 5

Guidance

a. NPR 8000.4, Agency Risk Management Procedural Requirements, Fault Tree Handbook with Aerospace Applications
b. JPL D-17868, JPL Guideline: Design, Verification/Validation and Operations Principles for Flight Systems
c. NASA/SP-2011-3421, Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners

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 Development 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 its 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.

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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 Development 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, the following may be used for guidance in determination of material usage:*

a) ASTM E595, Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

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b) *MSFC-STD-506C, Standard Materials and Processes Control*
c) *MSFC-STD-3029, Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments*
d) *NHB 8060.1, Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion*
e) *Materials and Processes Technical Information System (MAPTIS - http://maptis.nasa.gov/home.aspx)*
    1) *Provides a single-point source for materials properties*
    2) *Contains physical, mechanical, and environmental properties for metallic and non-metallic materials*
f) *JPL NASA Materials and Processes (M&P) (http://ndeaa.jpl.nasa.gov/nasa-mp/1-2-4pl.htm*

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.

<u>Documents</u>

Requirements

a. LPR 5300.1, Product Assurance Plan, Chapter 6

Guidance

7.5 Quality Assurance (QA)

<u>Practices (Compliance is mandatory)</u>

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

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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 with 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 supported by records evidencing their performance and outcome.

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

7.5.3 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 QA 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 QA 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.

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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. See section 5.7

7.5.9 In support of fabrication, assembly, inspection, and test activities, Projects use only 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 Langley Form (LF) 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. LF 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. 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.

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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, Workmanship Standard for Polymeric Application on Electronic Assemblies

b. NASA-STD-8739.2, Surface Mount Technology

c. NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring

d. NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation

e. NASA-STD-8739.6, Implementation Requirements for NASA Workmanship Standards

f. NASA-HDBK 8739.21, Workmanship Manual for Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)

g. IPC J-STD-001ES, Space Applications Electronic Hardware Addendum to IPC J-STD-001E Requirements for Soldered Electrical and Electronic Assemblies

Note: 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. 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 QA personnel by number. Every stamped impression is to be accompanied by a handwritten date. QSS are required to meet the specific

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criteria, application, procedures, issuance and control detailed in Chapter 7.9 of LPR 5300.1.

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 QA 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 ensures logbooks are kept current by the Project.

7.5.20 Projects assemble and disassemble all space hardware and associated GSE 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.

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.

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 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-8739.21, Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices).

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7.5.24 Projects develop a 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 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, workstations, 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 a lift involving special high cost 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, that 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 System 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)

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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 in the handling, preservation, and shipping of space flight hardware. Projects also follow applicable requirements of LMS-CP-4759 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. NASA-STD-8739.1, Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies

b. NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring

c. NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation

d. NASA-STD-8739.6, Implementation Requirements for NASA Workmanship Standards

e. NASA-STD-8739.21, Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)

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f. LPR 1740.2, Facility Safety Requirements

g. LPR 5300.1, Product Assurance Plan, Chapter 7

h. IPC J-STD-001ES, Space Applications Electronic Hardware Addendum to IPC J-STD-001E Requirements for Soldered Electrical and Electronic Assemblies

Guidance

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.

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

b. 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 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 QA representative, and the Project Manager or Project Management designee. The QA 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 QA representative has

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

7.6.3 To close an NFR, Projects complete all quality actions and dispositions and obtain verification from the designated QA 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 IDP.

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

b. LMS CP-8041, Master Configuration and Data Management Plan

Requirements

a. LPR 5300.1, Product Assurance Plan, Chapter 7.8

Guidance

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:

a. ELV payloads

b. International Space Station experiments

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

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meant to convey the content. Various 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 SSPs to the Mission Assurance Branch for approval.

> ***Note***: *Separate SSPs may be required for each flight project by the integrating organization, rather than 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 (SCDP) 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. FSAs 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

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e. Method of verification of the control(s)

f. Current status of the hazard control and verification

Note: *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 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. FSA

f. GSA

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. ELV payloads generally require

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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. NASA-STD-8719.13B, Software Safety Standard

7.8 Software Assurance & Software IV&V

Preamble

NASA has determined that 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 For 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 sets 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.*

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7.8.3 Each Project arranges for software assurance verification of the software traceability matrix to ensure requirements are correctly applied and 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 System Requirements Review (SRR).

b. Assessment of the baselined software development process and associated work products prior to 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-4754, Software Assurance (SA) for Development and Acquisition

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

Requirements

a. LPR 5300.1, Product Assurance Plan, Chapter 7.3

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Appendix A: Definitions and Acronyms

	Item	Definition
A.1	AA	Associate Administrator
A.2	ASIC	Application-Specific Integrated Circuit
A.3	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.4	Baseline a plan	1) Obtain the commitment of the performing organizations to constituent plans and to the Integrated Master Schedule (IMS), 2) Obtain the Center's approval of the budget, and 3) Establish an independently reviewed Integrated Master Schedule (IMS) as a baseline against which progress will be measured.
A.5	Benchmarking	Continual improvement activity of evaluating processes in relation to best practices.
A.6	BOE	Basis of Estimate
A.7	CADRe	Cost Analysis Data Requirements. Used to report information about the full cost of the project.
A.8	CAM	Control Account Manager--see definition of Control Account
A.9	CAPTracs	Langley Management System's Corrective, Preventive, and Improvement Action Tracking System
A.10	Category 1, Category 2 projects	Generally having a life cycle cost (LCC) greater than $250M, although priority can raise lower-cost projects up to one of the higher categories. Defined in NPR 7120.5D.
A.11	CCB	Change Control Board
A.12	CCP	Contamination Control Plan
A.13	CCR	Center Commitment Review
A.14	CDR	Critical Design Review
A.15	CM	Configuration Management
A.16	CMC	Center Management Council--a monthly review of project progress, problems, and plans
A.17	COD	Center Operations Directorate
A.18	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 (OBS). See the definition in PMBOK.
A.19	Critical events	In mission operations, events that if not executed properly and in a timely manner could result in failure to achieve mission success

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	Item	Definition
A.20	Customer	In general, any individual or organization who will use the project's products. In this Handbook, references to "the customer" generally mean the program or project element that has asked Langley to produce project products.
A.21	EDL	Entry, Descent, and Landing
A.22	EEE parts	Electric, Electronic, and Electromechanical parts
A.23	ELV	Expendable Launch Vehicle
A.24	EMI/EMC	Electromagnetic Interference, Electromagnetic Compatibility
A.25	Encumbrance	An expense not originally accounted for that must certainly be paid.
A.26	Engineering organizations	Engineering Directorate (ED), Research Directorate (RD), Systems Analysis and Concepts Directorate (SACD), and Center Operations Directorate (COD)
A.27	EOM	End of Mission
A.28	ESD	Electrostatic Discharge
A.29	ESOD	Exploration and Space Operations Directorate
A.30	Estimate at Completion	An EVM estimate of the total cost of the project when it is completed. See definition and discussion in PMBOK.
A.31	ETR	Eastern Test Range
A.32	EVMS	Earned Value Management System
A.33	Exploration Project	Langley-specific term for sub-projects of the NASA Constellation Program that are conducted at Langley
A.34	FIOS	Fabrication and Inspection Operations Sheet
A.35	FMEA	Failure Modes and Effects Analysis
A.36	FPD	Flight Projects Directorate
A.37	FPGA	Field Programmable Gate Array
A.38	FSA	Flight Safety Analysis
A.39	FTA	Fault Tree Analysis
A.40	FWR	Fabrication Work Request
A.41	GDS	Ground Data System
A.42	GIDEP	Government Industry Data Exchange Program, a source for alerts about bad or questionable electronics parts
A.43	GSA	Ground Safety Analysis
A.44	GSE	Ground Support Equipment
A.45	IBR	Integrated Baseline Review

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	Item	Definition
A.46	ID Number	Identification Number
A.47	IDP	Integrated Data Package
A.48	IMS	Integrated Master Schedule--see definition
A.49	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.50	Integrated Master Schedule (IMS)	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.51	IT	Information Technology
A.52	ITAR	International Traffic in Arms Regulations
A.53	ITP	Integrated Test Plan
A.54	IV&V	Independent Verification and Validation
A.55	JCL	Joint Confidence Level (1)The probability that cost will be equal to or less than the targeted cost and that the schedule will meet or be sooner than the targeted schedule dates. (2) A process and product that helps inform management of the likelihood of a project's programmatic success. (3) A process that combines a project's cost, schedule, and risk into a complete picture. JCL is not a specific methodology or a product from a specific tool.
A.55	JSC	Johnson Space Center
A.56	KSC	Kennedy Space Center
A.57	LCC	Life Cycle Cost
A.58	Lien	An expense not originally accounted for that is not certain, but which has at least a 10 percent chance that it will have to be paid.
A.59	LMS	Langley Management System. A repository of Langley management documentation found at: https://lms.larc.nasa.gov
A.60	LSSM	NASA Launch Site Support Manager
A.61	MCR	Mission Concept Review. Normally at the end of Concept Studies phase.
A.62	MDAA	Mission Directorate Associate Administrator
A.63	Milestone A	Project Maturity Milestone A, corresponds to Key Decision Point A, nominally at the end of the Concept Studies phase (Mission Concept Review (MCR))

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	Item	Definition
A.64	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.65	Milestone C	Project Maturity Milestone C, corresponds to Key Decision Point C at the end of the Preliminary Design and Technology Completion phase (Preliminary Design Review)
A.66	MCM	Multi-Chip Module
A.67	MOS	Mission Operations System
A.68	MRB	Material Review Board
A.69	MSFC	Marshall Space Flight Center
A.70	MUA	Material Usage Agreement
A.71	NFR	Non-conformance/Failure Report
A.72	NLS	NASA Launch Services
A.73	NX	A Langley repository system used for ESOD and FD configuration and document management
A.74	OBS	Organizational Breakdown Structure--see definition
A.75	OCFO	Office of Chief Financial Officer
A.76	OCI	Organizational conflict of interest
A.77	OP	Office of Procurement
A.78	Organizational Breakdown Structure (OBS)	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.79	ORT	Operations Readiness Test
A.80	OS	Operations system
A.81	OSO	Office of Space Operations
A.82	PDR	Preliminary Design Review
A.83	PICM	Project Information and Configuration Management (also referred to as Information and Configuration Management: in NID to NPR 7120.5D “NASA Space Flight Program and Project Management Requirements”) and Configuration and Data Management (CDM)
A.84	PIP	Project Implementation Plan
A.85	Planning Approval Official	The Director of FPD, unless it is delegated

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	Item	Definition
A.86	PMBOK	Project Management Body of Knowledge, Project Management Institute, an ANSI standard (*ANSI/PMI 99-001-2004)* for Project Management
A.87	PMP	Project Management Plan
A.88	Pre-CMC	Monthly review of project progress, problems, and plans by FPD, generally the week before projects present to the CMC
A.89	PP&C	Project Planning and Control
A.90	PRA	Probabilistic risk assessment
A.91	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.92	Project Maturity Milestone A	Corresponds to Mission Concept Review (MCR)
A.93	Project Maturity Milestone B	Corresponds to System Definition Review
A.94	Project Maturity Milestone C	Corresponds to Preliminary Design Review
A.95	QA	Quality Assurance
A.96	QSS	Quality Status Stamps
A.97	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.98	RF	Radio Frequency
A.99	RFP	Request for Proposal
A.100	RD	Research Directorate
A.101	SACD	System Analysis and Concepts Directorate
A.102	SAP	Software Assurance Plan
A.103	SAR	System Acceptance Review
A.104	SCDP	Safety Compliance Data Package
A.105	SDR	System Definition Review. Normally at the end of Concept Definition phase.
A.106	SEE	Single Event Effect
A.107	SEMP	Systems Engineering Management Plan
A.108	SN Number	Serial Number

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	Item	Definition
A.109	SSP	System Safety Plan
A.110	SED	Systems Engineering Directorate
A.111	SFPPH	Space Flight Project Practices Handbook
A.112	SMAO	Safety and Mission Assurance Office
A.113	Software Class	Classification of software by complexity; Defined in NPR 7130.2, Appendix B
A.114	SOW	A contract or RFP Statement of Work
A.115	STS	Space Transportation System (Shuttle)
A.116	SRR	System Requirements Review
A.117	TA	Technical Authority
A.118	TID	Total Ionizing Dose
A.119	VAFB	Vandenberg Air Force Base
A.120	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.121	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.122	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.
A.123	WTR	Western Test Range

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

B.1 NPR 7120.5 compliance

Projects shall demonstrate compliance with this document through a completed NPR 7120.5 compliance matrix and a completed LPR 7120.5 tailoring tool matrix.

B.2 Additional Compliance

Projects shall generate an additional compliance matrix showing compliance with the specific requirements in the seven paragraphs below:

5..1, Planning and Project Initiation, LPR 7510.1 reviews
5.2.1, 60-day review
5.6.1, Funded schedule margin
5.6.1, Cost estimating, FPDO cost estimate review, and approval
5.6.2, Cost Reserves
5.22, Crisis Reporting
5.22.1, Crisis Management Plan

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Appendix C: 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 of identifying the Project Manager.

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. Project Office with collocated Project Team is established.
f. 60-day review (t = 8 weeks, 4 days)

C.1.5 A template for the 60-Day Review is available from the Flight Projects Directorate (FPD). 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

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C.2.2 Second wave – to be complete by the end of week 4.

a. Lead Subsystems Engineers
b. Integration and Test Manager
c. Risk Manager

C.2.3 Team meetings

a. Project initiation is a period of rapid change. 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, Risk Manager, 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 Schedule (IMS).
j. Reference Organizational Breakdown Structure (OBS).
k. Reference map of OBS to WBS, identifying Control Account Manager (CAM) points (names not needed).
l. Reference cost estimate, including Basis of Estimate (BOE).
m. Reference funding profile.
n. 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. Project Team is collocated or a location has been identified.

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

C.3.3 Set up Earned Value Management System (EVMS)

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
d. Send a weekly e-mail to the Center Director and other Center leaders, if appropriate.

C.5 Timeline

C.5.1 Put first wave team in place (by end of week 2)

C.5.2 Define deliverables (by end of week 4)

C.5.3 Begin planning collocated office space

C.5.4 Set up WBS (by end of week 4)

C.5.5 Set up financial system (by end of week 4)

C.5.6 Plan top-level task network (by end of week 4)

C.5.7 Develop schedule (by end of week 4)

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C.5.8 Bring second wave of team on (by end of week 4)

C.5.9 Review draft Project Reference Planning Documents with customers and stakeholders (by end of week 6)

C.5.10 Complete project team office move

C.5.11 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 2 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 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 Collocated office space has been established.

C.6.9 Lessons are being recorded that will improve Langley's system for initiating projects.

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Appendix D: The Seven Principles of Earned Value Management

D.1 Plan all work scope for the project to completion.

D.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.

D.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.

D.4 Use actual costs incurred and recorded in accomplishing the work performed.

D.5 Objectively assess accomplishments at the work-performed level.

D.6 Analyze significant variances from the plan, forecast impacts, and prepare an estimate at completion (EAC) based on performance to date and work to be performed.

D.7 Use earned value information in the Project's decision-making and review processes.

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Appendix E: Elements of the Earned Value Management (EVM) Implementation Procedures

E.1 The procedures listed represent LaRC's best practices to implement Earned Value Management on NASA programs and projects through adherence to the 32 EVM guidelines in the ANSI/EIA-748 standard and compliance with Appendix E in this document: The Seven Principles of Earned Value Management.

E.2 Guides to the application, implementation, and utilization of the procedures listed below are further defined in:

E.2.1 The NASA Cost Estimating Handbook
http://www.nasa.gov/offices/pae/organization/cost_analysis_division.html

E.2.2 The Integrated Baseline Review (IBR) Handbook December, 2009
http://evm.nasa.gov/handbooks.html

E.2.3 The NASA Schedule Management Handbook, March 2011
http://evm.nasa.gov/handbooks.html

E.2.4 The NASA Work Breakdown Structure (WBS) Handbook, January 2010
http://evm.nasa.gov/handbooks.html

E.2.5 The ANSI/EIA-748-B EVMS Guideline, September 2007.
http://nxout.larc.nasa.gov/?c=25392 or Langley Integrated Financial Environment (LIFE) > Policies and Procedures > Earned Value Management > EVM Guidelines and Implementation Guide

E.3 Outline of EVM Procedures

EVM PROCEDURES

1.0 Define the WBS and WBS dictionary tailored for effective internal management control.
2.0 Identify the project organizational structure, including contractors. Define organizational structure in which work will be planned and controlled.
3.0 Schedule the authorized work in a manner that describes the sequence of work and identifies significant task interdependencies and risk mitigation required to meet the requirements of the project.
4.0 Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure progress.
5.0 Establish and maintain a time phased budget baseline at a control account level against which program performance can be measured.

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6.0 Budget development and planning, including resource planning, for authorized work with identification of significant cost elements (labor, material, etc).
7.0 Identify management reserve (MR) and undistributed budget (UB). (Recognized risks that are not quantifiable should be considered when developing MR).
8.0 Provide that the project target cost goal is reconciled with the sum of all internal project budgets and MR.
9.0 Record direct cost consistent with the budgets in a formal system controlled by the general books of account.
10.0 On a monthly basis, generate the following information at the control account level using actual cost data from, or reconcilable with, the accounting system:
- 10.1. Schedules with progress, performance, and other data as required to reflect both the current plan and the approved baseline.
- 10.2 A comparison planned value and earned value for work accomplished.
- 10.3 A comparison earned value and actual cost for the same work.
- 10.4 Variance explanations in the detail needed by program management.
- 10.5 Revised estimates of cost at completion based on performance to date, commitment values for material and estimates of known cost variance not included in the plan but falling within the SOW. Compare this information with the performance measurement baseline to identify variances at completion.
- 10.6 Updated financial forecasts based on 10.5
- 10.7 Managerial actions taken as a result of earned value information.

11.0 Incorporate authorized changes in a timely manner, recording the effects of such changes in budgets and schedules. Work Authorization Documents (WADs), BCWS, BCWP, ACWP, and WBS data should be subject to configuration controls.
12.0 Prevent revisions to the project budget except for authorized changes.
13.0 Document changes to the performance measurement baseline.
14.0 Define Contractor EVM requirements. Determine need for schedule integration or milestone management.
- 14.1 Ensure that EVM requirements are included in each Request for Proposal (RFP) and the responses are evaluated for compliance with these requirements.
- 14.2 The RFP includes language that requires a logic network schedule and defines the logic network schedule requirements.
- 14.3 The RFP includes Technical Progress Reports (TPRs) that are consistent with NPR 7120.5 and applicable to the project scope content. The TPRs provide a useful link between technical achievement and the cost and schedule indices used in EVM.
- 14.4 Include an integrated Risk Management process. Consider time and cost estimates for reasonable risks.
- 14.5 Provide Data Requirements Documents (DRDs) for all contracts that have an EVM requirement. These include:
  - 14.5.1 Contract Performance Report (CPR) reporting requirements, including contract reporting formats and tools.

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14.5.2 A WBS and WBS dictionary
14.5.3 An EVM System Description
14.5.4 IBR requirements
14.5.5 Schedule reporting requirements, contract reporting formats, and tools.

14.6 Conduct an Integrated Baseline Review (IBR) within six months of contract award as required by NASA Procurement Notice (PN) 04-19 1852.234-2(c). http://www.hq.nasa.gov/office/procurement/regs/pn04-19.html Guidance for the IBR process is provided in the NASA IBR Toolkit.

15.0 Coordinate with and obtain concurrence from supporting NASA centers throughout the development of project plans regarding implementation, maintenance, surveillance, and reviews of the project's EVMS.

Guidance

a. Integrated Baseline Review (IBR) Handbook, December 2009 http://evm.nasa.gov/handbooks.html
b. NASA Schedule Management Handbook, March 2011 http://evm.nasa.gov/handbooks.html
c. NASA Work Breakdown Structure (WBS) Handbook, January 2010 http://evm.nasa.gov/handbooks.html

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Appendix F: List of Referenced Requirements, Standards, and Guidance

F.1 Requirements

F.1.1 NPD 7500.1, Program and Project Life-Cycle Logistics Support Policy

F.1.2 NPR 7120.5, NASA Space Flight Program and Project Management Requirements

F.1.3 NPR 7123.1, NASA Systems Engineering Processes and Requirements

F.1.4 NPR 7150.2, NASA Software Engineering Requirements

F.1.5 NPR 8000.4, Agency Risk Management Procedural Requirements

F.1.6 NPR 8020.12, Planetary Protection Provisions for Robotic Extraterrestrial Missions

F.1.7 LAPD 1440.7, Langley Research Center (LaRC) Records Management

F.1.8 LPR 1740.2, Facility Safety Requirements

F.1.9 LPR 7120.7, Space Flight Independent Life Cycle Review Procedural Requirements

F.1.10 LPR 7600.1, Closeout Photographs for Flight and Ground Hardware Procedural Requirements

F.1.11 LMS-CP 4501, Procurement Process Overview

F.1.12 LMS-CP 4523, Contractor Performance Monitoring

F.1.13 LMS-CP-4750, Develop Product Assurance Plans

F.1.14 LMS-CP-4754, Software Assurance (SA) for Development and Acquisition

F.1.15 LMS-CP-4756, Handling, Preservation, Storage, and Shipping of Space Flight Hardware and Ground Support Equipment

F.1.16 LMS-CP-4759, Acquisition of Hazardous Materials

F.1.17 LMS-CP-4892, Bonded Storage

F.1.18 LPR 5300.1, Product Assurance Plan

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

F.1.19 LMS-CP-5502, Systems Engineering Requirements Definition & Implementation Planning for Development Project/Experiments

F.1.20 LMS-CP-5507, Reporting and Disposition of Nonconforming Aerospace Hardware Items and Products

F.1.21 LMS-OP-5515, Electric, Electronic, and Electromechanical (EEE) Parts Assurance

F.1.22 LMS-CP-5526, Product Requirements Development and Management Procedure

F.1.23 LMS-CP-5528, Software Planning, Development, Acquisition, Maintenance, and Operations

F.1.24 LMS-CP-5640, Requesting, Performing, and Closing Fabrication Services Requests

F.1.25 LMS-CP-8621, Reporting, Investigating, and Recordkeeping for Mishaps, Close Calls, and Previously Unidentified Serious Workplace Hazards

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.2.8 NASA-HDBK 8739.21 Workmanship Manual for Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)

F.2.9 IPC J-STD-001ES, Space Applications Electronic Hardware Addendum to IPC J-STD-001E Requirements for Soldered Electrical and Electronic Assemblies

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F.3 Guidance

F.3.1 NPD 8020.7, Biological Contamination Control for Outbound and Inbound Planetary Spacecraft

F.3.2 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.3.3 PMI, Practice Standard for Project Configuration Management, Project Management Institute, Inc, Newtown Square, PA

F.3.4 PMI, Practice Standard for Earned Value Management, Project Management Institute, Inc, Newtown Square, PA

F.3.5 PMI, Practice Standard for Scheduling, Project Management Institute, Inc, Newtown Square, PA

F.3.6 PMI, Practice Standard for Work Breakdown Structures, Project Management Institute, Inc, Newtown Square, PA

F.3.7 NASA Cost Estimating Handbook http://www.nasa.gov/offices/pae/organization/cost_analysis_division.html

F.3.8 CALIPSO Lessons Learned

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